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The Mobility-Productivity Paradox

Exploring Negative Relationships Between Mobility and Economic Productivity

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By Todd Litman
Victoria Transport Policy Institute

All else being equal, there tends to be a negative relationship between vehicle travel and economic productivity due to costs and inefficiencies it imposes on users and communities.

Abstract

This paper explores a paradox: the negative correlations between mobility and productivity, and positive correlations between mobility constraints (higher road use prices or traffic congestion) and productivity. These relationships contradict common assumptions that policies and projects that increase vehicle travel (roadway expansions and lower road user charges) support economic development. This can be explained by the following: First, planning decisions often involve trade-offs between mobility and other accessibility factors such as the quality of non-auto modes and land use accessibility. Second, many policies that increase mobility violate efficient market principles, which tends to reduce productivity. Third, motor vehicle travel increases many costs, including many that are economically burdensome. Fourth, increased vehicle travel increases the portion of household budgets devoted to vehicles and fuel, expenditures that generate low regional employment and business activity. This paper examines these issues, describes empirical evidence of these impacts, and discusses their implications.

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Introduction

Many current policies and planning practices reflect the assumption that constraints on motor vehicle travel (traffic congestion, high fuel prices, road tolls, etc.) reduce economic productivity, and policies which increase vehicle travel (roadway expansions, low road user fees, etc.) increase productivity and support economic development.

However, there are reasons to question those assumptions. Certainly, motor vehicle travel is an important input in most economic activities: it delivers raw materials to producers, goods to markets, employees to work, students to schools, and customers to markets. All else being equal, an increase in transport system efficiency should increase productivity. Increased transportation efficiency has contributed significantly to past economic productivity gains. But motor vehicle travel also imposes significant costs. Evidence described in this paper indicates that in regions with high levels of mobility, a significant portion of vehicle travel is economically inefficient: vehicle travel that consumers would forego if they had better options and more efficient pricing, which increases total transportation costs, including costs to businesses. In such circumstances, policies that reduce vehicle travel can increase productivity and support economic development.

This paper explores this paradox. It discusses ways that accessibility and mobility affect economic productivity, examines evidence of the relationships between mobility and economic productivity, and discusses their implications.

How Accessibility and Mobility Affects Productivity

This section discusses various ways that mobility affects economic productivity.

Access to Productive Activities

Conventional planning tends to evaluate transport system performance based primarily on mobility, using indicators of vehicle travel speed and delay such as roadway level-of-service and average traffic speed. However, mobility is seldom an end in itself, the ultimate goal of most transportation is *access* to services and activities (retails, employment, education, recreation, etc.). Several factors affect accessibility (1, 2):

- Motor vehicle travel.
- The quality of other modes (walking, cycling, ridesharing, public transport, etc.), including mobility substitutes such as telecommunications and delivery services.
- Transport network connectivity (the quality of connections between paths, roads, and different modes).
- Land use accessibility, which is affected by development density and mix.

Planning decisions often involve trade-offs between these. For example, expanding urban roadways tends to improve automobile access but creates a barrier that reduces pedestrian and bicycle access, and therefore public transit access since most transit trips include walking and cycling links. Similarly, urban fringe locations that are easy to access by automobile tend to be difficult to access by other modes. As a result, the benefits of increased mobility are often partly offset by declines in other forms of access, reducing net efficiency gains. A newer planning paradigm evaluates transport system performance based on overall accessibility, not just mobility (3, 4). Recent research improves our understanding of how land use factors affect accessibility:

- Kuzmyak found that travelers in more compact neighborhoods experience less congestion than in more sprawled, suburban neighborhoods due to better travel options, more connected streets, and shorter trip distances (5).
- Levine, et al. found that changes in development density affect the number of jobs and services available within a given travel time about ten times more than proportional changes in traffic speed (6).
- A study that measured the number of jobs accessible by automobile within certain time periods for the 51 largest US metropolitan areas found that the five cities with the most intense congestion (highest Travel Time Index ratings) are among the *best* for automobile employment access because their lower traffic speeds are more than offset by higher employment densities which reduce commute distances (7).
- Cortright found that roadway expansions that stimulate sprawl can increase total travel times because higher traffic speeds are more than offset by longer travel distances (8).

These studies indicate that transport system changes intended to increase vehicle traffic speeds often reduce overall accessibility thereby reducing the efficiency of other modes and stimulating more dispersed development.

Certain types of accessibility most directly affect productivity, including commercial deliveries (freight, service vehicles, etc.), business travel, and commuting to work and school. Reducing the resource (time, vehicle, fuel) costs of such travel tends to increase productivity. The magnitude of these impacts varies depending on the type of industry and conditions. For example, interregional shipping is a major portion of resource and bulk retail industry costs. Local services, such as plumbers and utilities, are affected by local travel conditions, including traffic speeds, congestion, and land use accessibility. Commuting is a major input in service industries (retail, restaurants, hotels, etc.) and therefore businesses' ability to attract and retain suitable employees. Changes in these transport costs can affect those industries' productivity.

Although most high-value freight is transported by truck, most local services are distributed by motor vehicle, and most commuting is by automobile, alternative modes, more accessible land use patterns, and demand management strategies are sometimes the most cost effective way to improve accessibility, in which case they can provide the greatest productivity gains. For example, road pricing that gives priority to commercial and high occupant vehicles on congested roads, more compact and mixed development, and commute trip reduction programs that shift travel from automobiles to higher occupant vehicles, can improve accessibility while reducing total vehicle travel.

