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Review of U.S. and European Regional Modeling Studies of Policies Intended to Reduce Motorized Travel, Fuel Use, and Emissions

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Summary

With the enactment of a new federal transportation law in 2005, State and regional transportation plans and programs are for the first time required to achieve the objectives of the SAFETEA-LU planning process, which focus on enhancing mobility and supporting economic development while minimizing fuel use and emissions.

This paper reviews the experience to date in dozens of metropolitan regions and advanced industrial economies as they have used scenario planning to evaluate an array of pragmatic and feasible policies and investment strategies that are available to help states and regions satisfy this new federal legal requirement.

The results from 40 long-range scenario exercises performed in the U.S. and Europe demonstrate that substantial reductions in vehicle-miles of travel (VMT), fuel use, and emissions of both criteria pollutants and greenhouse gas emissions are possible using transportation pricing policies and investment priorities that have been demonstrated as acceptable and effective in a modest but growing number of metropolitan areas and regions around the world.

VMT reductions in 20 years range from 10% to 20%, compared to the future trend scenario, are achievable with reductions in emissions and fuel use roughly proportionate to the decrease in VMT, while supporting the same level of future job and housing growth. In most studies, the highway levels-of-service are the same as, or better than, the trend scenario.

The studies reviewed also suggest that these reduced-VMT scenarios generally produce higher transportation system productivity, positive net user economic benefits, greater equity in the distribution of transportation system benefits, reduced congestion delays, and a reduction in other adverse environmental impacts.

The most-effective policy sets combine land use policies, such as compact growth, with strong transit provision and not expanding highway capacity. The addition of auto pricing policies, such as fuel taxes, work trip parking charges, or all-day tolls increases the effectiveness of the land use and transit policies. Peak-period tolls, by themselves, increase travel. Expanding road capacity, along with transit capacity, but without changing market incentives to encourage more efficient use of existing roads and parking, results in expensive transit systems with low ridership.

The U.S. Studies

The following is excerpted from:
Bartholomew, Keith (2005), *Integrating Land Use Issues into Transportation Planning: Summary Report*, DOT Cooperative Agreement No. DTFH61-03-H-00134, Dept. of Architecture, University of Utah (http://faculty.arch.utah.edu/bartholomew/SP_SummaryRpt_Web.pdf).

Bartholomew surveyed National Association of Regional Councils (NARC) members in 2003-04 for examples of scenario planning using land use, transit, and other policies to reduce travel. Land use policies typically included density increases, clustering development in transit corridors or around rail stations, and urban limit lines. Both travel models and geographic information system (GIS) evaluation tools were used in the scenario evaluations. The median reduction in VMT in the 20-year scenarios for 31 exercises with adequate data was 2.3% but 11 scenarios resulted in reductions of 5% or more.

Five scenarios resulted in reductions of 10% or more. These studies generally evaluated modest growth management policies and did not employ the pricing of parking or fuels or roadways. So, these results may be viewed as lower bounds on what VMT reductions could occur in scenario exercises.

Example data from the projects are:

1. Arizona, Maricopa Association of Governments. ~ 3% VMT reduction in 20 yrs.
2. S.F. Bay Area Alliance for Sustainable Development. 4.6% reduction in VMT by 2020. Most of the growth in this scenario is located in the existing urban cores of the region.
3. Georgia Regional Transportation Authority. 7% VMT reduction.
4. Baltimore Regional Transportation Board. 8.2% VMT reduction. Redevelopment was emphasized, road capacity maintained at current levels, and transit capacity moderately expanded.
5. Portland Metro. ~8.8% VMT reduction in 20 yrs (17.6% VMT reduction in 40 yrs). Growth contained within urban growth boundary, plus auto pricing, transit investment, and pedestrian improvements.
6. Southern California Association of Governments. ~10% VMT reduction in 25 yrs. Housing and jobs focused in existing centers and corridors.
7. Denver Regional Council of Governments. 12.5% VMT reduction in 25 yrs. Most growth would locate in infill development sites within the central city and existing suburbs.
8. Envision Central Texas. ~17% VMT reduction compared to current trend. New growth in existing developed areas, which would accommodate 1/3 of anticipated new households and 2/3 of new jobs.
9. Contra Costa County, CA. 17.3% reduction in VMT in 20 yrs. Growth placed in existing urbanized areas, and along rail transit routes.
10. EPA, Atlanta, GA. ~38% difference in VMT between worse and best scenarios.

