CHAPTER

1

Truth in Transportation Planning

By Donald Shoup

It ain't what you don't know that gets you into trouble.
It's what you know for sure that just ain't so.

Mark Twain

How far is it from San Diego to San Francisco? An estimate of 632.125 miles is precise—but not accurate. An estimate of somewhere between 400 and 500 miles is less precise but more accurate because the correct answer is 460 miles. Nevertheless, if you had no idea how far it is from San Diego to San Francisco, which would you believe: a manual published by the National Geographic Institute that reports the distance to be 632.125 miles, or someone who tentatively says somewhere between 400 and 500 miles? Probably the first, because institutional prestige and extreme precision imply certainty.

Although reporting estimates with extreme precision implies confidence in their accuracy, transportation engineers and urban planners often use extremely precise numbers to report highly uncertain estimates. To illustrate this practice, I will draw on two manuals published by the Institute of Transportation Engineers (ITE)—*Parking Generation* and *Trip Generation*. Urban planners rely on parking generation rates to establish off-street parking requirements, and transportation planners rely on trip generation rates to predict the traffic effects of proposed developments. Unwarranted trust in these precise but uncertain estimates of travel behavior lead to bad policy choices for transportation, parking, and land use.

TRIP GENERATION

Trip Generation reports the number of vehicle trips as a function of land use. The 6th edition of *Trip Generation* describes the database used to estimate trip generation rates:

> This document is based on more than 3,750 trip generation studies submitted to the Institute by public agencies, developers, consulting firms, and associations. … Data were primarily collected at suburban localities with little or no transit service, nearby pedestrian amenities, or travel demand management (TDM) programs (ITE 1997, vol. 3, pp. ix and 1).

ITE says nothing about the price of parking, but the 1990 Nationwide Personal Transportation Survey found that parking was free for 99 percent of vehicle trips in the U.S., so the surveyed sites probably offer free parking. Of the 1,515 trip generation rates reported in the 6th edition, half were based on five or fewer studies, and 23 percent were based on a single study. Trip generation rates thus typically measure the number of vehicle trips observed at a few suburban sites with free parking but no public transit, no nearby pedestrian amenities, and no TDM programs. Urban planners who rely on these trip generation data as guides when designing transportation systems are therefore skewing travel toward cars.

Figure 1-1 is a facsimile of a page from the 4th edition of *Trip Generation* (1987). It shows the number of vehicle trips to and from fast-food restaurants on a weekday. Each point in the figure represents a single restaurant, showing the number of vehicle trips it generates and its floor area. Dividing the number of vehicle trips by the floor area gives the trip generation rate for that restaurant. The rates ranged from 284.000 to 1,359.500, with an average of 632.125 trips per 1,000 square feet of floor area.

A glance at the figure suggests that vehicle trips are unrelated to floor area in this sample, and the equation at the bottom of the figure confirms this impression. The R^2 of 0.069 implies that variation in floor area explains less than 7 percent of the variation in vehicle trips. The correlation between trips and floor area is not significantly different from zero, but ITE reported the sample's average trip generation rate (which urban planners normally interpret as the exact relationship between floor area and vehicle trips) as precisely 632.125 trips per day per 1,000 square feet. The trip generation rate looks accurate because it is so precise, but the precision is misleading. Few planning decisions would be changed if ITE reported the trip generation rate as 632 rather than 632.125 trips per 1,000 square feet, so the three-decimal-point precision serves no purpose except to falsely suggest that the estimate is accurate.

