The Transit "Field of Dreams:" If You Operate It, Will They Ride?

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Abstract

Various sources claim that transit patronage per capita in a given city or urban region depends primarily on factors outside the control of transit managers and elected officials; see, for example, Meyer, Kain, and Wohl (1965), Kain (1988), Pickrell (1992), Taylor et al. (2003) Cox (*www.publicpurpose.com*) and O'Toole (*www.ti.org*). Mees (2000) asserts the opposite: that transit patronage is *primarily* a function of service quality and quantity. The authors present data and analysis supporting Mees but with caveats under U.S. conditions. This includes patronage increases experienced during the 1930s by Indiana interurban railways (Hilton and Due 1960), accurate prediction of patronage changes based on long-term service elasticities in Britain (Dargay and Hanly 2002), and the strong correlation between service levels and per-capita transit ridership in small U.S. cities (Neuzil 1975). The authors, applying Neuzil's analysis to a 2001 data set for the U.S., find an even stronger correlation between annual transit capacity and annual transit passenger-miles per capita. The authors critique Taylor et al. (2003) whose primary finding appears moot: the fact that transit service changes do not generate ridership increases in proportion is well-known - and has long been known - to transit managers. The authors present supporting examples; one could summarize as follows: "If you operate it, they will ride . . . but don't expect sellout crowds at once." The factors outlined by Mees (2000) have significant impact but not during "short-term" intervals. In the face of "peak oil," (see for example, (*www.peakoil.net*), Mees' advice for improving transit appears wise and prescient.

1. Introduction

It is often claimed that the magnitude of the “transit riding habit” in a given city or urban region depends primarily on factors outside the control of transit providers and political decision-makers. This point of view is presented in a large percentage of the academic literature dealing with transit written during the past forty years, including key works such as Meyer, Kain, and Wohl (1962), Kain (1988), and Pickrell (1992), and most recently by Taylor et al. (2003)[1].

The extreme opposite point of view is presented by Australian transit advocate and academic Paul Mees in his 2000 book *A Very Public Solution* – that the magnitude of transit patronage in a given urban area is *primarily* a function of the quality and quantity of service. This may seem perfectly obvious to transit advocates and professionals. But this viewpoint is alien to large segments of the automobile-dependent American public, transportation academics, and transit critics. For example, UCLA researchers Taylor, Fink, Iseki, and Miller, in a paper presented to the 2003 Annual Meeting of the Transportation Research Board, present views that are very common among academics studying transportation and transit:

> . . . Transit ridership is largely, though not completely, a product of factors outside of the control of transit managers. Among those factors that transit systems do control, the quality of transit service and adroit pricing of transit services to target particular travel markets have proven most effective. The quantity of transit service is, of course, strongly related to transit use, but it is also determined by ambient levels of transit demand.
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> While many of the factors which most affect transit ridership are outside of the control of transit managers, they are not beyond the bounds of public policy . . .
>
> . . . With respect to factors over which transit systems exercise some control, improvements to service supply–frequency, coverage, reliablity, etc.–have been shown to be more important than price (fares) in determining ridership. However, most research has measured service supply (vehicle hours, miles, etc.) rather than service quality (on-time performance, etc) . . .
>
> . . . In a nutshell, we find that most of the variation in transit ridership between urbanized areas–in both absolute and relative terms–can be explained by (1) the size (both population and area) of the metropolitan area, (2) the vitality of the regional economy (measured in terms of median housing costs), and (3) the share of the population with low levels of private vehicle access (measured in terms of zero-vehicle households).

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[1] This perspective is also characteristic of prominent transit critics funded by conservative “think tanks,” e.g. Cox (www.publicpurpose.com) and O’Toole (www.ti.org).

Cox (2000) argues that it is virtually impossible to make high quality transit a practical choice for the vast majority of urbanized area residents[2]. O'Toole (2003) argues that transit stands no chance of competing against automobiles, given low auto costs paid by consumers[3].

Mees (2000) presents an empirical comparison of transit outcomes in Melbourne, Australia and Metro Toronto, Canada. His findings contrast sharply with those of Taylor et al. (2003), and the dogmatic rhetoric of Cox (2000) and O'Toole (2003). Mees asserts that:

> ". . . With sensible planning, it is actually possible to have 'European-style' public transport, even in dispersed urban environments."

As described by Mees, the Toronto Transit Commission once maintained a transit riding habit in the range of 300 annual rides per capita in Metro Toronto, Canada, comparable to New York City proper, Munich, or Zürich. Toronto accomplished this feat because transit often enjoyed much political and funding priority as road expansion (until a "neo-conservative" government

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[2] . . . Transit plays a significant role in the nation's largest downtown areas. More than one-third of commuters ride transit to work in nine downtowns, such as New York, Chicago and San Francisco. But in other downtowns the numbers are much smaller. And outside downtowns, such as in the suburban "edge cities" like Tyson's Corner in Washington, Perimeter Center in Atlanta or Schaumburg in Chicago and elsewhere, transit's market share is insignificant, often two percent or less. . .

. . . The fact is that transit, rail or bus, is not a choice for at least 90 percent of people commuting to work in the nation's metropolitan areas. It not a choice for an even larger percentage of non-work trips. This is because transit is incapable of competing with the convenience and especially the travel time of the automobile. That is why transit's urban market share is under two percent, and why every year, the increase in urban automobile usage alone exceeds total transit usage (measured in person miles).

[3] . . . One reason people drive more is the cost of driving has decreased, which can be calculated using *National Transportation Statistics table 1-30* (showing passenger miles) and the previously mentioned table 2-7 (showing auto expenses). In 1960, Americans spent an average of 23.5 cents per mile (in 1997 dollars) to drive their cars and light trucks. Today this has fallen 26 percent to just 17.4 cents per mile. This is partly because of more fuel-efficient cars and partly because today's better-quality cars and trucks last longer.

Another reason people drive more is that they make more money. In 1960, disposable personal income averaged $9,900 (again in 1997 dollars). In 1997 it came close to $22,000. This represents a 118-percent increase.

A 118-percent increase in income combined with a 26-percent decrease in the cost of driving each mile makes it possible for Americans to drive 124 percent more yet spend a significantly smaller portion of their income on autos than they did in 1960.