Economic Efficiency

There are two basic requirements for economic efficiency:

1. *Consumer sovereignty*, which means that consumers can choose the goods they demand (for which they are willing to pay marginal costs). As a result, efficiency can increase with transport system diversity if it allows users to choose the combination of modes, services and qualities that best meet their needs. There is little reason to maintain options with minimal demand (for example, cycling facilities or transit services that attract few users), but transport system efficiency is likely to increase if alternative modes receive at least as much support as automobile transport, and often more for equity sake (to provide basic mobility for non-drivers and affordable mobility for lower-income people), and to help achieve strategic objectives (such as preserving openspace and increasing public health). For example, if society spends $5.00 on roads and parking facilities to accommodate an automobile commute it should be willing to devote at least that much for other commute modes, and often more for equity sake and to achieve other objectives.
2. *Efficient pricing*, which means that prices (direct costs to users for consuming a good) reflect the full marginal costs of producing that good, unless a subsidy is specifically justified. This tests users' willingness-to-pay for the goods they consume so society does not spend $2 on a good (including roads and parking facilities) that users only value at $1. As a result, economic efficiency tends to increase if travelers are charged for the costs they impose, including congestion, road and parking facilities, accidents, and pollution.

People sometimes assume that policies that make vehicle travel cheaper increase productivity, but this is only true of true resource savings; economic transfers that externalize costs tend to reduce productivity. For example, if roads are financed through general taxes rather than user fees, savings to motorists will be offset by higher costs elsewhere in the economy, and cheaper vehicle costs are likely to induce additional vehicle travel that increases total transport costs, including externalities such as traffic congestion, parking subsidies, accidents, pollution damages, and sprawl-related costs.

Table 1 summarizes various transportation market requirements, distortions, reforms and their travel impacts. Although these distortions may individually seem modest and justified, their impacts are cumulative and synergistic (total impacts are greater than the sum of their individual impacts). For example, planning practices that undervalue active transport (walking and cycling), by ignoring the parking cost savings and health benefits they provide, can lead to underinvestment in sidewalks and bike paths, which not only reduces walking and cycling access, it also reduces public transit access, since most transit trips include links by these modes. Similarly, underpricing road use (for example, by financing roads through general taxes rather than user fees) not only increases traffic congestion and roadway costs, by inducing additional vehicle travel it increases parking costs, accidents and pollution emissions. Conversely, underpricing parking facility use, by including them as building costs instead of charging users directly not only increases the number of parking spaces needed, by inducing additional vehicle travel it also increases traffic congestion, accidents and pollution costs.

Table 1 **Market Principles, Distortions, Reforms and Travel Impacts** (9)

Market Requirements	Common Distortions	Potential Reforms	Travel Impacts
Optimal transport planning. Planning practices should be comprehensive and multi-modal, considering all impacts and options, and investing in the most cost-effective option overall.	Conventional planning evaluates transport system performance based primarily on automobile travel conditions, and tends to overlook benefits of other modes (parking savings, affordability, basic mobility for non-drivers, environmental benefits). This favors automobile-oriented transport improvements. A major portion of transport funds are dedicated to roads and parking facilities and cannot be used for alternative solutions, even if they most cost effective.	Evaluate transport system performance using multi-modal level-of-service ratings and other indicators of overall accessibility. Comprehensive and multi-modal planning which considers all impacts, modes and improvement options, including demand management strategies. Least-cost planning invests in the most cost effective options, considering all impacts (benefits and costs).	More comprehensive and neutral planning could significantly improve transport options (walking, cycling, public transit, carsharing, etc.) and support demand management, reducing automobile travel 10-20%.
Integrated planning. Integrate planning by different agencies and jurisdictions to help optimize overall accessibility.	Current land use planning practices, such as land density limits and generous minimum parking requirements, result in dispersed, automobile-dependent communities.	Integrate transport and land use planning to create more accessible, multi-modal communities.	Residents of more accessible, multi-modal communities tend to drive 10-40% less than they would in automobile dependent areas
Efficient pricing. Prices should reflect marginal costs unless a subsidy is specifically justified.	Motor vehicle travel is significantly underpriced. Many costs are either fixed or external.	Cost-based pricing of roads, parking, insurance and vehicle fuel.	Efficient pricing is likely to reduce automobile travel 20-40%.

Efficient markets reflect certain principles. Current transport planning and pricing often violate these principles in ways that stimulate mobility. Transport market reforms, such as more neutral and multi-modal transport planning and more efficient pricing, tend to reduce motor vehicle travel. If these reforms were fully implemented, per capita vehicle travel would probably decline 35-50%.

This suggests that a significant portion of current vehicle travel is economically inefficient; it results from market distortions that reduce transport options, disperse development, and underprice vehicle travel. With more efficient planning and pricing, travelers would choose to drive less, rely more on alternative modes, and be better off overall as a result (10). Other researchers reach similar conclusions, although they consider a smaller set of distortions and reforms (11, 12).

