1-2006

Sustainable Highways: Destination or Mirage?

John R. Bartle
University of Nebraska Omaha, jbartle@unomaha.edu

Jijesh Devan
Queens Business School

Sustainable Highways: Destination or Mirage?

John R. Bartle, Professor

School of Public Administration

University of Nebraska at Omaha

6001 Dodge St.

Omaha, NE 68182-0276

Voice: (402) 554-3989

Fax: ((402) 554-2682

jbartle@mail.unomaha.edu

and

Jijesh Devan, Doctoral Candidate

Queens Business School

Kingston, Ontario Canada

jdevan@business.queensu.ca

Prepared for Symposium on Sustainable Development

Public Works Management and Policy

September, 2005

Biography

John R. Bartle is a Professor in the School of Public Administration at the University of Nebraska at Omaha. He teaches and does research in the areas of public finance policy and management, public budgeting, transportation, and applied economics. He is the Chair-Elect of the Association for Budgeting and Financial Management, and is on the Executive Committee of the Section on Transportation Policy and Administration of the American Society for Public Administration.

Jijesh Devan is a doctoral candidate at the Queens Business School in Kingston, Ontario. Prior to joining Queens he was a doctoral student at the University of Nebraska Omaha's School of Public Administration. His current research focus is information systems in public sector.

Abstract

Highway travel is forecasted to increase steadily worldwide in the foreseeable future. However this pattern is unsustainable environmentally, economically, financially and socially. Federal legislation, in particular the Intermodal Surface Transportation Efficiency Act, has made progress towards the goal of sustainability; and technological improvements offer potential for reduced emissions, but both potentials have not been fully realized. Reduced use and redesigned taxes are unlikely possibilities. Ultimately, institutions will have to change. The European Union offers an example of how the institutional change can be implemented in a durable way. This change is important not just for environmental reasons, but also for long-term prosperity.

Sustainable Highways: Destination or Mirage?

Introduction

This paper applies the concept of sustainable development to highway transportation. It begins with a discussion of current problems along the four dimensions of sustainability: environmental, economic, financial, and social. It then discusses current policies and some proposed reforms. The following section discusses the potential for an institutional perspective to offer new solutions. A final section concludes.

Sustainability Issues in Highway Transportation

Highway transportation affects all four dimensions of sustainability. The issues raised by highway transportation are likely to be intensified in the future as mobility needs increase in the U.S. and globally. Many of those in the 85 percent of the global population that does not own an automobile are likely to purchase one in the near future (Hawken, Lovins, & Lovins, 1999). Between 1990 and 2000, passenger-kilometers traveled increased by 24 percent in the U.S. (BTS, 2003). Forecasts imply a rapid increase in global highway travel, doubling from 1990 to 2020, and then redoubling again by 2050. In the U.S., highway travel is projected to double from 1990 to 2050 (Schafer & Victor)**.** This increase in mobility will challenge the attainment of long-run sustainability.

ENVIRONMENTAL

The principal ecological problems of road transportation are emissions, noise, and land use. The transportation sector is the fastest-growing and most intractable source of carbon dioxide emissions (Hawken, Lovins, & Lovins, 1999). Emission of gases and particles lead to changes in atmospheric composition, causing harm on local, regional (acid rain, smog) and global scales

(melting polar icecaps and rising sea levels) (NRC, 1998). According to the Bureau of Transportation Statistics, highway vehicles were the largest contributors of pollution in the transportation sector. In 2001, they contributed 66 percent of total U.S. carbon monoxide, 31 percent carbon dioxide, 47 percent of nitrogen oxide, and 35 percent volatile organic compounds. Transportation emission of greenhouse gases (GHG) grew by 22 percent from 1990 to 2001, while the percentage of carbon dioxide emissions increased by 24 percent (BTS, 2003). The National Research Council (1998) also points out that highways alter land surface and reduce habitat, leading to losses in biodiversity.

The World Business Council for Sustainable Development (WBCSD), a group of leading industry transportation and energy companies, issued a report that set seven goals for moving towards sustainable mobility. Two of these seven goals concern conventional and greenhouse gas emissions, specifically: "[e]nsure that the emissions of transport-related conventional pollutants do not constitute a significant public health concern anywhere in the world, [and] limit transport-related GHG emissions to sustainable levels" (WBCSD, 2004).