. . . In 1960, when most transit companies were private and not subsidized, the cost of transit averaged 18 cents per passenger mile (in 1997 dollars), a little less than the cost of driving. By 1975, when virtually all transit agencies were publicly owned and heavily subsidized, the cost per passenger mile reached 44 cents -- most of which was paid by taxpayers, not transit riders. Today transit costs exceed 50 cents per passenger mile. This is three times as great as the cost of driving per passenger mile.

came to power in Ontario in the early 1990's and drastically cut transit funding). Toronto's European-level transit riding habit was nearly as high at 1990 as at 1950, despite typically North American levels of auto ownership, rapid auto-based suburban growth and decentralization, low gasoline prices and relatively low development densities (closer to the North American than the European norm). Mees continues:

> ...Just as "all happy families are alike but each unhappy family is unhappy in its own way", all genuinely successful urban public transport systems, be they in Zurich, Munich, Metro Toronto or Vancouver, share a common feature, namely central, regional planning by a public agency. Only central planning enables the provision of flexible travel options through a fully integrated network. This requires the following conditions:
>
> ☑ an integrated route structure which maximises opportunities for interchange and reduces duplication and overlap;
>
> ☑ fast, frequent, reliable service on the trunk (rail, busway or whatever) routes;
>
> ☑ high service levels on all routes (cross-suburban as well as radial) throughout the day and evening;
>
> ☑ convenient, safe, and attractive interchange facilities;
>
> ☑ matching hours of operation on the different routes serving interchanrges and either coordinated timetables or very frequent services;
>
> ☑ multi-modal fares (free transfers);
>
> ☑ easy-to-obtain, well-presented route and timetable information covering the whole multi-modal network.

Mees explains how these things work together to create an auto-competitive transit network:

> . . . With public transport itself, the critical issue is flexibility. And the key to flexibility for passengers is simplicity and predictability, not a bewildering array of constantly changing options. This produces confusion, not convenience. Paradoxically, to be flexible, public transport must be rigidly predictable: perhaps the best analogy is with the road system, rather than with cars themselves. Flexible public transport can take advantage of the increasing diversity of travel patterns in post-modern cities to produce a more even flow of passengers throughout the day, reducing the economic costs of heavy "peaking". It can also provide a genuine alternative to multiple car ownership, reducing the financial burden on struggling households and reducing car ownership levels generally.

> . . . Even though conventional economists will object, public transport needs to be supply- rather than demand-led. This is the way to achieve flexibility and innovation, and to respond to changing travel needs. As was noted in Chapter 5, it is only by offering a complete service that a public transport operator enables passenger demands to manifest themselves. Once this has occurred, even questions about technology become easier to answer. For example, with an excellent bus service in place across an urban area, it is easy to select the promising sites for upgrades to light rail or busways: these will be the corridors with high, and rising, patronage.

Mees' conclusions provide a stark counterpoint to various works on transit published during the past 40 years by American academics, e.g. Meyer, Kain and Wohl (1965), Kain (1988), Pickrell (1992), Richmond (1991), Taylor et al. (2003), etc[4].

Corroboration of Mees' assertions would require demonstration of a strong, consistent relationship between transit service levels (offered capacity) per capita and service consumption per capita. Absence of such a relationship would tend to corroborate the more common thesis - that the magnitude of the transit riding habit depends more on external demographic and economic factors (that in general are not controlled by transit management and elected officials), and is little influenced by service quality and quantity. If this is so - that is, if others are correct and Mees is not - then there should be wide variations in transit utilization rates relative to service (offered capacity) in random cases (systems and times), i.e. weak correlation and tenuous relationships between the quantity of transit service offered and utilization per capita between cities and over time.

The authors investigated by comparing transit riding habits relative to service levels provided. "Transit riding habit" is measured by calculating annual rides per capita, or by estimating annual transit passenger-miles per capita. Throughout this paper, we define "annual rides per capita" to include all boarding rides, including transfers. These data are readily available and, in most urban regions, approximate of the number of "linked trips" (i.e. the proportions of revenue and transfer passengers with respect to boarding passengers vary much less between systems than the magnitudes of service levels provided and overall system patronage).

2. Interurban Electric Railways - Indiana, 1933 - 1936

The pattern of economic decline experienced by the U.S. interurban electric railway industry in the 1920s and 1930s provides early evidence of the relationship between transit patronage and

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[4] and the rhetoric of transit critics such as Cox and O'Toole.

service levels. Hilton and Due (1960) extensively document the rise, decline and finances of the industry. As these authors point out, the record of the interurban industry parallels that of its close technological cousin, the street railway industry:

> In a sense the [interurban] industry never reached a high level of continued prosperity. The seeds of the decline were ripening even before the expansion was completed . . . The industry raised as much capital as it did only because of the strong and largely unfounded optimism of investors . . .
>
> . . . Underlying these financial problems were the basic physical limitations of the interurbans . . . These disabilities included lack of high-speed entrances to downtown areas, poor track construction, excessive grades and curvature, poor signal systems, and inadequate ballast. As the roads began to emphasize longer-distance travel, such limitations became more serious, yet by then the funds for major improvements were often lacking.
>
> . . . A final disability was the hostile attitude of many local governments to street running . . .
>
> . . . The interurbans also suffered from the hostility against utility companies that was prevalent after 1900 . . . This was particularly true when they were affiliated with city streetcar systems, which were particularly unpopular in this period. One consequence, in many states, was the tendency to place excessive burdens on the companies for the use of public property.

Despite many operating shortcomings, and handicaps placed on the interurbans by outside forces, the direct relationship between patronage and level of service offered remained very strong even as the industry was being swept away by the Great Depression. According to secondary data presented by Hilton and Due (1960), Indiana interurban passenger revenues totaled slightly more than $9 million at 1929. By the “bottom” of the Depression (1933), this had declined to slightly less than $3 million. Between 1929 and 1933, Indiana’s interurban mileage declined through abandonment from about 1,800 miles to approximately 900 miles.

Service was reduced accordingly. Indiana interurban passenger car-miles declined by half, from about 50 million at 1929 to approximately 24 million at 1933. Total patronage also declined by half during 1929 – 1933, from roughly 44 million passengers to about 22 million passengers. Average fare per passenger also declined appreciably, reflecting pressures from Depression-era deflation to cut fares in order to retain patronage.

Thereafter, from 1933 to 1936, the Indiana interurbans experienced a short-lived revival as surviving operators made determined efforts to continue. By 1936, annual interurban service levels had been increased to about 32 million car-miles – that is, by 35 percent. This was operated over a much smaller network – less than 700 route-miles – than existed only a decade earlier, during the mid-1920s. Passenger volumes and revenues responded positively, increasing, respectively, to about 38 million passengers (up by 77 percent) and about $4.2 million in passenger revenues (up by 53 percent, adjusting for inflation) at 1936.