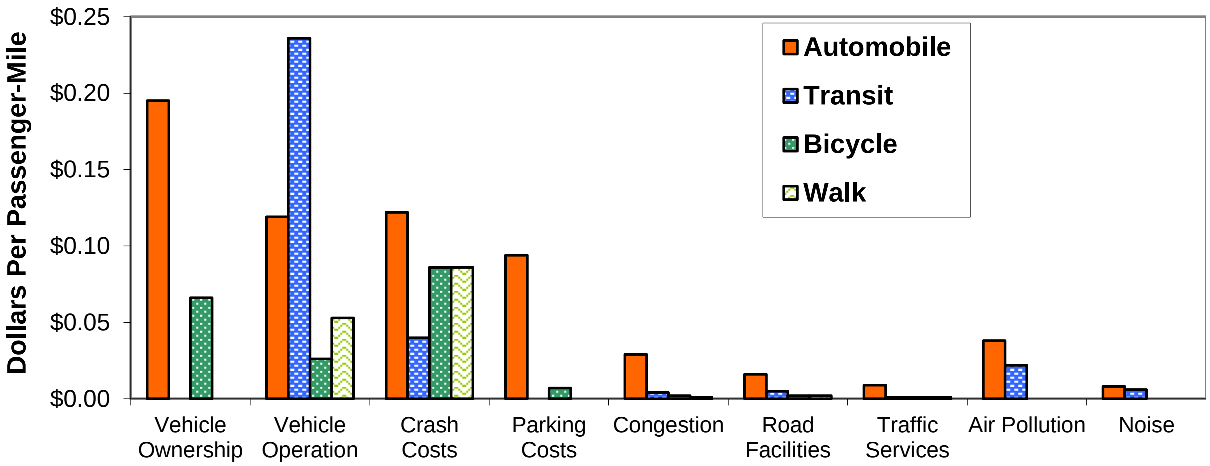
Economically inefficient vehicle travel tends to reduce productivity. For example, underinvestment in alternative modes tends to increase traffic and parking congestion, and reduces non-drivers' access to schools and jobs, and therefore the labor pool available to businesses, particularly service industries that require lower-wage workers). Transport underpricing imposes costs on other economic sectors, as discussed in the following section.

Cost Burdens

Motor vehicle travel is relatively costly, including costs for vehicles and fuel, roads and parking facilities (and therefore land), accident and environmental damages. Other transport modes also impose costs, but less per passenger-mile. For example, automobile passengers typically require an order of magnitude more road space than walking, cycling and public transit, plus space for parking, which increases congestion and facility costs.

Figure 1 compares estimated costs of car, bus, bicycle and walking. According to this analysis, total costs per passenger-mile (including infrastructure, vehicle, crash and pollution costs) are approximately 63¢ for cars, 61¢ for bus passengers (this is relatively high because most bus travel occurs under urban conditions; car travel costs more than $1.00 per passenger-mile under such conditions), 19¢ for cycling and 14¢ for walking.

Figure 1 **Estimated Average Costs for Car, Bus, Bicycle and Walk** (13)



Automobile travel tends to have higher total costs (infrastructure, vehicles, crash and pollution costs) than most other modes.

Many of these are external costs imposed on other industries, which reduce productivity. For example, businesses bear a significant portion of general taxes that finance roads, they bear substantial parking subsidy costs, traffic congestion delays and accident damages. Some industries (tourism, farming, fishing) are harmed by pollution emissions.

Consumer Expenditures on Imported Goods

Vehicles and fuel are capital intensive, most of the inputs are imported from other regions and countries. As a result, expenditures on these goods tend to generate less employment and business activity than most other goods. For example, a million dollars shifted from fuel expenditures to a general bundle of consumer goods adds 4.5 jobs to the U.S. economy, and each million dollars shifted from vehicle fuels to public transit operation generates 18.5 jobs (14). As a result, policies that increase motor vehicle travel, and therefore the portion of household budgets devoted to vehicles and fuel, tend to reduce regional and domestic employment and productivity.

Productivity Impact Summary

The table below summarizes how four types of transportation policies affect mobility and the four categories of productivity impacts just described.

Table 2 **Comparing Transportation Improvement Strategies**

	Unpriced Road Expansions	Improve Alt. Modes	Eff. Transport Pricing	Smart Growth Policies
Mobility impacts	Expanding unpriced roads increases mobility.	Improving alternative modes reduces mobility.	More efficient pricing reduces mobility.	More compact, multi-modal development reduces mobility.
Accessibility for productive activities	Increases automobile access but can reduce other forms of access.	Can increase all types of access, including access for non-drivers.	Tends to increase higher-value access (such as freight and service vehicles).	Tends to increase overall accessibility.
Economic efficiency	Generally economically inefficient (would not be justified if users paid the incremental costs).	If demand exists for alternative modes, improving them tends to increase efficiency.	Increases economic efficiency (assuming price reforms reflect market principles).	If demand exists for more accessible development, smart growth policies increase efficiency.
Cost burdens	By increasing total vehicle travel it tends to increase total transport costs, including many external costs borne by industries.	By reducing total vehicle travel it tends to reduce total transport costs, including many external costs borne by industries.	By reducing total vehicle travel it tends to reduce total transport costs, including many external costs borne by industries	By reducing total vehicle travel it tends to reduce total transport costs, including many external costs borne by industries.
Consumer expenditures on imported goods	Tends to increase total vehicle and fuel expenditures.	Tends to reduce total vehicle and fuel expenditures.	Tends to reduce total vehicle and fuel expenditures.	Tends to reduce total vehicle and fuel expenditures.

Unpriced (or underpriced) roadway expansions tend to increase mobility, which increases automobile access (at least in the short-run) but tends to reduce other forms of access, is generally economically inefficient, tends to increase total transportation costs (including many costs to industry) and increases consumer expenditures on imported goods.

Empirical Evidence

This section discusses empirical evidence of the relationships between mobility and economic productivity.