While the degree of climate change induced by greenhouse gases is somewhat uncertain, global temperatures have been rising steadily. The climate change induced by the emission of GHG has already had an impact on economic risks and insurance costs. Air pollution from emissions has local effects in the form of deteriorating public health, and transportation bears major responsibility. Nearly half of all Americans live with unhealthy levels of air pollution (Ernst, Corless, & Greene-Roesel, 2003). Research has linked air pollution to a host of public health concerns including asthma, cancer, heart disease, heart attack, stroke, high blood pressure, birth defects, and brain damage (American Lung Association, 2002).

Increasing traffic volumes will result in increasing noise pollution. Studies done by the

European Union (EU) show that noise pollution costs roughly € 10-40 billion. Major European cities, such as London, are working to control noise (Dooley, 2004). Another obvious health effect is deaths and injuries in travel and provision of transportation. In 2001, nearly 93 percent of the 45,130 transportation-related fatalities were highway-related. This was an increase of 1.8 percent from 1991 (BTS, 2003). Motor vehicle crashes in the U.S. cost an estimated $231 billion in 2000, two percent of the Gross Domestic Product (BTS, 2003).

ECONOMIC

The economic dimension of sustainability injects the concept of economic efficiency into sustainability. An efficient economic system corrects for market failures, achieves cost-effectiveness, and achieves the highest return on all capital (financial, human, physical, and natural capital). The social costs of highway transportation due to congestion, traffic delays, accidents, roadway damage, land use, and other side effects have been estimated by Miller and Moffet (1993) at over a trillion dollars. Unless these costs are internalized into production and consumption decisions they will cause economic inefficiency. Pigouvian solutions potentially offer one approach to induce behavioral and social changes necessary to achieve an efficient and sustainable transportation system but they have rarely been pursued in practice (Verhoef & Pels, 1999). Part of the problem is that in the U.S., negative externalities caused by transportation are subsidized by long-standing policies. Policies that undercharge for highway use have imposed a large number of unsupportable costs leading to economic unsustainability of the current transportation system.

Cost has always been a driving factor in making transportation decisions, yet in most cases non-pecuniary costs such as congestion, pollution, noise and other externalities are not included in transportation decision-making (Gómez-Ibáñez & Tye, 1999). For most of the last century,

U.S. federal surface transportation policy focused on accommodating the demand for mobility and favored the automobile as the mode of travel (Giuliano & Wachs, 1992). Two unique characteristics of U.S. transportation systems are indirect subsidies and the high level of private sector involvement in developing policy and managing transportation systems (McKenna & Anderson, 1990). Though most highway policies, including the 1962 Federal Aid Highway Act and the 1973 Federal Aid Highway Act, mandated integrated transportation planning processes, they lacked effective organizational structure or financial resources to follow through (Horan, Dittmar, & Jordan, 1999). While the 1991 Intermodal Surface Transportation Efficiency Act (ISTEA) improved on this short-coming, it is still a work in progress towards achieving the implementation of its holistic approach (Gifford, Horan & White, 1994). Today the primary goal of federal highway policy is still to accommodate the demand for mobility rather than to create a sustainable system (Yarma, 2002).

The absence of an appropriate price signal for the use of environmental capacity leads to wasting natural capital. Public policies that accurately correct for market failure would make parking and driving bear their true costs, foster genuine competition between all modes of travel, improve land use, and increase accessibility by clustering business and residential areas together. Optimum transportation pricing is economically desirable as has been suggested by many economists, but the adoption and implementation of such an approach is the Gordian knot of the attempt to attain sustainability in transportation (Verhoef & Pels, 1999). In the face of increasing congestion, U.S. transportation policy has been slow to pursue user fees or congestion pricing. Despite these problems, the surface transportation industry is cognizant of the issue of sustainability. The WBCSD called on governments to provide the necessary incentives to promote research, production of vehicles and consumption of fuels that could help meet

sustainability goals (WBCSD, 2004).