The European Studies

For many years the European Commission has performed sophisticated studies of policies to reduce pollution, traffic accidents, noise, and greenhouse gas emissions. We review the three main reports here. In these studies, urban models were used, which are state-of-the-practice methods representing both travel and land development and use. These model sets are composed primarily of discrete choice models based on microeconomics and so give elasticities of demand with respect to price. These statistics permit comparisons across regions and validation of most model components.

Quite significant policies were evaluated, including higher taxation of fuels, larger auto purchase and registration fees, and tolling of roadways, both all-day and for peak periods, as well as urban limit lines, and density increases. So, we may view these projections as the upper bounds of what could be achieved in most regions in the U.S. As these are the most complete and best designed studies ever done, this review gives some detail about the policies and results.

F.V. Webster, P.H. Bly, and N.J. Paulley, eds. (1988), *Urban Land-use and Transport Interaction*, Avebury (Brookfield, MA).
Seven urban models were run on seven cities around the world on the same policy sets, intended to reduce VMT and emissions. Each region ran a 20-year Future Base Case, different for each region, but basically a trend scenario plus any major investments already programmed. All results are reported as differences from the future base case.

The results were reasonably coherent and showed that only urban limit lines reduce residential sprawl. Such controls did not raise housing prices, however, due to increased density.

Increasing land use density is effective in reducing VMT, especially if the walk and bike modes are well-provided for. Parking charges in the central business district (CBD) decentralize employment, whereas vehicle purchase and registration taxes (or fuel taxes) reduce auto ownership and VMT. The vehicle taxes are much more effective, if supported by good transit service, especially to the CBD and other employment centers. **Land use and transit policies have little effect, unless supported by pricing.**

Faster radial travel by freeway or rail increases the decentralization of upper-income households, thereby increasing segregation by income. **Increasing the cost of both auto travel and transit by 50% decreases travel and energy use about 10%. Increasing auto costs by 400% reduces VMT and emissions about one third. (Note that making workers pay for parking or providing cash-in-lieu-of-parking incentives in the U.S. increases "felt" travel costs by around 400%, without actually increasing costs, as the parking costs are merely being unbundled from wages.) All pricing scenarios decreased travel delays.**

Travel models must include an auto ownership step and the walk and bike modes in order to represent these policies accurately. Also, the peak and non-peak periods must be modeled separately.

The following summarizes:
SPARTACUS: Final Report (1998), European Commission, Environment and Climate Research Programme (www.ltcon.fi/spartacus).

This study used MEPLAN, one of the most-advanced urban models, on Helsinki, Bilbao, and Naples. A raster (grid) GIS program was added to MEPLAN to calculate impacts from noise and emissions on households and to produce maps. A user interface was also added to simplify the input of policies and also the production of output tables, maps, and graphs. Policy impacts were net from the future base case, as above.

Overall, only the travel pricing policies were found to reduce VMT substantially. For example, increasing auto costs by 50% decreased VMT by 16%. Land use policies were not very effective, except to back up the transit system. Pricing is required in order to gain large increases in transit use.