Average Vehicle Trip Ends vs: **1,000 Square Feet Gross Floor Area**
On a: **Weekday**

TRIP GENERATION RATES

Average Weekday Vehicle Trip Ends per 1,000 Square Feet Gross Floor Area

Average Trip Rate	*Range of Rates*	*Standard*	*Number of Studies*	*Average 1,000 Square Feet GFA*	*Deviation*
632.125	284.000–1359.500	*	8	3.0	

DATA PLOT AND EQUATION

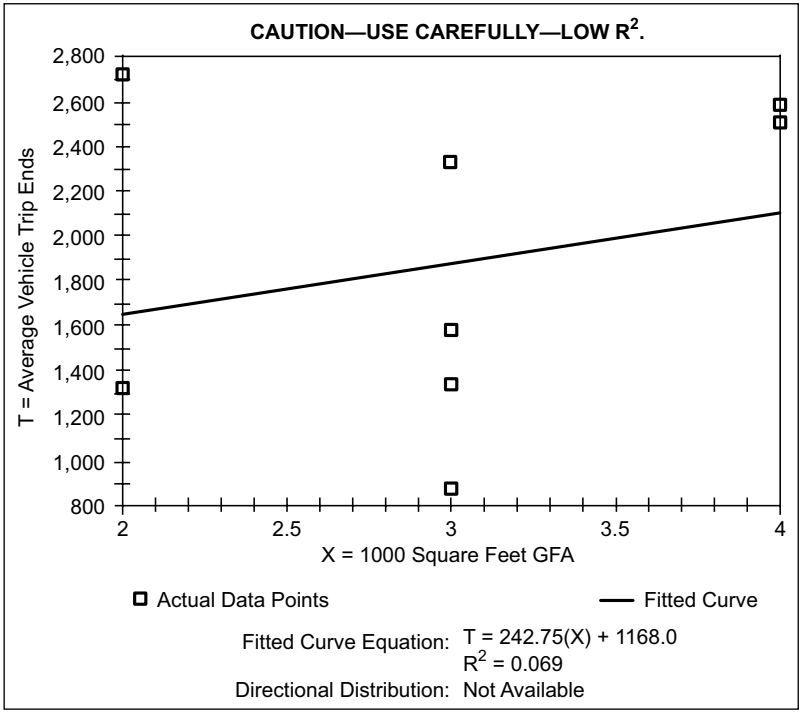

Figure 1-1 ITE trip generation rate for a fast-food restaurant with a drive-through window, 1987

Source: ITE, 1987, p. 1199

Figure 1-1 suggests that larger restaurants generate more vehicle trips but the smallest restaurant generated the most trips, and a midsize restaurant generated the fewest. The page does contain the warning, "Caution—Use Carefully—Low R^2," which is good advice because

the data show no relationship between vehicle trips and floor area. Nevertheless, the average trip generation rate is reported at the top of the page as if it were accurate. Despite its precision, the number is far too uncertain to use in transportation planning.

PARKING GENERATION

Parking generation rates suffer from similar uncertainty. *Parking Generation* reports the average peak parking occupancy as a function of land use. The 2nd edition of *Parking Generation* (ITE 1987, p. vii and xv) explained the survey process:

> A vast majority of the data … is derived from suburban developments with little or no significant transit ridership. … The ideal site for obtaining reliable parking generation data would … contain ample, convenient parking facilities for the exclusive use of the traffic generated by the site. … The objective of the survey is to count the number of vehicles parked at the time of peak parking demand.

Half the 101 parking generation rates in the 2nd edition were based on four or fewer surveys, and 22 percent were based on a single survey. Therefore, parking generation rates measured the peak parking demand observed at a few suburban sites with ample free parking and no public transit. Urban planners who used these rates to set off-street parking requirements were therefore planning a city where people drive wherever they go and park free when they get there.

Figure 1-2 shows the page for fast-food restaurants from the 2nd edition of *Parking Generation* (1987). The equation at the bottom again confirms the visual impression that parking occupancy is not related to floor area in this sample. The R^2 of 0.038 implies that variation in floor area explains less than 4 percent of the variation in parking occupancy. The largest restaurant generated one of the lowest peak parking occupancies, while a midsize restaurant generated the highest peak parking occupancy. ITE reported the average parking generation rate for a fast-food restaurant as precisely 9.95 parking spaces per 1,000 square feet of floor area although it is not significantly different from zero.

I am not saying that vehicle trips and parking demand are unrelated to a restaurant's size. Common sense suggests some correlation. Nevertheless, Figures 1-1 and 1-2 do not show a statistically significant relationship between floor area and either vehicle trips or parking demand. It is misleading and irresponsible to publish precise average trip and parking generation rates based on these data.