FINANCIAL

Financial incentives in the U.S. highway transportation financing system are problematic in several ways. First, the fuel taxes that have historically financed American highways are increasingly being replaced by local general revenue sources (Wachs, 2003), leading to more subsidized driving compared to other modes of transportation (Benfield & Replogle, 2002; Hawken, Lovins, & Lovins, 1999). Second, at both federal and state levels, fuel taxes are the main source of revenue for highway trust funds. These in turn are used for new road construction that often promotes more travel, negatively affecting land use, modal choice, and environmental regeneration. The externalities caused by vehicle emissions suggest that these revenues should not be deposited in trust funds supporting further pollution.

Third, highway tax policy does not reflect the costs of damage to pavement, and therefore sends the wrong incentives to users and producers, wasting resources and creating premature obsolescence of roads (Small, Winston, & Evans, 1989). Fourth, the structure of federal aid for highways and airports generally uses predetermined matching rates in distributing funds. These matching rates tend to be too high with overly restrictive rules regarding use of funds (Gramlich, 1994). ISTEA stimulated the examination and application of flexible matching grant programs, and congestion pricing under the "value pricing program." The NRC (1994) has recommended that the federal government play an active role in pursuing this path.

SOCIAL

One of the goals of sustainable development can be described as sustaining or improving the quality of life of all people, now and in the future (World Commission on Environment and Development [WCED], 1987). The social equity concerns of highway-related transportation are

focused on access, congestion relief, health, and the effects of noise and pollution on various populations -- the poor, the disabled and the powerless. Pollution has particularly adverse effects on children and the elderly, which exacerbates inter-generational equity.

The Bureau of Transportation Statistics indicates that half of the working poor in the U.S. spend 10 percent of their income on commuting expenses in 1999. Between 1991 and 2001 the annual expense of driving an automobile increased by 16 percent (BTS, 2003). Forecasts predict a significant increase in auto travel volume globally and within both the U.S. and E.U. (Schafer & Victor). The reasons for this "car dependence" are attributable in part to the physical structure of modern societies (central business districts with suburban residential areas) (Gorham, 1999). This heavy car dependence leads to congestion, traffic, accident risk, and commuting stress (Steg & Vlek, 1997). Urban and metropolitan forms are heavily influenced by transportation systems. According to McKee & McKee (2001) the emergence of "edge cities" can be attributed to the advancement in transportation and communications. These edge cities and new suburban developments create social issues particularly involving the mobility of the young and elderly due to the dependence on automobiles (O'Kelly & Mikelbank, 1999). The lack of a car causes an individual or family to feel cut off from the social fabric -- friends, family, social activities, businesses, shops, and work (Gorham, 1999). The WBCSD (2004) called for a narrowing in the mobility gap between the poorest and richest nations, and between the poor and the middle class within nations. This would enhance the mobility of the poor, although it may do so at the expense of sustainability.

Current Solutions

CURRENT POLLUTION CONTROL POLICIES

Mobility has both positive and negative effects; increasingly the danger is that the negative

effects on the environment and society outweigh the positive. Since the 1992 Earth Summit, some governments have been involved in agreements and laws that seek to address the sustainability problems in transportation. These include both international treaties and national legislation, which are briefly reviewed here. The most prominent international treaty, the Kyoto Protocol of 1997, recently went into effect despite the lack of assent by the U.S. It set goals for reductions in the emissions of carbon dioxide, methane and nitrous oxides by 2008-2012. The major pieces of legislations that address the social and environmental impacts of transportation in the U.S. are summarized below.

The Federal Aid Highway Act of 1962 is one of the most significant federal acts that established links between transportation, communities, and environmental values (Horan, Dittmar, & Jordan, 1999). The act mandated use of an integrated transportation planning process for highway construction, and created ten "planning elements" related to land use and social and community values. The Department of Transportation Act of 1966 restricted the use of highway development in parks, recreation areas, wildlife and waterfowl refuge, historic sites and cultural sites. The Federal Aid Highway Act of 1968 mandated public hearings and citizen participation for highway projects, and assistance for people displaced by highways.