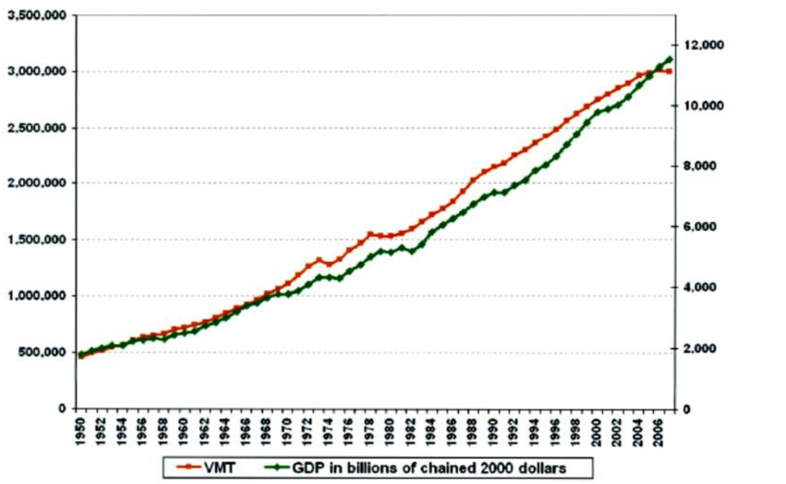
Evidence of Positive Relationships Between Mobility and Productivity

There is some evidence of a positive relationship between mobility and economic productivity. For example, the Highway Users Alliance claims that the graph below proves that, because VMT and GDP have historically been correlated, efforts to reduce vehicle travel must reduce economic productivity.

Figure 2 **US VMT and GDP Trends** (15)

Vehicle Miles Traveled (VMT) and Gross Domestic Product (GDP) are extremely closely correlated:

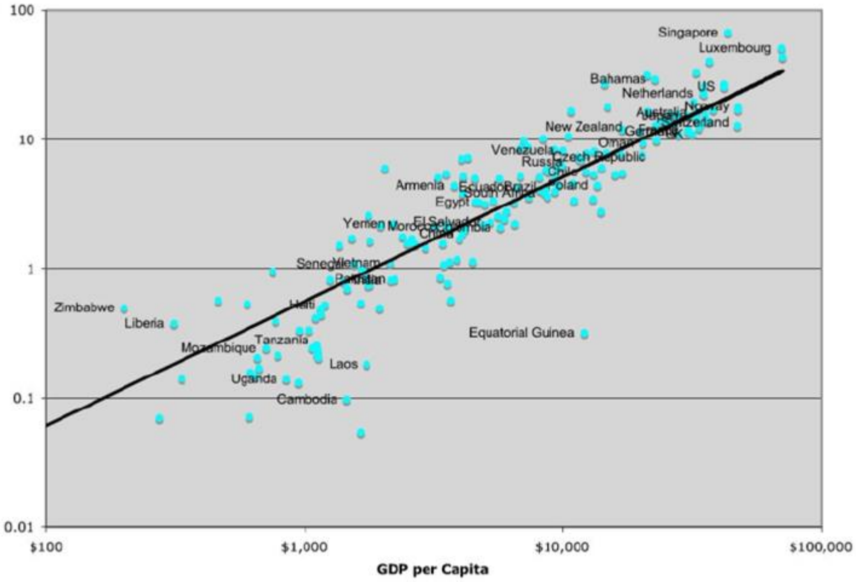
Since 1950, the cumulative correlation rate between VMT and Real GDP, calculated using Pearson's R, is .9946. This is an extraordinarily strong correlation even when calculating the R-square value of 98.9% which indicates the predictive value between the two variables (VMT or GDP).



The Highway Users Alliance claims that this graph proves that reductions in vehicle travel will reduce economic productivity, but correlation does not prove causation.

Similarly, economist Randall Pozdena claims that the correlation between income and energy use shown in Figure 3, and because recessions often follow petroleum price spikes, efforts to reduce per capita vehicle travel reduce economic productivity. He concludes that, "a one percent change in VMT/capita causes a 0.9 percent change in GDP in the short run (2 years) and a 0.46 percent in the long run (20 years)." Certainly energy use, vehicle travel and GDP tend to increase together, but much of this effect is the result of increased wealth allowing consumers to purchase more vehicles and fuel, so increased VMT is an productivity output rather than an input. The log-log format in Figure 3 exaggerates the relationships between energy and economic development. For example, although the U.S. and Norway appear close together, Norwegians actually consume about half as much fuel per capita as U.S. residents. The graph includes countries with very different levels of industrialization. An increase in per capita vehicle travel in low income countries such as Zimbabwe or Laos has a very different productivity impacts than in wealthy, countries like the U.S. or Norway.

Figure 3 **Per Capita GDP Versus Barrels of Oil** (16)



Pozdena claims this graph proves that increased energy consumption increases economic productivity. A log-log graph such as this exaggerates such relationships.

