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Martin Wachs

Winston Churchill once wrote an insightful analysis of architecture (1). According to Churchill, we first designed buildings to accommodate our behavior and our social and cultural patterns as we understood them. But our understanding of these things was imperfect, and different architects interpreted them differently. Moreover, buildings reflected limitations posed by their sites, by their budgets, and by the building materials used. Over time, the buildings we constructed shaped our behavior and became the determinants of new social and cultural patterns.

Some truly exciting and wonderful buildings emerge from this process. Eventually, however, they are seen as outmoded in relation to their current functions, even if they remain elegant in other ways. We are always shooting at a moving target in designing buildings because new designs themselves create new functions and expectations.

Churchill's analysis is a nearly perfect metaphor for the relationship that has evolved in transportation among databases, analysis, and policy making. We formulate the statement of a problem that is vexing, and design strategies for data collection and analysis to address that problem. But the data we choose to examine are limited by questions previously asked, which in turn reflect the power of older statistical tools and mathematical models. Further limitations result from factors such as the costs of data collection and analysis and concerns regarding privacy. We address problems the best we can with the data at hand and, realizing the inadequacies in our databases, reformulate our data collection approaches. Our understanding of the phenomena we study is shaped by the data we have and the models we use, and is therefore far from perfect, and our databases and analytical approaches are deeply flawed in part because they are derived from inadequate understanding of the phenomena we study. We achieve major breakthroughs and dramatic advances in understanding, while at the same time our knowledge quickly becomes insufficient or obsolete.

An example, perhaps, can illustrate these points. For decades in many travel surveys, "trips" were defined in our databases as movements from zone to zone that involve vehicles. This framework

greatly hampered the ability to analyze intrazonal travel and travel by nonmotorized modes, such as walking and cycling When activists asserted that pedestrian travel and bicycling were important modes in urban areas, worthy of careful analysis, some of us responded that these modes were not important because the data showed they accounted for a relatively insignificant proportion of all trips It was extremely difficult to extract useful data about walking and cycling out of our databases until the format of home interview studies about travel was changed to include questions about these modes In the process, we began learning that in some places, walking and cycling account for a large proportion of all trips We now think about a broader range of policy choices involving nonmotorized travel, and have also reformulated the way we record information about walking and cycling

Historical Perspective

While the above example is illustrative, the subtleties of the evolution of transportation data collection and analysis and policy making are perhaps better understood through an historical perspective than through immersion in current problems People were concerned about urban traffic congestion for centuries About a hundred years ago we began counting traffic on streets in large metropolitan areas and portraying traffic patterns on maps using lines whose widths were proportional to the traffic flows In the days before traffic counters, somebody had to stand at each intersection and count the vehicles passing per unit of time As late as 1930 this task was commonly done in American cities by Boy Scouts, who were trained in how to count and collect and record the data, and were pressed into service in the late afternoons and on weekends when they did not have to be in school

These efforts resulted in reams of data of unspecified accuracy and quality that were widely used for decades in transportation planning Indeed, our first understanding of traffic congestion was very much shaped by these data, however limited they may have been After examining these maps, our professional forebears began to understand that streets of different width and slope and with different spacings between intersections differed in capacity, and that various strategies, including signs and signals, could be used to adjust and manage that capacity

As early as 1912, with calculations done by hand, a simple gravity model was used to relate traffic flows to levels of economic and social activity in different portions of a city or county (2) Use of this model led to the collection of information on population, employment, and retailing as part of the transportation planning effort Yet much earlier than most of us would imagine—well before 1920—others of our forebears came to the conclusion that looking at traffic flow patterns on maps provided an incomplete picture and was leading to false conclusions

The maps showed where traffic flowed, but those traffic flows could be understood to result from two different sets of causes one was where people wanted to go, and the other was where the patterns of roads actually forced them to go Did heavy traffic between points A and B imply that people wanted to go from A to B? Or did the traffic flow imply that traffic heading from C to D was funneled along the road between A and B, where traffic was observed simply because drivers had no option but to go that way? Thus the notion of "desire lines" as distinct from traffic flow diagrams emerged Instead of inferring where new capacity was needed simply by observing that the streets were crowded or that volume exceeded capacity we could attempt to identify the points between which large numbers of people wanted to travel And we realized that to serve travelers better, we might conceive of direct, diagonal transit routes or highways or of high-capacity elevated or depressed facilities that could be overlaid on existing traffic flow patterns