The National Environmental Policy Act of 1969 mandated inclusion of environmental impact statements with all federal projects affecting the environment. The Clean Air Act of 1970 created emission standards leading to national ambient air quality standards (Horan, Dittmar, & Jordan, 1999). The Clean Air Act of 1977 institutionalized conformity regulations and sanctions against non-compliance with air quality standards and later the Clean Air Act of 1990 strengthened compliance regulations and emission standards.

The next major piece of legislation was ISTEA which declared the policy of the U.S.

government to develop a transportation system that is "economically efficient and environmentally sound while moving individuals and property in an energy efficient way" (cited in Benfield & Replogle, 2002, p. 10638). The biggest influence of ISTEA was its emphasis on linking the various transportation modes in order to achieve a wide variety of goals: mobility, environmental quality, equity and aesthetic and cultural values (Horan, Dittmar, & Jordan, 1999, p. 218). Along with the restructured Federal-Aid Highway Program, this caused major changes in how transportation projects are undertaken. ISTEA allowed the states to use funding for new programs such as those that would mitigate traffic congestion, increase safety, and contribute to the attainment of air quality standards. ISTEA also mandated specific steps to open up the transportation planning process to the public. Unlike previous legislation, ISTEA had more effective implementation tools to ensure that transportation projects would be sensitive to the environment (Schweppe, 2001). One such provision was the Congestion Mitigation and Air Quality Improvement Program, which earmarked funds for air quality improvement. Another was the Transportation Enhancement Program which funded community enhancement projects. A third major provision was the strengthening of Metropolitan Planning Organizations (MPOs) through the planning mandates. ISTEA helped move the decision making and planning towards the MPOs to enhance local community involvement and control. The enhanced role of MPOs has to some degree strengthened the sustainability practices in transportation sector (Horan, Dittmar, & Jordan, 1999). Ernst, Corless, and Greene-Roesel (2003) have declared that "ISTEA has transformed the transportation planning process by recognizing the long-term economic, social and environmental impacts of transportation decision."

According to Braum (1994), ISTEA and its successor Transportation Equity Act for the 21st Century (TEA-21) have reinforced the integration of environmental sensitivity and transportation

investment. TEA-21 focused on improving safety, protecting health and the environment. The bill emphasizes congestion mitigation and air quality standards, developing advanced vehicle programs for fuel efficiency, and increasing alternate forms of mobility (Federal Highway Administration [FHWA], 1998).

While substantial progress is being made towards developing administrative structures that support sustainability goals, the growing problems reviewed earlier indicate that the current structure of laws and agency powers still leaves highway transportation short of the goal of sustainable development.

TECHNOLOGY

Historically, technology has reduced pollution and improved the performance of automobiles. With the onset of the information revolution, information technologies are available for improved performance of the highway transportation system. The adoption of certain technologies can alleviate transportation problems, but major barriers remain (Yacobucci, 2004).

Fuel and powertrain technologies will play a significant role in moving towards sustainability goals. Light-duty road vehicles are the most common types of vehicles today and they are expected to increase from 700 million in 2000 to over 2 billion by 2050 (WBCSD, 2004). The efficiency of the internal combustion engine can be increased and conventional and GHG emissions can be reduced by employing hybrid-electric powertrain. Though hybrids are not zero-emission vehicles, they do represent a significant reduction in emissions. Fuel cells have tremendous potential to move toward zero-emissions. Hydrogen based proton exchange membrane fuel cells offer great promise but there are technological hurdles with the fuel cells (Truett, 2004). One of the primary challenges of hydrogen-based fuel cells is the distribution and storage of hydrogen (WBCSD, 2004). The National Academy of Engineers & Board on Energy

and Environmental System (2004) concluded that before the vision of hydrogen-based economy can become a reality, many technical, social, and policy challenges must be overcome.

Other factors that help move towards more sustainable automobiles are technology for automotive weight reduction, improved aerodynamics of the automobile body and technologies for reducing rolling resistance. Highway noise pollution can be reduced by improved tire technology, as tire noise is the biggest contributor to highway noise. There is clear consensus on the theoretical achievements of these technologies (Hawken, Lovins, & Lovins, 1999; WBCSD, 2004), yet the potential remains to be realized.