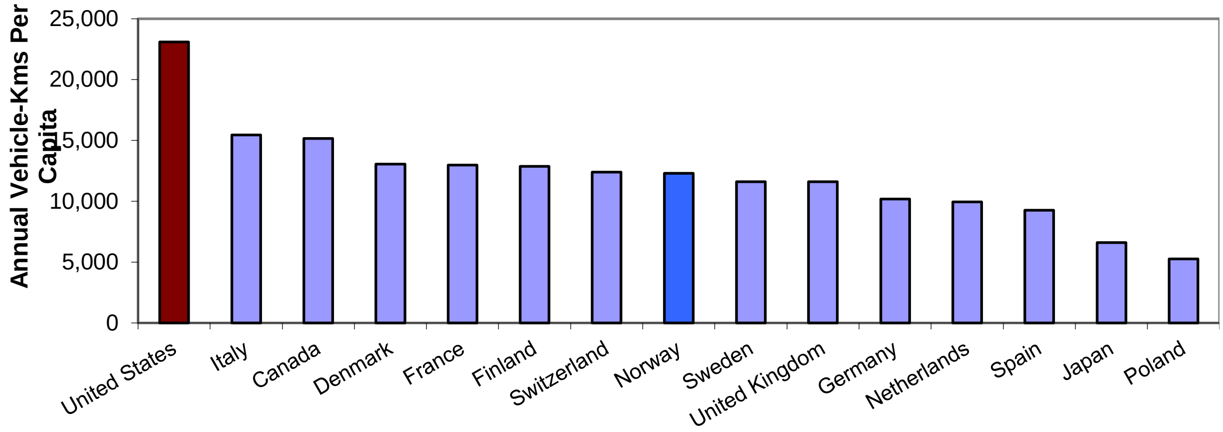
Evidence Of Negative Relationships Between Mobility and Productivity

Many researchers find weak or negative relationships between personal vehicle travel and economic productivity (17, 18, 19). Increasing from very low to moderate levels of mobility tends to increase productivity, since motor vehicles are used for high-value trips, but as mobility increases marginal productivity benefits are likely to decline, and may become negative as external costs and inefficiencies increase (20, 21).

For example, farmers and tradesmen (carpenters, bricklayers, etc.) can significantly increase productivity by using truck transport rather than headloading or animal carts, but there is often no increase in productivity when workers shift from commuting by bicycle or public transit to driving; such shifts can provide consumer benefits (workers have a wider range of housing options), but only if automobile travel significantly increases employers employment pool is it likely to increase productivity. On the other hand, shifting from bicycle or transit to automobile commutes tends to increase some costs – costs of roads and parking facilities, congestion, accident and pollution – which is likely to reduce productivity.

Among wealthy countries there is considerable variation in per capita vehicle travel. Although per capita VMT grew during most of the last century, it has become saturated in most wealthy countries and the level at which this saturation occurs varies depending on transport and land use policies (22). The U.S. averages more than twice the per capita vehicle travel as most other OECD countries, as indicated in Figure 4. Of particular interest is Norway, which produces petroleum but maintains high fuel prices and has other policies to discourage vehicle travel and support alternative modes. These policies minimized domestic fuel consumption, leaving more oil to export. As a result, Norway has one of the world’s highest incomes, a competitive and expanding economy, a positive trade balance, and the world’s largest legacy fund.

Figure 4 **Per Capita Annual Vehicle Travel By Country** (23)

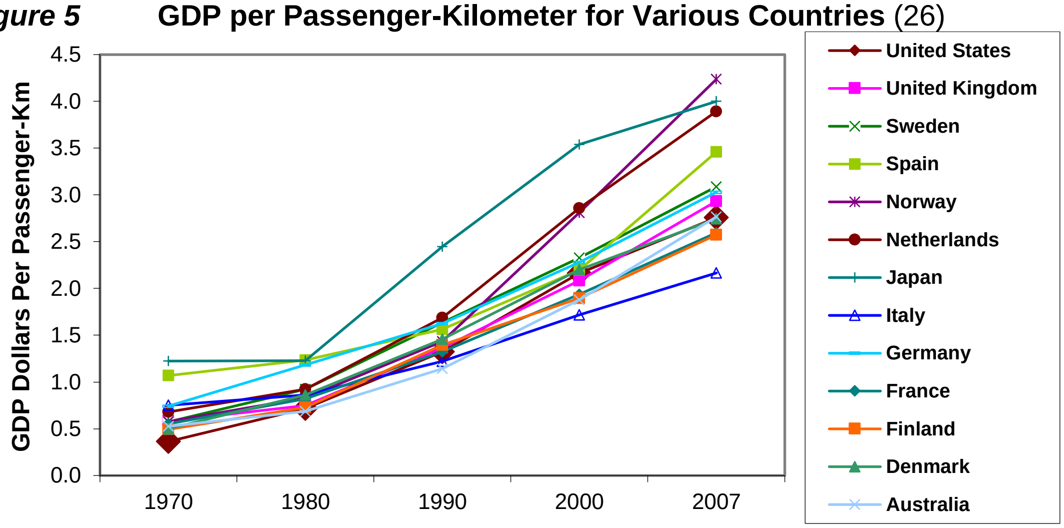


Per capita vehicle mileage is significantly higher in the U.S. than in other industrialized countries. Residents of wealthy countries such as Switzerland, Norway and Sweden drive about half as much as in the U.S. due to policies and planning practices that increase transport system efficiency.

Similarly, annual per capita vehicle mileage varies significantly among U.S. cities, from fewer than 5,000 average annual vehicle-miles per capita to more than 15,000. Although many factors influence these differences, they result, in part, from transport and land use policies that affect the travel options available, travel incentives, and land use patterns. There is no evidence that lower VMT cities such as New York, Sacramento, Chicago and Portland, are less economically successful than higher VMT cities such as Atlanta, Houston or Birmingham; in fact, the lower VMT cities tend to have higher per capita GDP, as indicated later in this paper.