Unfortunately, this remarkable turnaround proved unsustainable. Revenue per passenger fell by 42 percent during 1933-1936, and at 1936 was 57 percent below the 1929 level (adjusting for deflation). Revenue per car-mile actually increased by 13 percent, but at 1936 was still 10 percent below the 1929 level (adjusting for deflation). Long-term trends remained highly unfavorable, and the industry was not able to survive a second economic downturn – which materialized as the recession of 1937-1939.

By 1941, the hopeless economic position of Indiana's interurbans resulted in abandonment of most remaining mileage, with the notable exception of the Chicago, South Shore, and South Bend Railroad. The South Shore Line closely resembled mainline railroads in its construction and operation, surviving into the 21st Century as an important commuter route into Chicago's Loop. The South Shore was close to bankruptcy in 1925, but survived the Great Depression due mainly to massive investment in modernization made by Samuel Insull's Midland Utilities sydicate during the late 1920s (Hilton and Due 1960).

3. Transit Service Factor - U.S., 1955 - 1970

Dennis Neuzil, P.E., found a correlation statistic of $R^2=0.96$ comparing annual transit rides per capita with revenue vehicle miles in a 1975 article (Preliminary Transit Patronage Estimation for Small Urban Areas via Transit Service Factor, *Traffic Engineering,* August 1975). Neuzil summarized his research in various transit planning studies conducted in Washington State, and research published in the late 1960's (Carstens and Csanyi 1968).

Neuzil describes his findings as follows:

> " . . . Carstens and Csanyi, in their comprehensive analysis of correlates of transit use in smaller Iowa cities, showed that a transit service-factor correlated well with per-capita ridership. In the course of conducting transit feasibility studies for several smaller urban areas, the usefulness of the ridership / transit service-factor relationship was confirmed in terms of Washington state experience and for a number of smaller cities in the Eastern U.S. as well. Service-factor provides a highly useful and convenient basis for initial estimation of transit patronage, particularly in connection with sketch planning studies associated with preliminary evaluation of a wide range of alternative bus systems and levels of service.

> " . . . In general, smaller cities beyond the commuting influence of metropolitan areas exhibit few marked differences in terms of overall socio-economic and local geographic characteristics relative to the fundamental propensity to use transit. And transit service factors associated with the low-to-moderate levels of transit service typically considered for implementation in small urban areas do not vary substantially. In terms of overall or system-wide patronage estimation, the quantity or level of transit service relative to community size would therefore appear to be the primary determinant of transit use, as indeed revealed by the studies described below."

The transit ridership data for the studies cited by Neuzil, and much of his own data, were time series data collected over several years and for different decades.

Neuzil defined "Transit Service Factor" as the quantity of scheduled transit service provided per capita:

$$\text{Transit Service Factor} = \frac{\text{Annual revenue-miles of regular transit service}}{\text{Corporate population of service area}}$$

As described by Neuzil, Carstens and Csanyi found a very strong correlation ($R^2 = 0.96$) between annual ridership per capita (Rc) and transit service factor in various Iowa cities during 1955-1965. Neuzil found a similar strong correlation in his analysis of various small cities in Washington State during 1960-1970. Neuzil also summarized data for various U.S. cities that confirmed his findings and those of Carstens and Csanyi (adapted from: Simpson and Curtin. 1968. *Great Falls, Montana, Transit Study*).

The Carstens – Csanyi formula, confirmed by Neuzil and other researchers, is as follows:

$$R_c = -1.30 + 1.89*S + 0.081*S^2$$

Where Rc = Annual Ridership Per Capita S = Transit Service Factor

$R^2 = 0.96$

In addition to the transit service factor, Neuzil examined other variables and their correlation with annual ridership per capita. Results are presented in Table 1 (below).

Neuzil concluded on a cautionary note:

> " . . . Careful judgment should be exercised in application of the service factor / ridership relationships presented here to any particular urban area, however. Adjustments for local conditions–community factors and transit system parameters – and consistency checks with other patronage estimation criteria are essential in applications beyond gross preliminary patronage

Table 1. Correlation Factors, Annual Rides Per Capita

Variable	**Correlation (R^2)**
Revenue miles of service per resident of the service area	+0.96
Persons per registered automobile, 11 Iowa cities, 1955-1965	+0.75
Nonworker-worker ratio, corrected for population of central city	+0.52
Population of central city	+0.52
Persons per registered automobile in county of central city	+0.47
Population density in central city, persons per square mile	+0.30
Average fare, corrected for population of central city	-0.39
Median family income in central city, corrected for population	-0.44

> estimation. For example, for a given urban area identical service-factor values can be produced from a wide range of system route-miles, operating speed, bus fleet size and service hours; the same service-factor can result by increasing the planned (or presently operated) bus-miles by increasing the fleet size or by providing increased schedule frequency, or a combination of both. Patronage response will not be the same in each case, however. Patronage estimation for sub-areas of the community or for specific routes requires thorough analysis of service area or corridor characteristics and level-of-service factors.”

Neuzil added, optimistically:

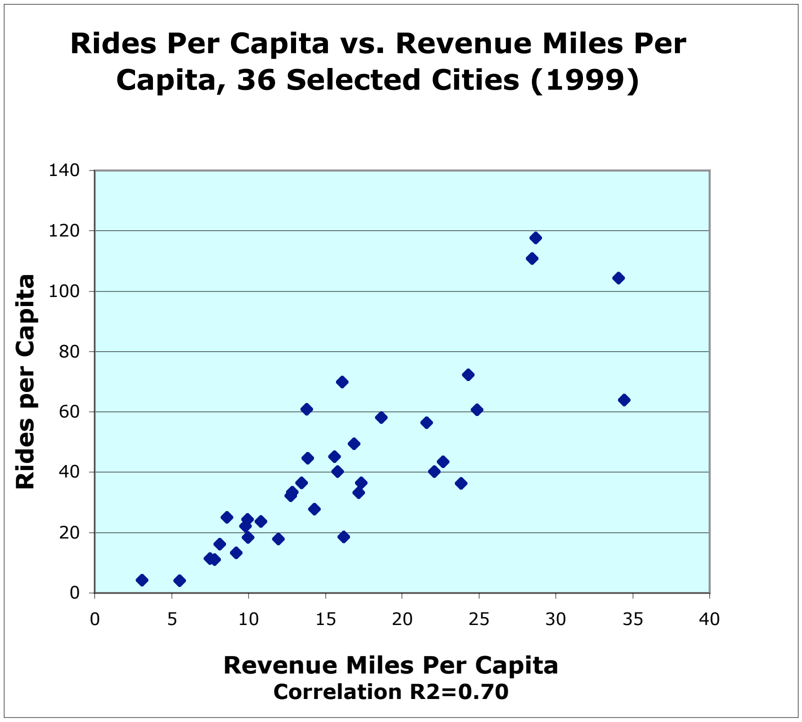
> “It should also be noted that the relationships presented herein are essentially based on experience of the 1960s. The energy crisis has amply demonstrated that dramatic change in transit use can result in fundamental shifts in economic factors and lifestyles. Nor do the curves give adequate allowance for latent demand response to major shifts in qualitative service factors. They do, however, provide a reasonable starting point for preliminary patronage analyses.”