Intelligent Transportation Systems (ITS) are another potential technological solution. They gather, process, analyze and disseminate information for improved efficiency of the transportation system. The FHWA divides ITS into nine infrastructure components, namely: freeway management, incident management, arterial management, electronic toll collection, electronic fare payment, transit management, highway-rail intersections, emergency management, and regional multimodal traveler information (Gordon & Trombly, 2004). While the FHWA (2004) has declared that the deployment of ITS is well on its way to being accomplished, its focus is not on achieving sustainability goals. Gordon and Trombly (2004) explain that ITS implementation is generally not focused on creating an integrated transportation management system. While this is being done in a few states such as Minnesota, it is not widespread. ITS and other technologies can contribute to sustainability if these improvements are focused on the environmental, economic, financial, and social dimensions of sustainability rather than on increased mobility and speed.

REDUCED USE

Over time, federal policies have been based on the belief that new technology could make

cars cleaner, more efficient and safer without the political pain and economic disruption of limiting driving (Leone, 1999). Today even the automobile industry is suggesting alleviating automobile dependence and travel. The WBCSD calls for the need to change social institutions and society's underlying values and attitudes about transportation if sustainability is to be attained (WBCSD, 2004).

In many developed regions, economic growth has led to income growth, which has increased car ownership and urban sprawl. Sustainability goals are more likely to be attained if economic growth can be decoupled from automobile use. While some federal legislation has attempted to mitigate the over-dependence on automobiles, the near ubiquitous use of cars by Americans has overwhelmed policy. Still, there are some indications of movement away from car dependence. The private sector is endorsing ways to reduce car dependence by strengthening multimodal planning processes and expanding commuter benefit programs (Association for Commuter Transportation, 2002). Singapore has attacked car dependence with heavy taxes on cars, auctioning the right to buy cars, and imposing high fees for driving to downtown. Denmark has banned cars in phases from central business districts to wean the dependence on cars (Hawken, Lovins, & Lovins, 1999).

The goals of mobility may always conflict to some degree with sustainability. However, it is possible to reduce some unnecessary travel or divert travel among modes at the margin. As Wachs (2004) points out, American attitudes have been changed by public education efforts in numerous areas. In addition to public education, financial incentives are another tool to make highway use more sustainable, as the next section describes.

TAXING EXTERNALITIES

The problems of greenhouse gases, air pollution, loss due to accidents and deaths,

congestion and noise pollution caused by highway transportation are negative externalities (Ingram & Liu, 1999). A widely recommended solution by economists is to tax the externality. Doing so would discourage uneconomic driving, induce a shift toward less-polluting modes, and produce revenue that could be used for mitigation expenses. Tax reforms that move towards correct pricing of goods and services are therefore an attractive tool to improve the sustainability of highway transport. Kyoto protocol signatories are using regulation and taxes as a way to meet their targets by either GHG reduction or enhancing carbon sinks[1] or both. For example, Canada intends to use "targeted measures" including incentives, regulation and taxes to meet their emission goals (Canada Office of Energy Efficiency, 2002).

Economic analysis has long argued for internalization of the externalities of pollution, noise, and congestion caused by transportation. Congestion pricing has been shown to reduce congestion, save time, improve air quality, promote efficient modal choices, and improve revenue generation (Finch, 1996). And yet this strategy is only just beginning to be implemented in Europe, and is not generally used in the U.S. Several barriers to this strategy were detailed in the article in this symposium by [Author X]: the political imbalance between polluters and those affected by pollution, the amount of information required to administer an efficient pricing system, and the presence of other economic distortions. These problems suggest that other means of addressing the externality problem need to be considered. Coase (1960) suggested that several other means of addressing externalities are possible. They include regulation, reassignment of property rights, and regulation. However, the common pool nature of the pollution problem suggests that there are important institutional barriers to these approaches. While technology may present some better opportunities to address the externality problem (such as use of ITS to tax individual vehicles based on the time- and place-specific charges caused) it is unlikely that

the externality problem will be solved without institutional reform. The potential in this area is now explored.