The amount of vehicle travel and energy required per unit of GDP varies widely. Virtually all developed countries are increasing GDP per unit of energy and mobility called *decoupling* (24, 25). Some extract far more productivity (material wealth and income) per unit of mobility and energy than others (Figure 5).

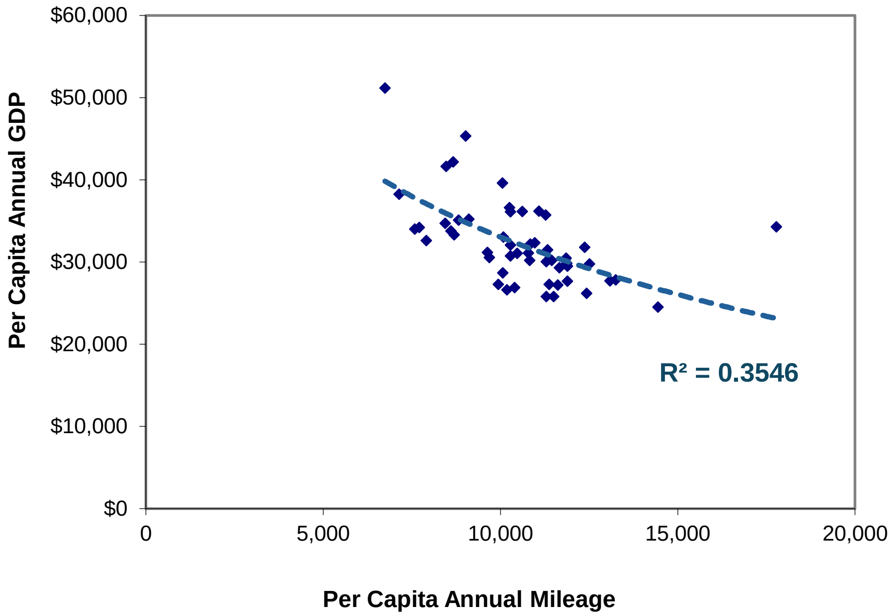
Figure 5 **GDP per Passenger-Kilometer for Various Countries** (26)



Most countries are increasing GDP per passenger-mile, some much more than the U.S.

Within developed countries there is a negative relationship between vehicle travel and economic productivity as illustrated in the following figures. State level GDP per capita tends to decline with increased VMT, as illustrated in Figure 6.

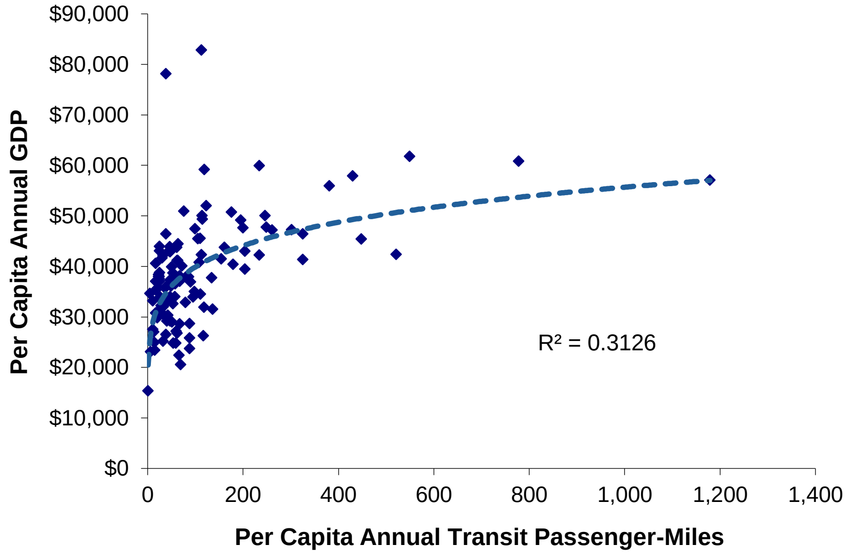
Figure 6 **Per Capita GDP and VMT For U.S. States** (27)



Per capita economic productivity increases as vehicle travel declines. (Each dot is a U.S. state.)

GDP tends to increase with public transit travel, as illustrated in Figure 7.

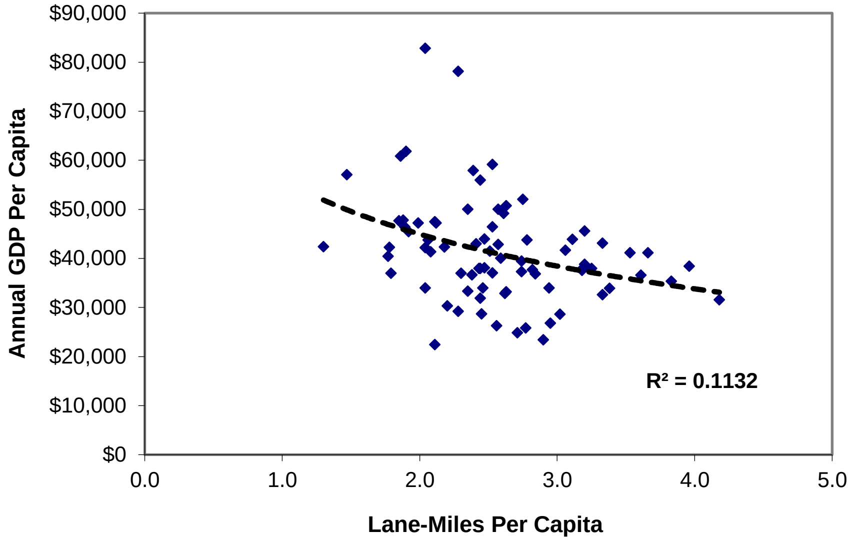
Figure 7 **Per Capita GDP and Transit Ridership** (27)



GDP tends to increase with per capita transit travel. (Each dot is a U.S. urban region.)