Unfortunately, no significant follow-up research is known. The only references relating specifically to “transit service factor” (as defined by Neuzil) that could be found online (using www.google.com) were to the 1975 article.

In spite of Neuzil’s ending caveats, one of the authors became curious about the applicability of his findings to U.S. urban areas large and small, 27 years later. He decided to investigate the current relationship between transit service levels – measured by annual revenue vehicle miles of service per capita – and the level of transit consumption – i.e. ”transit riding habit” measured by annual transit rides per capita.

The following is a summary of analysis conducted by Setty (2002). Data were obtained from the *National Transit Database* (NTD), maintained by the Federal Transit Administration (FTA). All transit operators receiving FTA funds are required to submit annual reports to the NTD, making this a rich source of basic transit data and statistics. Data-collection efforts for each urban area focused on obtaining total transit “boardings” (individual rides) and revenue vehicle miles operated regardless of mode for the 1999 reporting year (the most recent available at the time of research). All transit systems that submitted NTD reports and served a given urban area were aggregated, exclusive of paratransit and vanpools. Population data for the selected urban areas was obtained from the Texas Transportation Institute (TTI) database.

Figure 1.



The final list included 36 urban areas with more than one million population. The New York City tri-state area was excluded on grounds that it is unique in the U.S. urban hierarchy. Other urban areas were excluded based on a lack of comparable data on the highway side. The initial analysis examined the relationship between transit supply (annual revenue vehicle miles) and transit demand (annual rides per capita). The most recent version of Microsoft *Excel* for Macintosh Operating System 10 (*OS X*) was used, including the “correlation” spreadsheet function. The resulting “scatter diagram” is shown in Figure 1 (above).

The OLS regression model is: $R_{cap} = -8.038 + RVM_{cap}*3.048$.

$R^2 = 0.70$ ($R = 0.84$; $0.84^2 = 0.70$); the relationship is very highly significant and RVM_{cap} explains 70 percent of the variation in R_{cap}.

(There might be a much stronger relationship if the definition of "population" was tightened to "population living within (x distance) of the nearest transit stop or station." However, data that would permit this analysis are not available.)

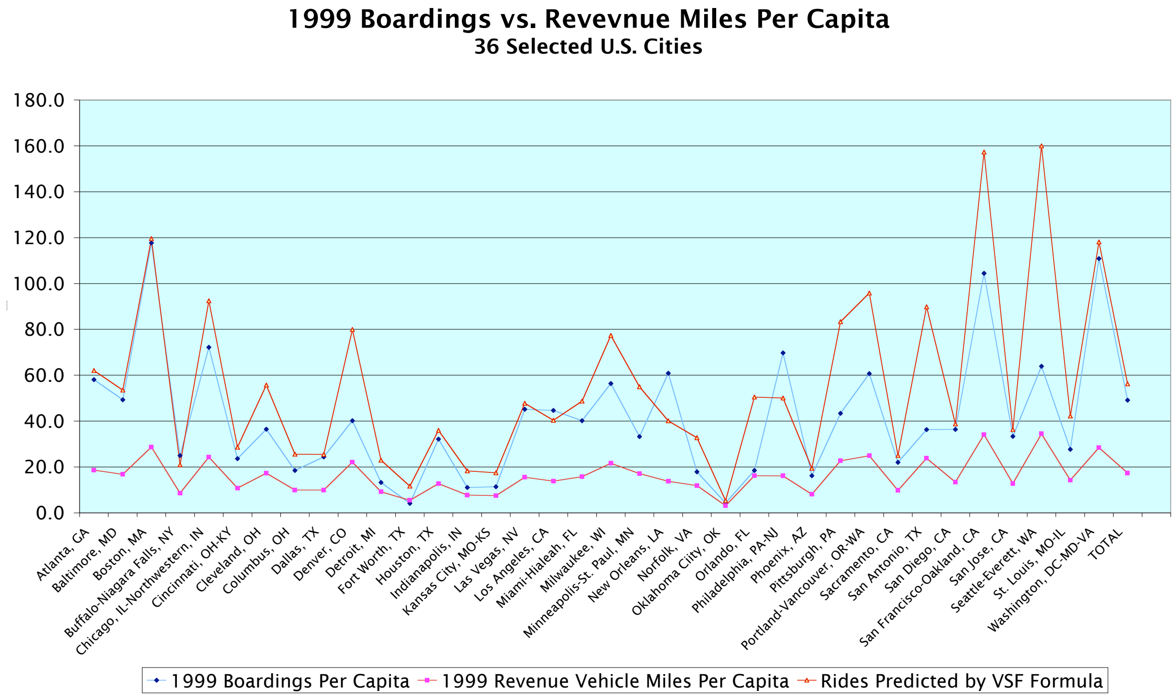
The t-statistic for the coefficient is 9.010; the coefficient is very significantly different from zero (99.9 percent level). The relationship does not arise from random chance. The "95-percent confidence interval" extends from 2.360 to 3.735; this finding is based on a 95 percent confidence level. The t-statistic for the intercept is -1.330; the intercept is not significantly different from zero.

The direct applicability of the “transit service factor” (TSF) equation to large urban areas was also tested. Results are shown in Figure 2a (below).

Application of the TSF equation to large urban areas with more than one million residents accurately predicted R_c in most cases. However, R_c was over-predicted in some regions.

Longer trips in some areas require operation of relatively more revenue vehicle-miles, such as for freeway express bus routes. Using total train-miles rather than total revenue vehicle- (car-) miles might improve TSF predictive accuracy in cases where rail transit is aggregated with

Figure 2a.