Institutional Reform

As has been discussed by Rietveld & Stough (2002), Rietveld (2002) and Connor & Dovers (2004), North's (1990) transaction cost model of institutions is a framework which may be useful in conceptualizing how institutional reform should proceed. Institutions provide a structure of exchange which determines both the cost of transactions and which exchanges will occur. The initial institutions (such as a constitution) establish this framework and the incentives facing actors. As they respond to these incentives, institutions change, further elaborating a path of development. The resulting development may or may not be efficient; if not, long-term economic growth will be retarded. As Rietveld and Stough point out, there are several examples of this in transportation:

- The Kyoto Protocol does not include all nations in emissions limits.
- Research and development leading to pollution reduction may be too costly for businesses in low profit-margin industries. Further, the public good nature of this research makes it likely to be under-supplied by the private sector.
- Free or subsidized parking can lead commuters to drive rather than to use public transit, making it easier for them to live farther away from their workplace and off transit lines, causing urban sprawl which makes public transit more expensive.

A major change like sustainability that affects so many dimensions of people's lives cannot be woven into the fabric of a nation's institutions quickly or easily. Further, the holistic emphasis of sustainability requires that it integrate across policy areas, which is especially challenging in a political system like ours with divided powers. However, the European Union is an example of a

federation which has transformed its institutions to embraced sustainability (Connor & Dovers, 2004). The concept is in the E.U. Constitution (European Union, 1999), which establishes a legally enforceable commitment to sustainable policies. The establishment of such rights (such as granting legal standing to those harmed by pollution) is an example of an institutional feature that supports this goal and will continue to reinforce political development sympathetic to sustainability.

Connor and Dovers (2004) have suggested two institutional tools of sustainability: Strategic Environmental Assessment (SEA) and Property Rights Instruments (PRI). SEA systematically evaluates the environmental consequences of policy, weighing them with economic and social concerns. SEA has been implemented fully or partially in several countries. SEA requires "teeth" to be implemented meaningfully, and so further study of the success or failure of its implementation is appropriate. The PRI approach is to establish entitlements to resource use, such as to capture the value from these rights and the ability to trade them. Property rights may be identified for various elements of resource use: access, withdrawal, management, exclusion, and alienation. PRI seems most applicable to situations where property rights are most meaningful, such as the cases of local emissions and noise pollution. It is hard to see how it would apply to a global problem such as greenhouse gas emissions, as no strong international governance exists to enforce these rights.

The WBCSD (2004) discusses the need for policy instruments such as pricing, regulation, subsidies, taxes and incentives to achieve and promulgate sustainability. The imposition of federal or international regulations and taxes to achieve emissions reductions may well be in the best interests of industry to put all companies in the industry on a level playing field. Uniform regulations are important to an industry that by its nature is not constrained by national

boundaries. As the National Research Council (2003) found, there are few financial incentives for industry to develop and deploy environmental technologies that go beyond regulatory requirements. The environmental impact would be reduced if manufacturers, service providers, and consumers all faced the full cost of their activities.

Of course, current political institutions are resistant to changes in regulations and taxes that are perceived to increase costs. This resistance creates a vicious cycle of institutional development where resources are not used to their highest potential and capital is wasted. Until actors see sustainability in their best interest, political and economic interests will resist changes moving in this direction, which reduces the incentives for reform. Connor and Dovers (2004) argue persuasively that this change needs to take place both inside and outside of government, and use both top-down and bottom-up political authority in government. Ultimately the critical test is whether or not the policy will be implemented on a long-term basis by public and private organizations.

Conclusion

Making transportation policy more congruent with the goal of sustainable development is a persuasive policy goal not only for ecological reasons, but also for economic reasons because it will maximize the return from all forms of capital. Incentives that lead to waste of any form of capital lead to lower long-term growth and a lower future quality of life. The path-dependence of economic growth suggests that these incentives create a long-term distortion from which societies may not necessarily recover. Institutional reform therefore is central to the goal of using capital resources efficiently. Achieving this efficiency will not be done by a single policy approach because different institutional structures create different costs and incentives. Some current policies have moved in this direction, such as the environmental impact statement

process, the subsidization of research and development in emissions reduction, noise reduction and noise abatement, but there is still a long way to go. The looming threat of global climate change makes this reform one of the most important issues for the world today.

References

American Lung Association. (2002). *Annotated bibliography of recent studies on the health effects of air pollution*. Author.