Peak Parking Spaces Occupied vs: **1,000 Square Feet Gross Floor Area Leasable Area**
On a: **Weekday**

PARKING GENERATION RATES

Average Rate	*Range of Rates*	*Standard Deviation*	*Number of Studies*	*Average 1,000 SFG Leasable Area*
9.95	3.55–15.92	3.41	18	3

DATA PLOT AND EQUATION

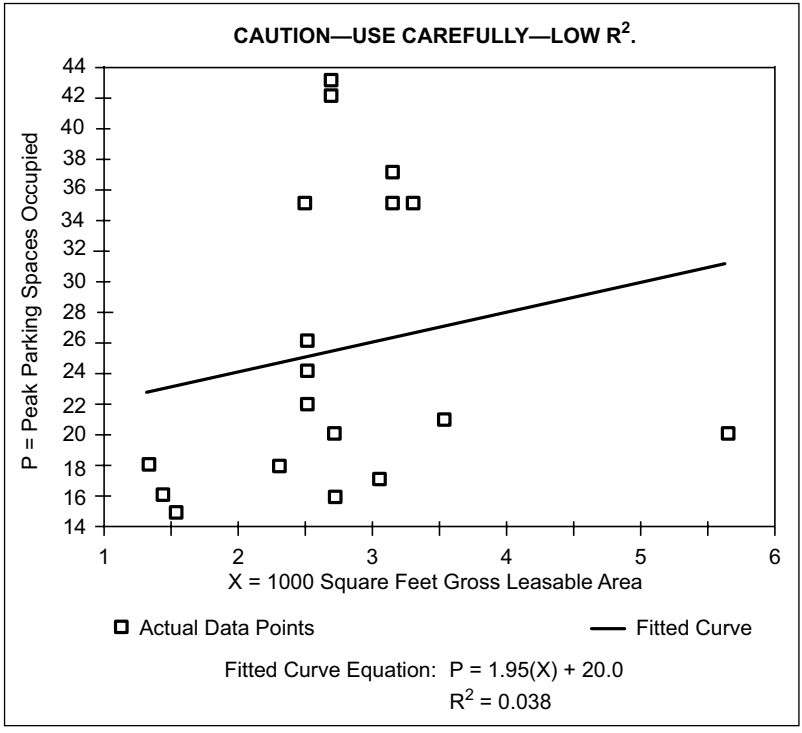

Figure 1-2 ITE parking generation rate for a fast-food restaurant with a drive-in window, 1987

Source: ITE, 1987, p. 146

ITE's stamp of authority relieves planners from the obligation to think for themselves about parking demand—the answers are right there in the book. ITE offers precise numbers about parking demand, although it does warn, "Users of this report should exercise extreme

caution when utilizing data that is based on a small number of studies." Nevertheless, many planners recommend the parking generation rates as minimum parking requirements because they are the only data available. For example, the median number of parking spaces required for fast-food restaurants in U.S. cities is 10 spaces per 1,000 square feet—almost identical to ITE's reported parking generation rate. After all, planners expect minimum parking requirements to meet the peak demand for free parking, and parking generation rates seem to predict this demand precisely! When ITE speaks, urban planners listen.

STATISTICAL SIGNIFICANCE

The breathtaking combination of extreme precision and statistical insignificance in parking and trip generation rates at fast-food restaurants raises an important question: How many of the rates for other land uses are statistically insignificant? ITE first stated a policy regarding statistical significance in the 5th edition of *Trip Generation* (1991):

Best-fit curves are shown in this report only when each of the following three conditions is met:

- The R^2 is greater than or equal to 0.25.
- The sample size is greater than or equal to 4.
- The number of trips increases as the size of the independent variable increases.

The third criterion is egregiously unscientific, even antiscientific. For example, suppose the R^2 is greater than 0.25 (which means that variation in floor area explains more than 25 percent of the variation in vehicle trips), the sample size is greater than four, and vehicle trips decrease as floor area increases. The first two criteria are met but the third is not. In this case, ITE would report the average trip generation rate (which states that vehicle trips increase as floor area increases), but not the equation (which would show that vehicle trips decrease as floor area increases). ITE's stated policy is to conceal evidence that contradicts expected relationship.