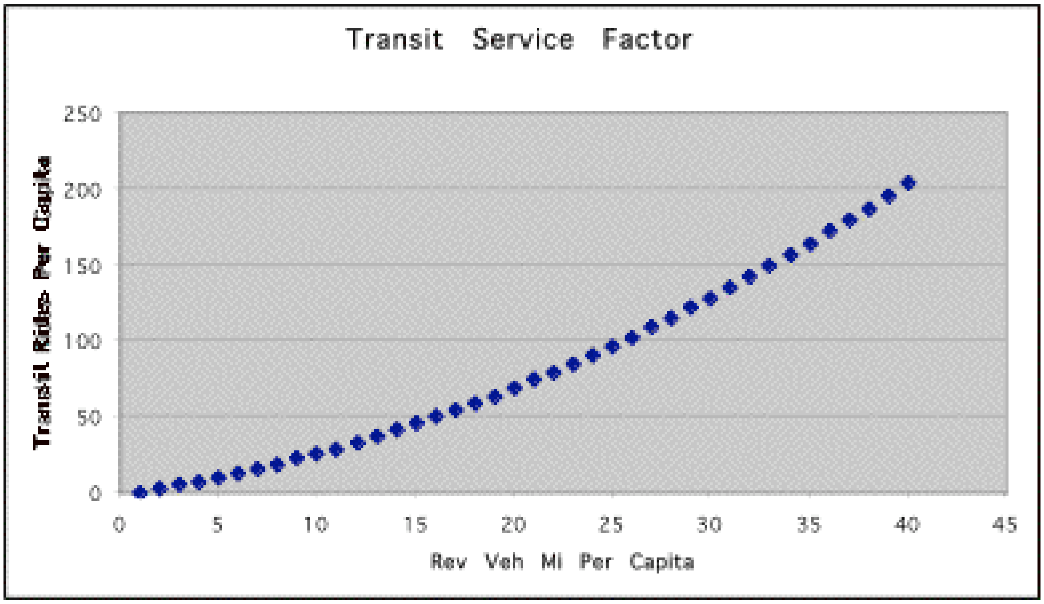


buses. Rail vehicle miles are usually a very large percentage of all transit service offered in rail-served urban areas. The impact on possible findings of modifying the TSF formula to account for transit passenger-miles should also be investigated.

However, the high R^2 (0.70) illustrated in Figure 1 suggests, and strongly, that total transit service provided directly influences demonstrated transit demand. Other service factors, such as segregation of transit from roadway congestion, certainly play significant roles.

In Figure 2b (below), the Transit Service Factor was plotted against results generated by the Carstens – Csanyi relationship: $R_{cap} = -1.30 + 1.89S + 0.081S^2$. This relationship is obviously nonlinear, as Figure 2b illustrates. Note that on Figure 2a, the Transit Service Factor ranged roughly between 10 and 20 for most of the 36 metro areas; only a very few provided more than 20 (San Francisco Muni provided a TSF of almost 32, which resulted in very high patronage per capita). Above a certain threshold, additional increments of service are correlated with GREATER ridership than previous increments.

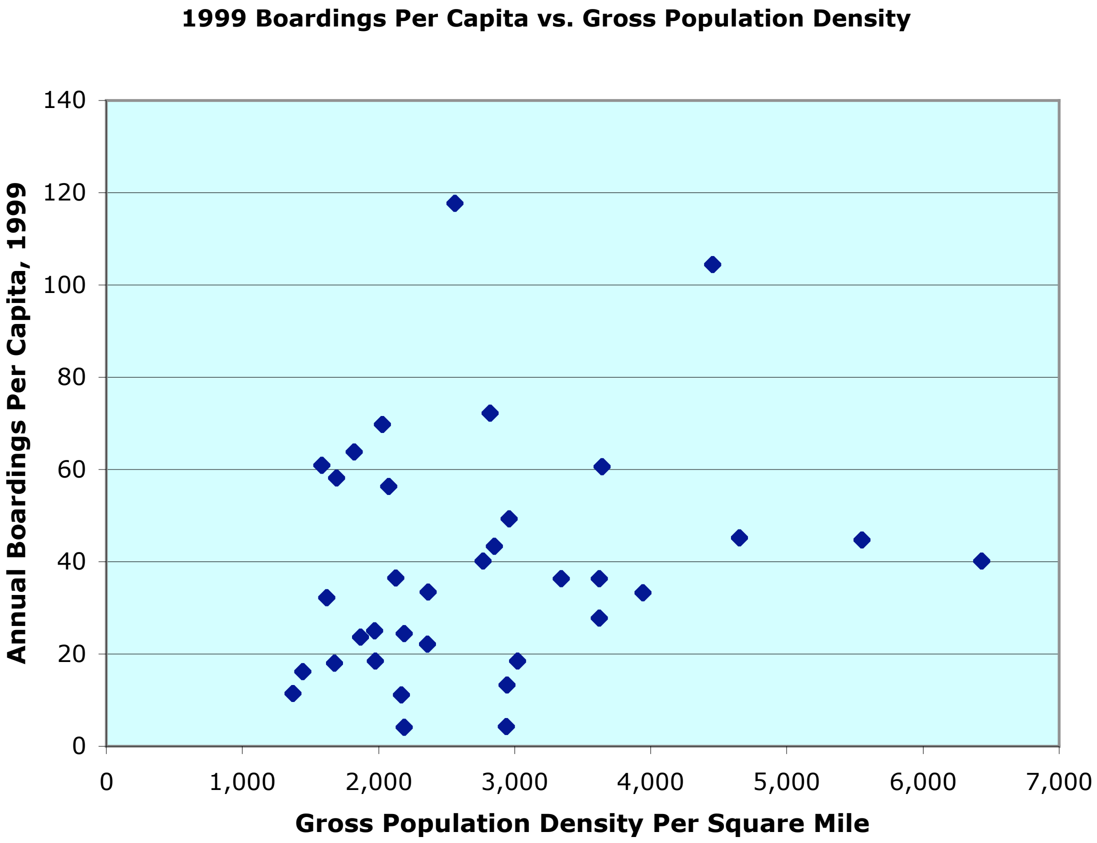
Figure 2b.



The relationship between gross population density and ridership per capita is illustrated in Figure 3 (below). The OLS regression model is: $R_{cap} = 22.071 + D_{pg}*0.0068$.

$R^2 = 0.08$; the relationship is just barely significant but D_{pg} explains only 8 percent of the variation in R_{cap}. (Again, the relationship might be stronger if "population density within (x distance) of the nearest transit stop or station" could be determined.)

Figure 3.