Per capita GDP tends to decline with roadway lane miles, as illustrated in Figure 8.

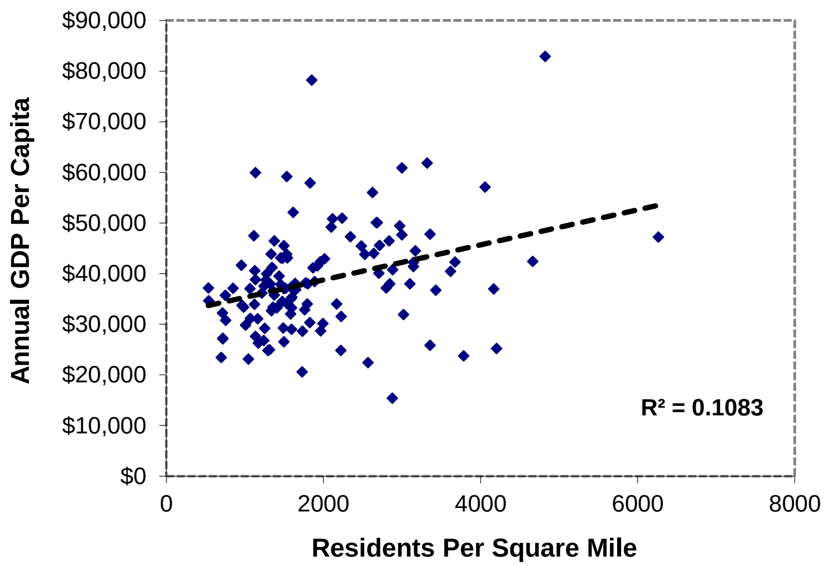
Figure 8 **Per Capita GDP and Road Lane-Miles** (27)



Economic productivity declines with more roadway supply, an indicator of automobile-oriented transport and land use patterns. (Each dot is a U.S. urban region.)

Per capita GDP tends to increase with population density, as illustrated in Figure 9. These *agglomeration efficiencies* reflect the benefits that result from improved land use accessibility (reduced distances between activities) and increased transport system diversity, which both tend to increase with density (28).

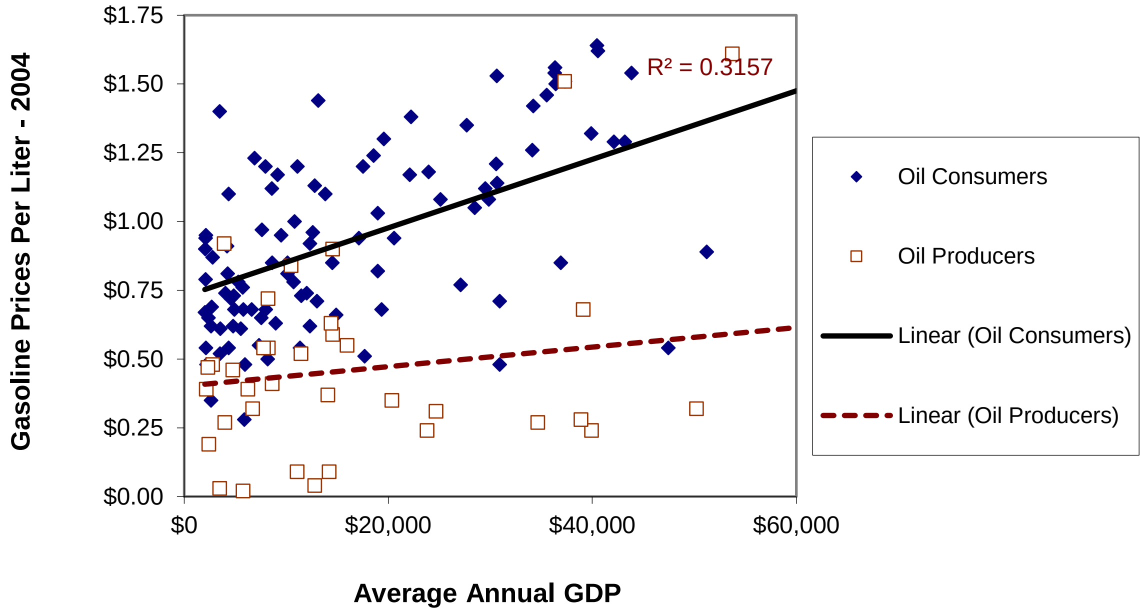
Figure 9 **Per Capita GDP and Urban Density** (27)



Productivity tends to increase with population density. (Each dot is a U.S. urban region.)

Figure 10 shows that per capita GDP increases with fuel prices, particularly among oil importing countries ("Oil Consumers"). This suggests that high fuel prices (and therefore, high vehicle operating costs) can increase rather than reduce productivity.

Figure 10 **GDP Versus Fuel Prices, Countries** (29)



Economic productivity tends to increase with higher fuel prices, indicating that substantial increases in vehicle fees can be achieved without reducing overall economic productivity.