Association for Commuter Transportation. (2002). *ACT's TEA-21 platform & recommendations*. Washington DC.

Benfield, F. K., & Replogle, M. (2002). The road more traveled: Sustainable transportation in America or not. *Environmental Law Reporter, 32*, 10633-10647.

Braum, P. (1994). ISTEA planning factors in the transportation planning process. In M. Franko (Ed.) *ISTEA planners workbook*. Washington DC: Surface Transportation Policy Project.

Bureau of Transportation Statistics. (2003). *Transportation statistics annual report*. Washington: Author.

Canada Office of Energy Efficiency. (2002). *Climate change plan for Canada*. Retrieved November 11, 2004, from http://www.climatechange.gc.ca/plan_for_canada/plan/summary.html

Coase R. (1960). The problem of social cost. *Journal of Law and Economics 3*, 1-44.

Connor, R. & S. Dovers. 2004. *Institutional change for sustainable development.* Cheltenham UK: Edward Elgar Publishing.

Dooley, E. E. (2004). London hits volume control. *Environmental Health Perspectives*, 112.

Ernst, M., Corless, J., & Greene-Roesel, R. (2003). *Clearing the air, public health threats from cars and heavy duty vehicles - why we need to protect federal clean air laws*. Washington DC: Surface Transportation Policy Project.

European Union. (1999). Treaty establishing the European community. Retrieved November 11 2004, http://europa.eu.int/scadplus/leg/en/s50000.htm

Federal Highway Administration. (1998). *The transportation equity act for the 21st century: TEA-21*. Washington DC: Author.

Federal Highway Administration. (2004). *Deploying the integrated metropolitan intelligent transportation systems infrastructure FY 2003 report*. Washington DC: Author

Finch, G. (1996). Congestion pricing reducing traffic jams through economics. *Public Roads, 60*(2) 4-5.

Gifford, J. L., Horan, T. A., & White, L. G. (1994). Dynamics of policy change: Reflections on the 1991 federal surface transportation legislation. *Transportation Research Record 1466, 8*(13).

Giuliano, G., & Wachs, M. (1992). Managing transportation demand: Markets versus mandates. In Robert W. Poole, Jr., ed. *Congestion pricing for southern California: Using market pricing to reduce congestion and emissions*. Proceedings of a symposium sponsored by the Federal Highway Administration, Federal Transit Administration, and the Reason Foundation, Los Angeles, CA, September 1992.

Gómez-Ibáñez, J. A., Tye, W. B., & Winston C. (1999). *Essays in transportation economics and policy: A handbook in honor of John R. Meyer*. Washington DC: Brookings Institution Press.

Gordon, S., & Trombly, J. (2004). *Tracking the deployment of the integrated metropolitan*

intelligent transportation systems infrastructure in the USA: FY 2002 results. Washington DC: Federal Highway Administration.

Gorham, R. (2002). Car dependence as a social problem: A critical essay on the existing literature and future needs. In W. R. Black & P. Nijikamp (Eds.), *Social change and sustainable transport* (pp. 107-115). Bloomington IN: Indiana University Press.

Gramlich, E. (1994). Infrastructure investment: A review essay. *Journal of Economic Literature, 32*, 1176-1196.

Hawken, P., Lovins, A., & Lovins, L. H. (1999). *Natural capitalism: Creating the next industrial revolution*. Boston: Little, Brown and Company.

Horan, T. A., Dittmar, H., & Jordan, D. R. (1999). ISTEA and the new era in transportation policy: Sustainable communities from a federal initiative. In D. A. Mazmanian & M. E. Kraft (Eds.), *Toward sustainable communities: Transition and transformations in environmental policy* (pp. 217-245). Cambridge, MA: MIT Press.

Ingram, G. K., & Liu, Z. (1999). Determinants of motorization and road provision. In J. A. Gómez-Ibáñez, W. B. Tye & C. Winston (Eds.), *Essays in transportation economics and policy: A handbook in honor of John R. Meyer*. 325-356. Washington DC: Brookings Institution Press.

Leone, R. A. (1999). Technology-forcing public policies and the automobile. In J. A. Gómez-Ibáñez, W. B. Tye & C. Winston (Eds.), *Essays in transportation economics and policy: A handbook in honor of John R. Meyer*. 291-324. Washington DC: Brookings Institution Press.