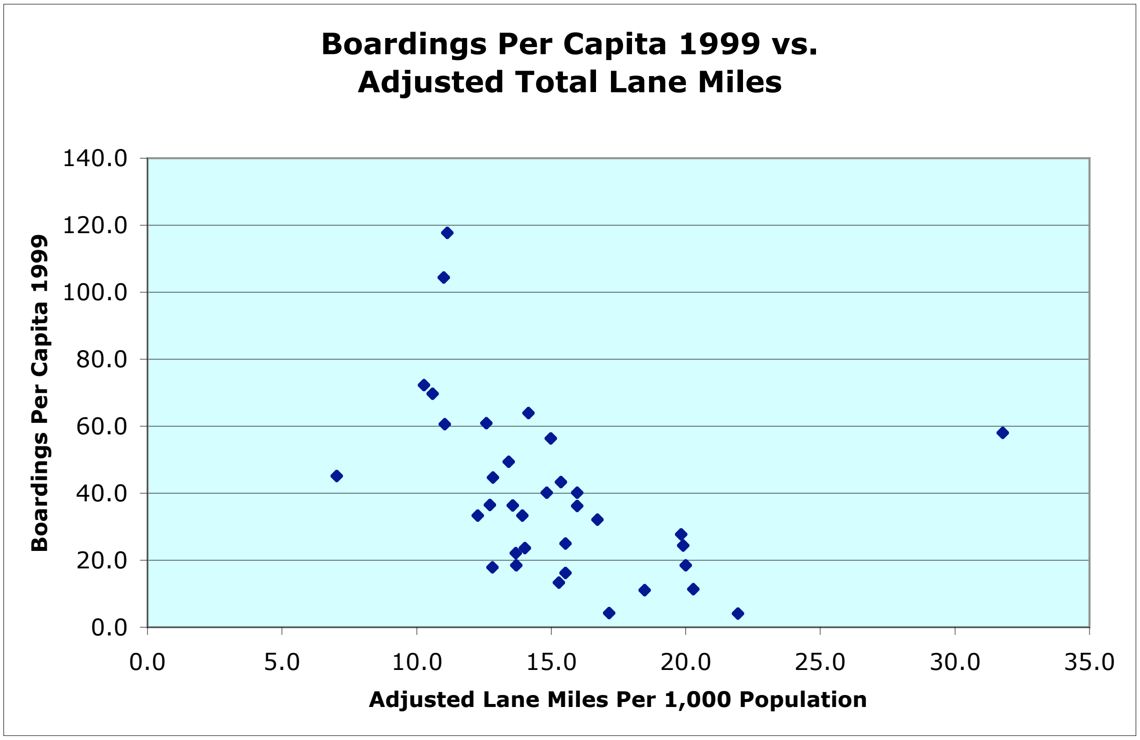
The t-statistic for the coefficient is 1.668; the coefficient is not significantly different from zero. The t-statistic for the intercept is 1.816; the intercept is not significantly different from zero.

At least on a "metropolitan area" basis, there is NO statistically significant relationship between "gross population density" and "rides per capita." The authors anticipate that multiple-regression analysis would probably demonstrate that density -- at least on a “service-area" basis -- does exert some influence.

Figure 4 (below) displays transit rides per capita against “adjusted roadway lane miles” for each urban region. “Adjusted roadway lane miles” equals one-way arterial lane miles, plus 3 times one way freeway lane miles, based on the fact one freeway lane mile has approximately three times the capacity of one arterial lane mile (Setty 2002).

The OLS regression model is: $R_{cap} = 105.106837 + LM_{adj}*(-2.360413)$.

Figure 4.



R^2 = 0.31; the relationship is highly significant but LM_{adj} explains only 31 percent of the variation in R_{cap}.

The t-statistic for the coefficient is -3.926; the coefficient is highly significantly different from zero. The relationship does not arise from random chance. The 95-percent confidence interval extends from -3.582 to -1.139.

The t-statistic for the intercept is 6.279; the intercept is highly significantly different from zero. The 95-percent confidence interval extends from 71.085 to 139.128. This number may be interpreted as representing the number of transit rides per capita that would occur if "Adjusted lane-miles" were reduced to zero; that is, if the supply of highway capacity were reduced to some "minimum" (e.g. no freeways; no four-lane arterials) This range of numbers sounds familiar -- rides per capita were "that low" 50-70 years ago in places where auto ownership was relatively high, and transit service supply relatively low – e.g. Oakland. (This relation could also be dismissed as meaningless because no data points had highway capacity = 0).

4. Transit Fares, Service, and Ridership - England, 1986 - 1996

During 1999 and 2000, Dargay and Hanly (2002) examined the demand for local bus services in England. The study examined the relationships between per capita bus patronage, bus fares, income, and service level, using time series and cross-section data for English counties.

In judging the impact of fare and service changes, Dargay and Hanly emphasize the importance of obtaining data that covers an adequate time frame. Often these impacts are defined by researchers as "short term" and "long term," which in turn requires precise definitions of the given time frames for each category of impacts. However, a more valid approach is to use time series data expecting that the responses will occur gradually over time. This approach lends itself to use of readily available records including service supply factors such as vehicle-kilometers (or miles) and vehicle-hours, fare data, and annual transit patronage.

Estimates of bus fare elasticities used by Dargay and Hanly (2002) were based on available operator data from 1986 to 1996. To estimate fare and service level elasticities, the authors related per capita bus patronage to several factors, including "real" per capita income, service level (bus-km), real motoring costs, and demographics.

Dargay and Hanly (2002) describe local bus patronage patterns in England that are reminiscent of the United States:

> . . . The variation is apparent, ranging from over 170 journeys in Tyne and Wear to around 20 in Lincolnshire. Of the metropolitan counties, Greater Manchester has the lowest *per capita* bus use–about half that of Tyne and Wear and London. Clearly, the metropolitan areas show the most intensive bus use, followed by Nottinghamshire, Durham, Lancashire, and Leicestershire. The majority of counties show an average bus use of between 20 and 60 journeys *per capita.* In general, the more densely populated counties have a more intensive bus use.

The estimated range of bus patronage is comparable to many U.S. urban regions, and remarkably low for "ambient" British economic conditions, e.g. relatively high gasoline prices, three to four times the U.S. average, and relatively low personal incomes, often 30 to 40 percent less than the U.S. average (the disparity might be much greater, given that high income British residents tend to concentrate in London. Local bus usage rates are often unrelated to densities, another similarity to the U.S.

> There are a number of exceptions, however. For example, the densely populated counties around London – Surrey, Berkshire, and Hertfordshire – have relatively low bus use, while sparsely populated Northumberland has a comparatively high *per capita* patronage.

Many of the counties surrounding London do have relatively high rail usage rates in contrast to low bus usage – a pattern consistent with U.S. urban regions with extensive commuter rail systems and extensive low density suburbs, e.g. New York, Chicago, Philadelphia, and Boston.

Dargay and Hanly (2002) estimated fares for each English county based on revenues and journeys, exclusive of government payments to the private bus operators made for "concessionary" fares, i.e. discounts to children, the elderly, and disabled. Calculated fares ranged from about 22 pence ("22p") in Merseyside ($0.40; U.S. Dollar to UK Pound Sterling exchange rates as of early April 2005), to 88p in Cambridgeshire ($1.67) for the bus systems examined:

> . . . Fares are, on average, considerably lower in the more urban counties–London, the six former Metropolitan counties of England, and Cleveland, than in the more suburban and rural counties.