Figure 1-3, from the 5th edition, shows how this policy affects the report on fast-food restaurants. It showed the same eight data points as the 4th edition, but omitted the regression equation and the R^2, as well as the warning "Caution—Use Carefully—Low R^2." The 5th edition was, however, cautious about needless precision: it truncated the average trip generation rate from 632.125 to 632.12 trips per 1,000 square feet.

ITE revised its reporting policy in the 6th edition of *Trip Generation* (1997). It showed the regression equation only if the R^2 is greater than

Average Vehicle Trip Ends vs: **1,000 Square Feet Gross Floor Area**
On a: **Weekday**

Number of Studies: 8
Average 1000 Square Feet GFA: 3
Directional Distribution: 50% entering, 50% exiting

TRIP GENERATION RATES

Trip Generation per 1000 Square Feet Gross Floor Area

Average Rate	*Range of Rates*	*Standard Deviation*
632.12	284.00–1359.50	266.29

DATA PLOT AND EQUATION

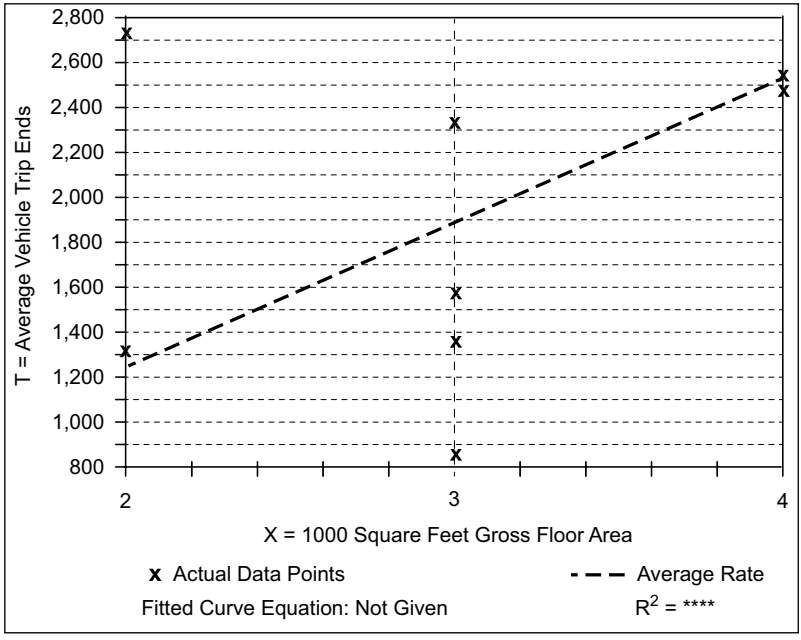

Figure 1-3 ITE trip generation rate for a fast-food restaurant with a drive-through window, 1991

Source: ITE, 1991, p. 1308

or equal to 0.5, but the other two criteria remained the same. Figure 1-4 shows the trip generation report for a fast-food restaurant from the 6th edition. The number of studies increased to 21, and the average trip generation rate fell to 496.12 trips per 1,000 square feet. Since the previous edition's trip generation rate was 632.12 trips per 1,000 square feet,

Average Vehicle Trip Ends vs: **1,000 Square Feet Gross Floor Area**
On a: **Weekday**

Number of Studies: 21
Average 1000 Square Feet GFA: 3
Directional Distribution: 50% entering, 50% exiting