The most effective pricing policies combined congestion pricing with mileage or travel pricing (fuel tax or all-day tolls). Increasing rail service increased all travel speeds in Bilbao and Helsinki, due to some auto travelers switching to rail, while in Naples the existing transit system was made more efficient. **This shows the need to not add highway capacity in long-range investment plans that are intended to reduce VMT and emissions.**

Combining land use policies for intensification in transit corridors and urban limit lines with transit investments and the pricing of auto travel was found to be the most effective approach to reducing VMT. **Greenhouse gases and fuel use are reduced between 13% and 24%, depending on pricing levels, with an increase in auto operating costs of about 100% being most effective. Delays were decreased significantly in all pricing scenarios.**

The raster system was effective for analysis and mapping. The user interface was also very useful in aggregating the outputs in various ways. Various weighting schemes with social, economic, and environmental indicators were tried. Also, sensitivity tests were conducted on the various equity measures and on indicator weighting ranges. They also found that such studies should include surrounding rural areas, as they often receive significant impacts. The authors also recommend that studies should also be for at least 20 years, to capture counterintuitive and changing effects over time.

The following summarizes:
PROPOLIS: Planning and Research of Policies for Land Use and Transport for Increasing Urban Sustainability: Final Report (2004), European Commission, Energy, Environment, and Sustainable Development Thematic Programme (www.wspgroup.fi/lt/propolis).

This study carried on the SPARTACUS approach, modeling 7 urban regions using three advanced integrated urban models. The study was firmly embedded in the sustainable development policy analysis paradigm, using many indicators of Social, Economic, and Environmental effects. All models used a raster analysis and mapping capability and a user interface for policy inputs and for the analysis of model outputs. Policy results were net from the future base case, as in the two previous studies.

The policy results were generally the same as in the SPARTACUS study, with more variation due to differences among the urban regions. The results were generally similar across all 7 regions, though. Methodologically, the findings were also the same as in the previous study. In the future baseline (trend) scenarios, the large number of European Commission sustainability indicators deteriorated in all regions.

By applying pricing, land use, and transit investment policies, most of the indicators could be reversed. **Increasing auto operating costs by 75%, adding parking charges, and decreasing transit fares by 50% was the most effective pricing policy component. It reduced greenhouse gas emissions and fuel use by 15-20% in all regions, over 20 years.** Because the same policy set gave the same general results in the 7 regions, the study concluded that this policy set would likely work in most EC regions. Making workers pay for work trip parking would increase “experienced” auto costs by 100-500% in most regions, since drivers choose modes based on out-of-pocket costs (gas, tolls, parking charges, transit fares). In the U.S., the true unbundled cost to employers of providing free parking is typically much larger than the employee’s out-of-pocket fuel costs to drive to work by auto.

The effects of the various pricing policies were found to vary by region and often had negative effects on sprawl (increased sprawl) and so all must be studied individually and in combination with other policies. **Increasing transit speeds increased sprawl unless accompanied by pricing and urban limit line policies. Increases in transit service often reduced road congestion and caused more sprawl. This finding shows that highways must be allowed to become congested, while improving transit. The VMT-reducing policy sets increased economic welfare by 1,000-3,000 Euros per person (net present value over 20 years) and also reduced traffic accidents, congestion, and noise.**

Studies by Robert A. Johnston

A dozen published papers simulating similar policies in the Sacramento, California region by this author have produced findings similar to those in the three EC studies. These studies, conducted over a 20-year period, used three versions of the official MPO travel model and three versions of an urban model, the last version being the official version adopted by the MPO. These were all 20-year studies, unless otherwise noted. All results are compared to the future trend scenario or to a no-build (do nothing beyond the funded 3-year Transportation Improvement Program (TIP) projects) scenario. Because SAFETEA-LU requires MPOs to include support for increased economic development as a factor in developing their adopted plans, economic welfare findings are also presented. These are similar to consumer surplus for travelers, calculated from the mode choice model logsums, a measure commonly used in this kind of analysis across the world.