These authors determined a relatively strong relationship between absolute fare levels and per capita patronage. Not surprisingly, those areas with relatively low fares have the highest per capita patronage levels. This is seen as a result of policy decisions made by each area:

> In general, the counties with the lowest fares have the most favourable concessionary schemes. The counties with the lowest fares–London, the Metropolitan counties and Cleveland–have a very high proportion of CFR, while those with the highest fares–Cambridgeshire, Surrey, Isle of Wight, Kent and Bedfordshire–have a low proportion of CFR. There are a few obvious exceptions: Cheshire, for example, has a relatively low fare, but also a low proportion of CFR . . .

It should be noted that absolute fare level is likely to have a significant impact on patronage levels, given relatively low incomes in Britain compared to the United States. Fares are also likely to be more elastic for low income, non-auto owning persons than in the U.S. Much of England is still more "walkable" than the United States, and so walking is a viable option for a higher proportion of trips – the percentage of trips made by walking in England is still three to four times higher than in the U.S. Most regions of England also retain a basic level of rail passenger service that although markedly inferior to, say, Switzerland or Germany, is essentially non-existent in the U.S. except in a handful of large metropolitan areas.

The quantity of local bus service supplied in English counties also varies dramatically as in the U.S., from a low of approximately 15 - 16 annual bus-km (10 bus-mi) *per capita* in West Sussex, to 81 annual bus-km (50 bus-mi) per capita in Tyne and Wear.

Dargay and Hanly discuss how their bus patronage model was developed:

> Because of the aggregate nature of the available data, a relatively simple model is used to model bus patronage. We assume that the long-run equilibrium of demand for bus services in terms of journeys per capita, Q^*_{Rt}, in county *R* in year *t* can be expressed as a function *f* of the bus fare F_{Rt}, the service level, SRt, per capita disposable income, I_{Rt}, demographic factors, D^{Rt} (population density, the percentage of pensioners in the population), and the cost of alternative modes...
>
> In estimating the demand model, we assume that all explanatory variables are given or determined exogenously. Although the service variable (bus kilometers *per capita*), can also been seen as a measure of supply, which itself is determined by demand, we assume that supply in any given year is unaffected by demand changes within the same year. This may be a strong assumption, and it would be preferable to estimate the complete supply-demand system.

Since local bus deregulation was imposed – outside of Greater London – in 1986 by the government of Prime Minister Margaret Thatcher, "local authorities" (local governments) in England have not had the freedom to increase transit subsidies significantly, a much different situation than in the U.S. or continental Europe. The main policy control exercised is the level of "concessionary fares" offered. This was apparent in that the English counties with the highest level of concessionary fares also tended to have the highest patronage and service levels. Since all local bus operators in England are privately owned, for-profit businesses, service is unlikely to expand unless sufficient revenues can be collected, as is the case when concessionary fares receive funding approved by local authorities.

Dargay and Hanly (2002) lament that " . . .it would be preferable to estimate the complete supply-demand system." However, given that the level of funding is a political decision, these authors believe that placing such decision-making into a statistical model is virtually impossible and largely a waste of time (much in contrast to Taylor et al. 2003).

The results obtained by Dargay and Hanly are summarized in Table 2:

Table 2. Results - Dargay and Hanly (2002):

Constrained & Unrestrained Model Estimates / Variable Fare Elasticity

Factor	Short Run		Long Run	
Constant Elasticity	Constrained	Unconstrained	Constrained	Unconstrained
Fare	-0.33	-0.43	-0.68	-0.74
Income	-0.39	-0.57	-0.82	-0.98
Service	0.49	0.48	**1.02**	**0.83**
Motoring Costs	0.32	0.65	0.66	1.12
% Pensioners	-0.08	0.44	-0.17	0.75
Variable Elasticity				
Fare	-0.13 low -0.41 mid -0.74 high	-0.13 low -0.44 mid -0.79 high	-0.26 low -0.86 mid -1.53 high	-0.23 low -0.75 mid -1.35 high
Income	-0.39	-0.60	-0.81	-1.02
Service	0.49	0.42	**0.83**	**0.79**
Motoring Costs	0.35	0.65	0.72	1.12
% Pensioners	-0.01	0.49	-0.03	0.85

Dargay and Hanly (2002) summarize their results as follows:

> The econometric results presented above suggest that the most likely values of the fare elasticity for England as a whole are around -0.4 in the short run and -0.9 in the long run. the evidence suggests that the long-run elasticities are about twice the short-run elasticities.
>
> . . . There is statistical evidence that demand is more price sensitive at higher fare levels. This conclusion is drawn on the basis of models in which the fare elasticity is related to the fare level. The variation in the elasticity ranges from -0.10 in the short run and -0.20 in the long run for the lowest fares (17p at 1995 prices) to -0.80 in the short run to -1.40 in the long run (One pound at 1995 prices).
>
> Separate estimates of the fare elasticity for the Shire counties and the Metropolitan areas (excluding London) indicate that patronage in the former is on average more sensitive to fare changes than in the latter, and significantly so. The less-elastic demand in the Metropolitan

> areas can be explained in terms of their urban characteristics, better bus service provision, and lower fares.

As stated previously, it is not surprising that fare elasticity becomes more dramatic as the absolute fare levels increase given significantly lower income and relatively higher bus fares in England compared to the U.S. This finding is also consistent with the general experience of the travel industry, e.g. airlines and intercity rail.

> The measure of service quality used in this study is per capita bus kilometres for the market considered. Clearly, this is a very crude approximation for the many factors that make up the quality of a bus service. It is, however, the only feasible measure on the aggregate level, and the one most commonly used in such studies. In general, the estimated service elasticities are the same order of magnitude as, or slightly larger than, the fare elasticities, although opposite in sign. This suggests that an increase in fares combined with an increase in service would leave demand unchanged. For example, if fares were increased by 10 percent and the number of vehicle kilometres also increased by 10 percent, patronage would remain approximately the same as previously.
>
> . . . Motoring costs are shown to have a significantly positive influence on bus use, particularly in urban areas. Of the demographic variables included in the model - population density and the percentage of pensioners - only the latter is found to have a significant effect on bus patronage. The non-significance of population density is most probably explained by the fact that differences in population density between counties are captured by the county-specific fixed effects.