TRIP GENERATION RATES

Trip Generation per 1000 Square Feet Gross Floor Area

Average Rate	*Range of Rates*	*Standard Deviation*
496.12	195.98–1132.92	242.52

DATA PLOT AND EQUATION

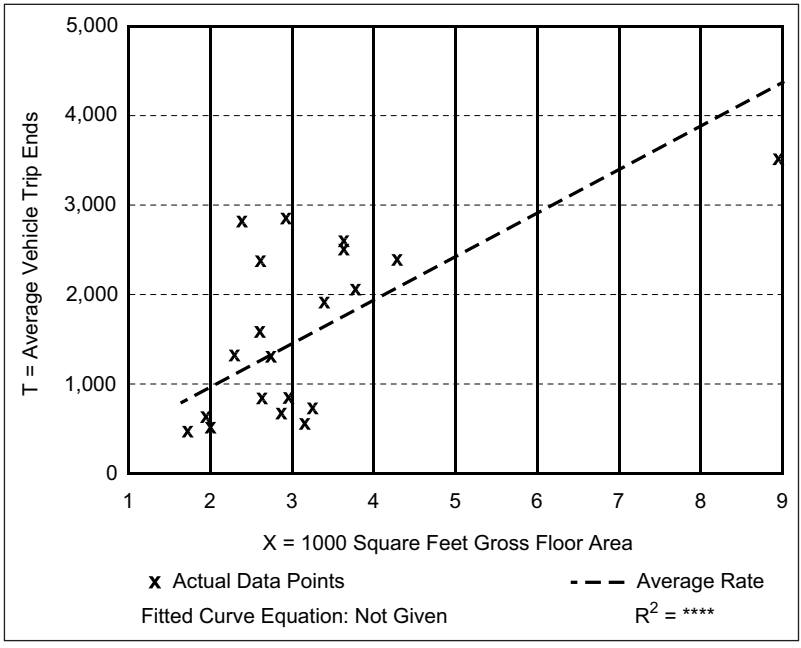

Figure 1-4 ITE trip generation rate for a fast-food restaurant with a drive-through window, 1997

Source: ITE, 1997, p. 1401

anyone comparing the two editions might conclude that vehicle trips to fast-food restaurants declined 22 percent in the six years between 1991 and 1997, perhaps because of a recession in the fast-food industry. But both the 5th edition rate (632.12) and the 6th edition rate (496.12) were

derived from data that do not show a statistically significant relation between floor area and vehicle trips, so this 22 percent decline is spurious. The 9th edition of *Trip Generation* (2012) showed the same 21 trip generation studies shown in the 6th edition (1997), and the same trip generation rate (496.12) reported 15 years earlier.

The 6th edition (1997) showed regression equations for only 34 percent of the 1,515 trip generation rates. Although 66 percent of the rates failed to meet at least one of the three significance criteria, ITE nevertheless published a precise rate for every land use no matter how small the sample or how unrelated vehicle trips are to floor area. Consider, for example, the report of trip generation at a fast-food restaurant with a drive-through window and no indoor seating, a new land use that was reported for the first time in the 7th edition in 2003 (Figure 1-5). Two sites were surveyed, and the larger site generated fewer vehicle trips. Nevertheless, ITE reported the average trip generation rate at the two sites and plotted a line suggesting that larger sites generate more vehicle trips. The precision defies common sense, but there it is: 153.85 vehicle trips per 1,000 square feet during the peak hour of adjacent street traffic on a weekday. Two observations were thus sufficient to launch this new land-use category, even though both its precise trip generation rate and the plot are absurd.

The 9th edition of *Trip Generation* (2012) continued the unscientific practice of concealing evidence that contradicts expected relationships. It showed the fitted curve equation and R^2 for only 38 percent of the 1,725 reported trip generation rates, which means that 62 percent of them failed to meet at least one of the three criteria that must be met before ITE shows the R^2.

The large share of trip generation reports showing no R^2 is explained in part by the large number of specialized reports for each land use. For example, pages 1910 to 1931 in the 9th edition showed 20 different trip generation reports for fast-food restaurants with a drive-through window. Nine trip generation rates were expressed as the number of trips per 1,000 square feet of floor area, in nine time periods:

1. A weekday
2. A weekday during the peak hour of adjacent street traffic in the morning
3. A weekday during the peak hour of adjacent street traffic in the evening
4. A weekday during the peak hour of trip generation in the morning
5. A weekday during the peak hour of trip generation in the evening
6. A Saturday
7. A Saturday during the peak hour of trip generation

Average Vehicle Trip Ends vs: **1,000 Square Feet Gross Floor Area**
On a: **Weekday**
Peak Hour of Adjacent Street Traffic, One Hour Between 4 and 6 p.m.