Origin–destination studies grew from these insights Before World War II we had started gathering information on origins and destinations in two ways First, cordon lines were set up, and drivers were intercepted on trips and asked for their origins and destinations Later, home interviews and travel diaries were introduced that allowed planners and analysts to focus on trip interchanges between origins and destinations for large numbers of pairs of zones, instead of looking only at traffic flow on the networks By the end of World War II, some of the first awkward computers were being used to analyze these data in what were the earliest applications of computing to analysis of the performance of civil systems.

Five Key Themes

The circular process of redefining transportation policy problems on the basis of current data and redefining transportation data needs on the basis of current policy problems is, of course, an ongoing one In this process, there are five themes or trends that I believe will be the dominant concerns of transportation analysts and data managers during the first decade of the new century These themes are, in keeping with the above discussion, at once suggested by and inadequately addressed by our current data sources They indicate ways in which our understanding of travel is changing, and ways in which transportation data collection can and should be changing over time

Telecommunications and Travel

Clearly the telecommunications revolution is affecting every dimension of our lives, including travel Indeed, there are those who believe that the telecommunications revolution now occurring will have lasting consequences as dramatic as those of the industrial revolution The flow of information between computers, the existence of fax machines and pagers, and the rapidly approaching integration of computers with television must be reflected in the ways we think about and collect transportation data Two examples will illustrate the point

First is the emergence of intelligent transportation systems Electronic toll collection, smart cards, and integrated transit fare collection systems, global positioning systems, the availability of information on road conditions and transit schedules in advance of our trips, and real-time automated navigation aids—all are realities today And I believe the automated highway is only a few decades away It is not yet clear just how the new capabilities can provide us with new forms and types of data to describe travel, or how they will generate new policy problems that will change the way transportation data are collected Yet such changes will certainly come about, and I believe we should be thinking more actively than we have been about this phenomenon ITS capabilities will affect travel patterns in ways we are just beginning to understand, and this evolution should be reflected in the structure of our data collection and storage methods The new tools will produce as byproducts information that should be incorporated into our routine methods for analyzing travel

A second way in which telecommunications and travel interact is through changes in travel patterns In the early part of the 20th century, the telephone contributed to an increase in trip taking by making it possible for people to interact over greater distances This development hastened the spatial separation of activities, which in turn led to increased travel despite early expectations that the telephone would replace travel In the early part of the 21st century, faxes, e-mail, and the Internet will similarly result in a growth in travel because they will increase interaction over large distances (3)

At the same time, the new capabilities are changing the spatial and temporal distribution of travel The traditional morning and evening peak travel hours are extending over longer time periods because telecommunications makes it increasingly possible to work at different times and places Service people get their assignments for the day on line instead of having to drive to a central dispatching point, information workers can work at home part of the time, leaving when they need to attend a face-to-face meeting Likewise, Internet purchases have enormous consequences for the temporal and spatial distribution of travel for shopping and goods movement involving parcel services

Until now, travel has been modeled on the basis of data on the spatial locations of residences and places of employment because these were understood to be the principal determinants of travel Today we should also be gathering information on the spatial and temporal patterns of information flows, since they may some day eclipse land use patterns as the primary travel determinants We cannot know when and where people will travel if we fail to track when and where they communicate by wire and by wireless flows of information A better understanding of travel would result if information flows were included as independent variables in our travel forecasting analyses

Transportation and Urban Form

Transportation analysts once believed that the demand for travel was derived from urban form and that investments in transportation capacity were the principal determinants of urban form Urban centralization toward the end of the 19th century and the subsequent decentralization following first transit and later highway development resulted from the changing relationship between transportation and land use Responsibility for controlling land use has fallen to local governments, and we have manipulated the transportation–land use relationship primarily by investing in transportation It has only gradually and lately become popular wisdom that we can and should control traffic by deliberately manipulating land use Urban limit lines, neotraditional development, transit villages, and smart growth are all common themes in transportation circles today And places such as Portland, Oregon, and San Jose, California, are taking action in accordance with these principles