Synthesis of Findings:

1. Expanding road capacity increases auto travel and emissions, compared to doing nothing. New HOV lanes on radial freeways increase travel and emissions. They also increase sprawl. Congestion generally becomes worse, in spite of adding highway capacity.
2. **Expanding transit only decreases emissions about 1%,** compared to doing nothing. It decreases travel costs for lower-income households. It can increase sprawl somewhat, due to the outer rail stations.
3. **Expanding transit only and supporting it with land use intensification around Light Rail stations decreases emissions about 5%. It decreases travel costs for lower-income households.**
4. **Expanding transit only and supporting it with land use intensification around Light Rail stations and with urban growth boundaries decreases emissions about 10%. It decreases travel costs and travel delays for all households.**
5. **Expanding transit only and supporting it with higher fuel taxes and with workplace parking charges (refunded in higher wages as cash-in-lieu-of-parking incentives) and shopping parking charges (refunded through lower costs for goods and services) lowers emissions about 10%. It greatly increases economic benefits to all travelers, due to better transit and faster freeways. This scenario reduces congestion significantly.**
6. **Expanding transit only and supporting it with land use intensification and urban limit lines and with fuel taxes and parking charges, as above, lowers emissions about 15-30%. This scenario maximizes economic welfare for the region and reduces congestion the most.**

Results from the most recent study using the most advanced urban model:

This analysis was performed by the author with the MEPLAN urban model, developed for the Sacramento MPO. It assumed more ambitious transit investment levels than in previous studies. The model analysis was performed for a 50-year time horizon to enable comparison with the MPO's recent 50-year visioning study results.

1. **The transit-only scenario assumed many Bus Rapid Transit (BRT) lines,** in exclusive lanes within the urban areas, and on highways to the outlying cities in the region. The analysis did not include use of the California emissions model, but emissions and fuel use correlate very strongly with total travel (VMT). **This scenario reduced VMT by 8% in 2025 and 12% in 2050.**
2. **The MPO's transportation plan** assumed more freeways, more HOV lanes, more or wider ramps, and more Light Rail lines, was modeled **with an urban growth boundary (UGB). This scenario reduced VMT 7% in 2025 and 8% in 2050** and so performed somewhat worse than the transit-only scenario.
3. **The transit-only scenario was tested with a UGB. This reduced VMT by 15% in 2025 and 20% in 2050. Congestion was also reduced.**
4. **The transit-only scenario was tested with an extra fuel tax of $1.00 per gallon and parking charges for work trips. This reduced VMT by 14% in 2025 and 18% in 2050. Congestion was reduced substantially.**
5. **The transit-only scenario was tested with the pricing policies and with a UGB. This reduced VMT 20% in 2025 and 25% in 2050. In this scenario, congestion was reduced the most.**

Such strong results stem from the inclusion of a comprehensive transit scenario with fast BRT in exclusive lanes. Also, the urban model allows new development to complement the transportation systems.

All of the tested scenarios were found to be economically beneficial for low-income travelers. The three Urban Growth Boundary scenarios were strongly positive for all travelers together, with savings of about $0.5 million per day. The analysis method used includes only the morning peak period, so if the results are factored to get all daily travel, the savings become about $1.5 million per day ($500 million per year).

These scenarios all included only moderate pricing policies and thus the results should be viewed as the middle range of what is achievable for most large regions, where such levels of transportation pricing incentives will likely become acceptable within a few years.

Including transportation investment and policy scenarios together with pricing and Smart Growth policies has a significant positive impact on system performance (congestion) and on user satisfaction. This likely enhances the political feasibility of adopting such policies.

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BTS, *Special Issue on Methodological Issues in Accessibility: Journal of Transportation and Statistics* (2001), Vol. 4, No. 2/3, Bureau of Transportation Statistics (www.bts.gov), Sept/Dec.

CalTrans Office of Transportation Economics (www.dot.ca.gov/hq/tpp/offices/ote/ote.htm) describes methods used in California to evaluate transport conditions and options.

Economic Methods and Studies Website (www.ops.fhwa.dot.gov/freight/freight_analysis/econ_methods.htm) FHWA.

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