Number of Studies: 2
Average 1000 Square Feet GFA: 0.35
Directional Distribution: 54% entering, 46% exiting

Trip Generation per 1000 Square Feet Gross Floor Area

Average Rate	*Range of Rates*	*Standard Deviation*
153.85	124.37-191.56	*

DATA PLOT AND EQUATION

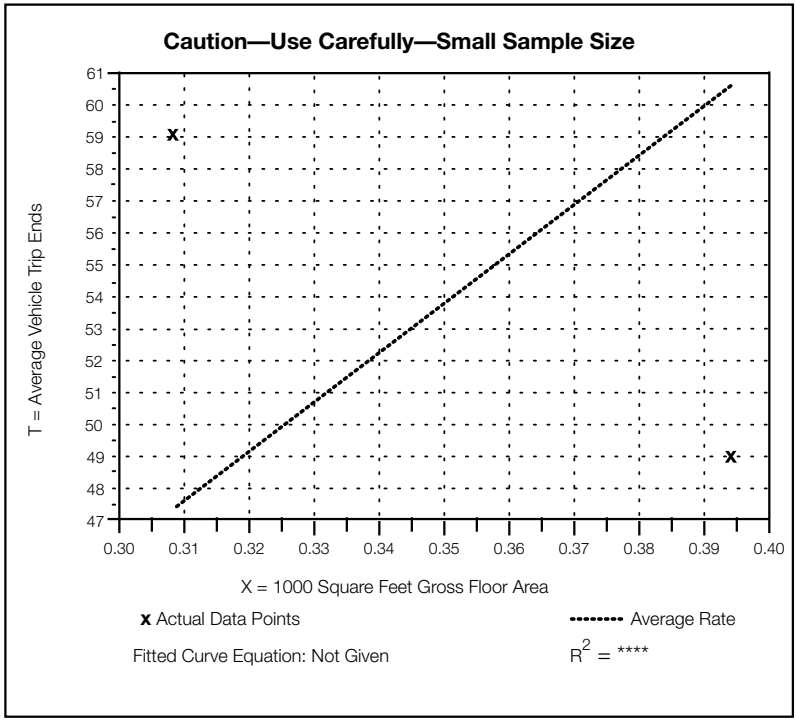

Figure 1-5 ITE trip generation rate for a fast-food restaurant with a drive-through window and no indoor seating, 2003

Source: ITE, 2003, p. 1773

8. A Sunday
9. A Sunday during the peak hour of trip generation

The 11 other trip generation rates were expressed as the number of trips per seat in the restaurant during various time periods, or as the number of trips divided by the volume of traffic on the adjacent street during the morning and evening peak hours.

Despite the heroic attempt to find a relationship between the number of trips and some factor at fast-food restaurants with a drive-through window, the 9th edition showed the R^2 for only one of the 20 trip generation reports—the number of peak-hour trips per 1,000 square feet of floor area during the peak hour on Sunday—and that R^2 was only 0.63 with a sample size of five observations.

ITE reported its policy regarding statistical significance for *Parking Generation* in the 4th edition, published in 2010: "For data sets with at least four study sites, a linear regression equation and line are presented if the coefficient of determination (R^2) is greater than or equal to 0.60" (ITE 2010, 14). How did this new policy affect the report of parking generation for fast-food restaurants? The parking generation rate was 9.98 vehicles per 1,000 square feet of gross floor area in 4th edition in 2010, almost identical to the 9.95 reported in 2nd edition in 1987 (Figure 1-2 above). The 2010 edition, however, omitted the fitted curve equation and the R^2 shown at the bottom of the data plot in the 1987 edition. As in 1987, the largest restaurant generated one of the lowest peak parking occupancies, while a midsize restaurant generated the highest. Omitting the R^2 and the regression line in 2010 implies that the R^2 is less than 0.60, which is no surprise since the R^2 reported in 1987 for a similar graph was only 0.038.