McKee, D. L., & McKee, Y. A. (2001). Edge cities and the viability of metropolitan economies: Contributions to flexibility and external linkages by new urban service environments. *American Journal of Economics & Sociology, 60*(1), 171.

McKenna, F., & Anderson, D. (1990). United States. In T. Akaha (Ed.), *International handbook of transportation policy* (pp. 269-300). New York: Greenwood Press.

Miller, P. and J. Moffet. (1993). *The price of mobility: Uncovering the hidden costs of transportation*. New York: Natural Resources Defense Council.

National Academy of Engineering & Board on Energy and Environmental Systems. (2004). *The hydrogen economy: Opportunities, costs, barriers, and R&D needs*. Washington DC: National Academies Press.

National Research Council. (1998). *Atmospheric change and the North American transportation sector: Summary of a trilateral workshop*. Washington: National Research Council.

National Research Council. (2003). *For greener skies: Reducing environmental impacts of aviation.* Washington: National Academy Press.

North, D. C. (1990). *Institutions, institutional change and economic performance*. Cambridge UK: Cambridge University Press.

O'Kelly, M. E., & Mikelbank, B. A. (2002). Social change and transportation in U.S. edge cities. In W. R. Black & P. Nijikamp (Eds.), *Social change and sustainable transport* (pp. 93-98). Bloomington IN: Indiana University Press.

Rietveld, P. (2002). Institutional Dimensions of Sustainable Transport. In W. R. Black and P.

Nijkamp (Eds.), *Social change and sustainable transport* (pp. 55-59). Bloomington IN: Indiana University Press.

Rietveld, P., & R. Stough. (2002). *Institutional dimensions of sustainable transport.* Presented to the Meeting of STELLA (Amsterdam).

Schafer, A., & Victor, D. (Oct 1997) The past and future of global mobility. *Scientific American, 277*(4): 58.

Schweppe, E. (2001). Legacy of a Landmark: ISTEA after 10 Years. *Public Roads, 65*(3): 2-6

Small, K. A., Winston, C., & Evans, C. A. (1989). *Road work: A new highway pricing and investment policy*. Washington, D.C: Brookings Institution.

Steg, L., & Vlek, C. (1997). The role of problem awareness in willingness-to-change car use and in evaluating relevant policy measures. In T. Rothengatter & E. C. Vaya (Eds.), *Traffic and transport psychology* (465-475). Amsterdam: Pergamon.

Truett, R. (2004). Cost, reliability issues delay fuel cell use. *Automotive News, 79*(6117), 32.

Verhoef, E. T. and E. Pels (2002). Implementation of Pricing Measures for Sustainable Transport: Investigating Economic Efficiency and Social Acceptability. In W. R. Black and P. Nijikamp (Eds.) *Social change and sustainable transport* (pp. 273-278). Bloomington IN: Indiana University Press.

Wachs, M. (2003) *Improving Efficiency and Equity in Transportation Finance*. The Brookings Institution Series on Transportation Reform (April): 1-19.

Wachs, M. (2004). What are the Challenges to Creating a Sustainable Transportation? How Can Transportation Systems Become More Sustainable? Prepared for the TRB/NRC Symposium on Sustainable Transportation (Baltimore MD).

World Business Council for Sustainable Development. (2004). *Mobility 2030: Meeting the Challenges to Sustainability* http://www.wbcsd.org/web/publications/mobility/mobility_full.pdf.

World Commission on Environment and Development. (1987). *Brundtland Report: Our Common Future*. Oxford: Oxford University Press.

Yacobucci, B. (2004). Alternative Fuels and Advanced Technology Vehicles: Issues In Congress. *CRS Issue Brief*.

Yarma, G. S. (2002). *Meeting the TEA-21 reauthorization challenge: Will system performance continue to be "Gone with the wind"?* Third National Conference on Transportation Finance, Chicago, Illinois, Transportation Research Board.

Notes

1. Carbon sinks are places of carbon accumulation, such as large forests or ocean sediments (calcium carbonate), thus removing carbon from the carbon cycle for long time.