Other researchers find similar results. Various studies indicate diminishing marginal benefits from roadway supply: once a paved roadway network exists in a region further roadway expansions do not seem to increase productivity (30, 31). Traffic congestion is *positively correlated* with economic productivity (32); this does not mean that congestion *causes* productivity to increase, but it appears to be a modest cost compared with other factors. A study of business growth trends in California found that, although most expanding firms locate near transportation infrastructure, such as highways and major airports, the majority of growth occurred near existing infrastructure rather than expanding to the urban fringe, indicating that policies that encourage infill development can support economic development by improving overall accessible (33).

A rigid relationship between mobility and economic productivity implies that economies are inflexible: there is only one efficient way to produce goods, and that economic development requires ever more energy and movement. A flexible relationship between mobility and economic productivity implies that economies are responsive and creative: if mobility is cheap, businesses and consumer will use more, but if prices increase or other policies encourage conservation, the economy becomes more efficient. Technological innovations that improve telecommuting and public transit service quality can increase transport efficiency (i.e., reduce the amount of vehicle travel required to produce goods and services), but this is only likely to occur if prices provide incentives.

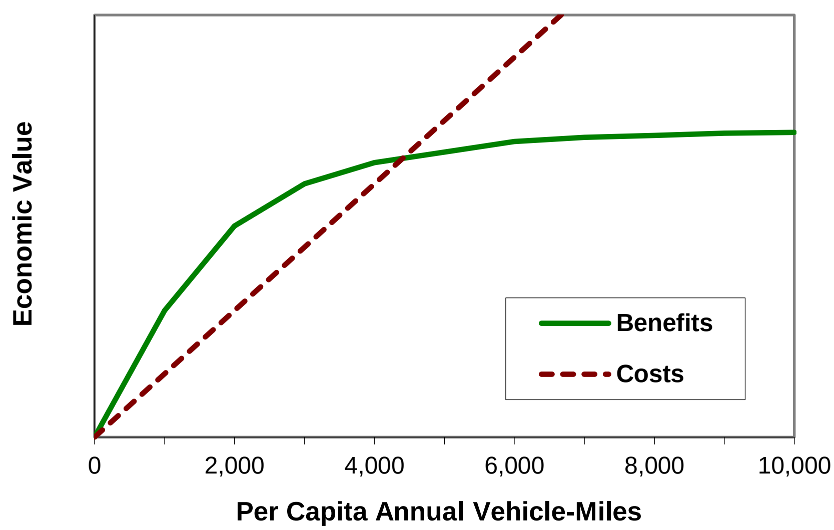
Conclusions

Motor vehicle transportation contributes to economic productivity in many ways: it delivers raw materials, distributes final products, and transport employees to worksites. However, this does not mean that increased motor vehicle travel necessarily increases productivity; like most economic inputs, there is an optimal level of beyond which marginal costs exceed marginal benefits.

Automobile transport is relatively costly, including road and parking infrastructure, vehicles and fuel, congestion impacts, accident risk and pollution emissions. Policies and planning decisions can affect motor vehicle use: households located in automobile dependent communities, where most trips are made by automobile, tend to drive about twice as much, and both bear and impose about twice the transportation costs, as they would if located in more multi-modal communities where it is common to walk or bike to local services and commuters often use public transit. Affluent economies can bear the additional costs of automobile dependency, but they are less productive than if they had more efficient transport systems.

An efficient transportation system reflects market principles including consumer sovereignty and marginal-cost pricing. Current planning and pricing are distorted in ways that tend to favor mobility over other forms of accessibility, and automobile travel over other modes, resulting in economically excessive mobility. More comprehensive and neutral planning and more efficient transport pricing tend to reduce motor vehicle travel while increasing productivity. If fully implemented, these reforms would probably reduce motor vehicle travel by 35-50%, suggesting that the economically optimal level of mobility (the level that maximizes productivity) is probably 3,500 to 5,000 annual vehicle miles, less in urban areas and more in rural areas. Figure 11 illustrates this concept.

Figure 11 **Vehicle Travel Economic Benefits and Costs**



As per capita vehicle travel increases, marginal economic benefits decline while costs increase linearly. As a result, beyond about 4,000 annual vehicle miles per capita overall, total costs exceed total benefits. More multi-modal planning and more efficient pricing encourage consumers to use the most efficient transport options for each trip, increasing productivity.

Empirical evidence supports this conclusion. Claims of a direct positive link between mobility and economic productivity, which would justify public policies that favor automobile transportation, are based on weak evidence, such as comparisons between countries at very different levels of development which primarily reflect the ability of more affluent consumers to purchase motor vehicle travel. Comparisons between affluent urban regions show negative relationships between mobility and productivity; in developed countries, productivity tends to be higher in areas where people drive less, rely more on alternative modes, and live in more accessible and multi-modal communities.

As a result, policies that increase motor vehicle travel, such as underpriced roads, parking supply mandates, and planning practices that favor automobile travel over alternatives, are probably economically harmful overall: they reduce productivity. Such policies may benefit some industries but harm a larger number of industries. Conversely, improving resource-efficient modes (walking, cycling, ridesharing and public transport), more efficient transport pricing, and more compact, multi-modal development, tend to increase economic productivity and development overall.

This suggests that in most situations, expanding unpriced highways, subsidizing vehicle parking, and minimizing fuel prices is likely to reduce economic productivity, while improving resource-efficient modes, transport pricing reforms, smart growth policies, and transportation demand management programs are likely to increase productivity.

This research is preliminary, based on limited and imperfect data. There is a need for better vehicle travel, transportation cost, and economic data, collected using consistent definitions and methods in numerous urban regions around the world, to help researchers understand the relationships between transport policy and economic productivity.

Endnotes

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