Not showing the regression equation is ITE's subtle way of pointing out that the information is flawed and irrelevant. Continuing to report misleadingly precise parking and trip generation rates, however, creates serious problems. Many people rely on ITE manuals to predict how urban development will affect parking and traffic. When estimating traffic impacts, for example, developers and cities often battle fiercely over whether a precise trip generation rate or parking generation rate is correct; given the uncertainty involved, the debates are ludicrous. But few seem to pay any attention to the statistical insignificance of this rigorous pseudoscience.

Many cities base their parking requirements on ITE's parking generation rates, and some cities base their zoning categories on ITE's trip generation rates. Consider the zoning ordinance in Beverly Hills, California:

> The intensity of use will not exceed either sixteen (16) vehicle trips per hour or 200 vehicle trips per day for each 1,000 gross square foot of floor area

for uses as specified in the most recent edition of the Institute of Traffic Engineers' publication entitled "Trip Generation."

The precise but highly uncertain ITE data thus govern which land uses a city will allow. Once they have been incorporated into municipal codes, parking and trip generation rates are difficult to challenge. Planning is an uncertain activity, but it is difficult to incorporate uncertainty into legal regulations. Admitting the flimsy basis of zoning decisions would also expose cities to countless lawsuits. It's easier to ignore the uncertainty and rely on the precise but statistically insignificant ITE numbers.

PLANNING FOR FREE PARKING

Not only are most ITE samples too small to draw statistically significant conclusions, but ITE's method of collecting data also skews observations to sites with high parking and trip generation rates. Larger samples might solve the problem of statistical insignificance, but a basic problem would remain: ITE measures the peak parking demand and the number of vehicle trips at suburban sites with ample free parking.

Consider the process of planning for free parking:

1. Transportation engineers survey peak parking demand at suburban sites with ample free parking, and ITE publishes the results in *Parking Generation* with misleading precision.
2. Urban planners consult *Parking Generation* to set minimum parking requirements. The maximum observed parking demand thus becomes the minimum required parking supply.
3. Developers provide all the required parking. The ample supply of parking drives the price of most parking to zero, which increases vehicle travel.
4. Transportation engineers survey vehicle trips to and from suburban sites with ample free parking and little or no transit ridership, and ITE publishes the results in *Trip Generation* with misleading precision.
5. Transportation planners consult *Trip Generation* to design the transportation system that brings cars to the free parking.
6. Urban planners limit density so that new development with the required free parking will not generate more vehicle trips than nearby roads can carry. This lower density spreads activities farther apart, further increasing vehicle travel and parking demand.