Yet if I am right, it may be too late to do too much good in this regard It is becoming necessary to think of transportation, land use, and telecommunications as having a three-way relationship

Modern telecommunications capabilities will change the transportation–land use connection I believe that in a world of ubiquitous telecommunications, it may be less possible to influence travel patterns through land use strategies, and it may be necessary to rethink these strategies given the rapid increase in telecommunications capabilities relative to physical mobility Efforts to incorporate data on telecommunications into transportation analyses and forecasts, as discussed above, will be essential to determine whether this supposition is correct

Goods Movement

One of the greatest limitations faced by transportation analysts is the absence of high-quality data on goods movement in urban areas Most of the transportation data collected today is on the movement of people, and these are the terms in which transportation problems—and solutions—are defined But goods movement is growing in importance and becoming a central issue in transportation policy making, and we are ill equipped to address this issue Although trucks are responsible for a substantial proportion of urban and intercity highway congestion and delay, many metropolitan areas continue to model truck movement by applying a multiplier to people movement In several metropolitan areas, proposals have been put forth for truck-only highways, for the separation of trucks from passenger vehicles, and for automated truck lanes as early steps in the evolution of an automated highway system Better information on goods movement, including its intermodal aspects, will be essential to the success of such efforts

Sustainability

It would not be an exaggeration to say that the dominant issue in transportation policy in the United States during the last quarter of the 20th century was air quality The provisions of the Clean Air Act and its several amendments have determined the direction of transportation planning in metropolitan America, leading many to observe that the transportation policy dog was being wagged by the air quality tail Primarily because of advances in vehicle technology, enormous progress has been made in meeting national ambient air quality standards, though along the way some additional dangers have been discovered from sources previously not recognized as critical, such as small particulates Interestingly, this progress toward cleaner air has been made despite the inadequacy of our data collection and analysis tools in characterizing or forecasting key pollutants under alternative policy options

The term "sustainability" is increasingly being used to denote the idea of planning transportation systems that conserve energy, limit greenhouse gas emissions, and recycle waste materials and fluids such that today's mobility does not lead to depletion of essential resources tomorrow (*4*) Like many Americans, I have in the past been more than a little cynical about sustainability, for I believe that growth in mobility worldwide brings many social economic, and cultural advantages But growing evidence that global warming is a credible threat must be taken seriously, and international treaties commit us to slowing the increase in emissions of greenhouse gases, a substantial proportion of which derive from the transportation system To build a more sustainable transportation infrastructure, we will have to define more precisely and to measure and monitor those elements that make up the sustainability of the transportation system I believe this will be as important a function of transportation planners during the coming decade as air quality issues have been in the last 15 to 20 years

Equity

Transportation analysis is generally focused on issues of effectiveness and efficiency Our databases and tools, such as benefit–cost analysis and corridor studies, are designed to tell us how well each alternative plan, design, or course of action satisfies project or program criteria, and how efficiently they do so per unit of capital and operating cost Yet one of the most pressing needs of policy makers is for more information about equity, and this issue is not nearly as well addressed by our standard methods and databases

Equity analysis, of course, implies a concern with fairness and with the distribution of benefits and costs among different groups The criteria by which we judge the equity of different transportation policies clearly are highly subjective, but in a way that makes the matter of data and modeling more urgent, more difficult, and more complex Recent disputes and increasingly frequent lawsuits have demonstrated the importance of analysis focused on the distribution of both project and program benefits and environmental, social, and economic impacts among different spatial communities, ethnic groups, and economic classes One of the most important ways in which our databases and tools can be strengthened in the relatively short run is by careful and thoughtful refocusing on these equity or distributional issues (5)

Conclusion

In summary, transportation databases, information systems, and analytical models interact with one another and change over time as our understanding of transportation systems and their social and economic contexts evolve New understandings both shape and are shaped by the data and models we use The five themes discussed above are areas I believe will define transportation planning needs, policy, and data requirements during the next decade

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