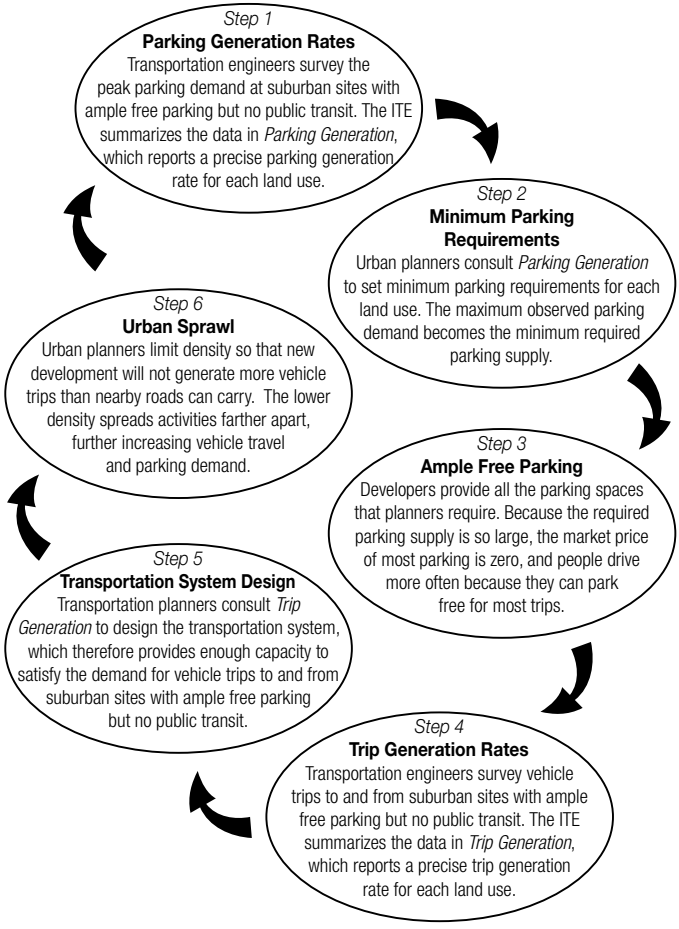

Figure 1-6 Six-step process

The loop is completed when transportation engineers again survey the peak parking demand at suburban sites that offer free parking and—surprise—find that more parking is needed. Misusing precise numbers to report uncertain data gives a veneer of rigor to this elaborate charade, and the circular logic explains why planning for transportation and land use has gone subtly, incrementally wrong.

The belief that minimum parking requirements are based on rational city planning resembles the belief that the earth is flat and balanced on the back of a giant turtle. In a debate between a scientist and a flat-earth-on-a-turtle believer, the scientist asked, what the turtle stands on.

The flat-earther replied that the turtle stands on the back of a far larger turtle. What does this second turtle stand on? The reply came, "You're very clever, young man, very clever. But it's turtles all the way down!" (Hawking 1988, 1).

Minimum parking requirements are also based on turtles all the way down. Cities require off-street parking without considering parking prices, the cost of parking spaces, or the wider consequences for transportation, land use, the economy, and the environment. Misinterpreting the peak demand for free parking as *the* demand for parking and then requiring that amount of parking everywhere has led to a planning disaster of epic proportions.

ITE manuals do not cause this circular and cumulative process, and ITE of course deplores any misuse of its parking and trip generation rates. In the early editions of *Parking Generation* and *Trip Generation*, ITE warned users to be careful when the R^2 is low (see Figures 1-1 and 1-2) but removed this advice from the data plots in recent editions (see Figures 1-3, 1-4, and 1-5).

The users of any data should always ask themselves whether the data are appropriate for the intended purpose. Only users can misuse data, but ITE invites misuse. The spurious precision of ITE data has helped to establish parking requirements and trip generation rates as dogma in the planning profession.

Parking requirements assume that everyone is parked at home, everyone is parked at work, everyone is parked at school, everyone is shopping on the day after Thanksgiving, and so on for every land use, simultaneously. If parking requirements do not meet the peak demand for free parking everywhere, there may be a shortage of parking somewhere, sometime, which is intolerable.

Parking requirements in zoning ordinances stem from the delusion that urban planners can estimate the right number of parking spaces needed at every site without considering the price that drivers pay for parking, the cost of providing the required spaces, or the wider consequences for transportation, land use, and the environment.

Parking requirements are closer to astrology than to astronomy and planners might just as well base parking requirements on signs of the zodiac. I have tried for years to let the theoretical hot air out of the tires of *Parking Generation* and *Trip Generation*, but the tires seem designed to run well even while flat.

LESS PRECISION AND MORE TRUTH

Parking and trip generation estimates respond to a real demand for information. Citizens want to know how development will affect their

neighborhoods. Developers want to know how many parking spaces to provide for their customers. Planners want to regulate development. Politicians want to avoid complaints about too little parking and too much traffic. These are all valid concerns but false precision does not resolve them. To unsophisticated users, the precise parking and trip generation rates look like constants similar to the boiling point of water or the speed of light, and the ITE data look like scientific observations. But parking and trip generation are poorly understood phenomena, and they both depend on the price of parking. Demand is a function of price, and this does not cease to be true merely because transportation engineers and urban planners ignore it. Cities are planned on the unstated assumption that parking should be free—no matter how much it costs to provide.

ITE's parking and trip generation rates illustrate a familiar problem with statistics in transportation planning. Placing unwarranted trust in the accuracy of precise but highly uncertain data leads to bad policy choices. Being roughly right is better than being precisely wrong. We need less precision and more truth in transportation planning.

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