Dargay and Hanly (2002) confirm the general contention of this paper – that transit riding habit, expressed as annual rides per capita, is generally consistent with the level of service offered, measured by annual bus-km or miles per capita. As previously found by Neuzil (1975), this relationship is remarkably robust, even when considering the impacts of varying fare levels. The reported long-run “service elasticity” of around 1.0 means that for every 10 percent increase in service, transit patronage will increase by about 10 percent. This rule probably holds with much larger service increases, such as a service doubling, particularly if fares are relatively low to begin with. The short-run elasticities found by Dargay and Hanly are significantly lower than long-run elasticities. Dargay and Hanly’s (2002) fare elasticity findings also suggest that increases in relatively low fares will have much less impact on net patronage than similar percentage increases in high fares. For example, the patronage loss on a transit system with a $0.50 base fare increased by 20 percent to $0.60 may lose 5 – 6 percent of its patronage. A fare increase of 20 percent at a system where the base fare is $2.00 is likely to cause much higher patronage losses, perhaps as much as 15 – 20 percent of pre-increase ridership.

5. Transit Capacity Offered and Utilized - U.S., 2001

An alternative to measuring patronage response to the level of transit service is to compare annual passenger miles per capita to estimated place miles per capita (a more refined indicator than gross annual rides per capita compared to annual service miles per capita). Cox (2003), a well-known transit critic, did exactly this a few years ago, using NTD data for U.S. metropolitan areas over one million population[5]. These data are reproduced in Table 3 (below). Data are arranged in order of calculated load factor.

The authors placed "Estimated Place Miles[6] Per Capita," "Passenger Miles Per Capita," "Transit Service Index" and the calculated load factor into a Microsoft *Excel* spreadsheet program. Using the *Excel* "Correl" (correlation) function, we calculated an R = 0.98 correlation factor between Estimated Place Miles Per Capita and Passenger Miles Per Capita. Excluding the New York region, this result was only slightly less at R = 0.96 (corresponding R^2 values are 0.96 and 0.92, respectively)[7].

These figures are remarkably consistent with the experience of the Indiana interurban electric railways during the mid-1930s,and the strong correlations and other findings presented by Neuzil (1975) and by Dargay and Hanly (2002).

High utilization rates tend to be correlated strongly with high levels of offered capacity. There are, of course, exceptions. For example, Salt Lake City has a relatively high level of service (987 annual place-miles per capita, comparable to a number of larger and older West Coast and Eastern cities), but very low utilization rates (9.9 percent load factor). Such examples suggest that factors in addition to service level play a role, including population, density, income, service design, percentage of service by mode, etc.

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[5] Cox's data compilation appears without comment or analysis as part of the (online) "Urban Transport Fact Book."

[6] A "place" refers to a passenger space aboard a transit vehicle. The number of "places" per vehicle is the sum of seated capacity and standing capacity.

[7] The correlation factor of the data manipulated by Cox, between "Estimated Place Miles Per Capita" and "Load Factor," is R = 0.69 (corresponding R^2 value is 0.48).

Table 3. Capacity Offered vs. Annual Passenger Miles Per Capita, FY 2001

Metropolitan Area	Estimated Place Miles Per Capita	Passenger MIles Per Capita	Calculated Load Factor	Transit Service Index (Average = 1.0)
Grand Rapids	250	17	6.7%	0.314
Raleigh-Durham	367	32	8.6%	0.460
Greensboro	154	14	8.9%	0.193
Oklahoma City	187	17	8.9%	0.235
Tampa-St. Petersburg	387	35	9.0%	0.486
West Palm Beach	343	31	9.0%	0.431
Providence	364	35	9.6%	0.457
Kansas City	346	33	9.7%	0.434
Salt Lake City	987	97	9.9%	1.239
Rochester	335	34	10.3%	0.420
Jacksonville	439	47	10.8%	0.552
Phoenix	420	46	10.9%	0.527
Louisville	480	53	11.0%	0.603
Indianapolis	266	31	11.7%	0.334
Buffalo	555	65	11.8%	0.696
Columbus	405	48	11.9%	0.508
Virginia Beach-Norfolk	436	53	12.1%	0.547
Austin	691	85	12.3%	0.868
Charlotte	361	45	12.4%	0.453
Cleveland	801	101	12.6%	1.005
Detroit	441	56	12.7%	0.553
Nashville	215	28	12.9%	0.270
St. Louis	702	92	13.2%	0.881
Hartford	422	57	13.4%	0.530
San Antonio	807	110	13.6%	1.013
Memphis	415	57	13.7%	0.521

Table 3. CONTINUED

Metropolitan Area	Estimated Place Miles Per Capita	Passenger MIles Per Capita	Calculated Load Factor	Transit Service Index (Average = 1.0)
Denver	1,055	150	14.2%	1.325
Milwaukee	896	129	14.3%	1.125
Richmond	304	44	14.6%	0.381
Orlando	454	69	15.2%	0.570
Portland	1,143	179	15.7%	1.435
Dallas-Fort Worth	532	85	15.9%	0.667
Sacramento	522	83	15.9%	0.656
Miami	973	156	16.1%	1.222
Las Vegas	669	110	16.5%	0.840
Pittsburgh	969	160	16.5%	1.217
New Orleans	745	126	16.9%	0.935
San Francisco	2,308	392	17.0%	2.898
Philadelphia	1,365	236	17.3%	1.714
Atlanta (MARTA service area)	1,217	212	17.4%	1.528
San Diego	1,071	187	17.4%	1.344
Cincinnati	504	88	17.5%	0.633
Minneapolis-St. Paul	640	115	18.0%	0.804
Chicago	2,149	399	18.6%	2.698
Washington-Baltimore	1,850	350	18.9%	2.323
Boston	1,649	321	19.4%	2.071
Seattle	1,057	206	19.5%	1.326
Houston	614	126	20.5%	0.771
New York	4,192	893	21.3%	5.263
Los Angeles	801	172	21.5%	1.006
Honolulu	1,367	401	29.4%	1.716
AVERAGE	**796**	**131**	**16.5%**	**1.00**

Table 3. Source Notes

> Adapted from Cox (2003). Analysis of primary data obtained online from NTD http://www.ntdprogram.gov. Capacity estimates used by Cox were from the 1991 NTD, the last year such data were reported.
>
> "Capacity factors" used by Cox were the estimated number of "places" per vehicle, varying by mode: Motor Bus, 64.5; Trolley Bus,68.2; Metro,137.5; Light Rail, 143.3; Commuter Rail,153.5. These factors were derived from the 1991 National Transit Database, according to Cox's source notes. The authors used these factors for consistency, although data from various U.S. and Canadian cities suggest these are unrealistically high. <<INSERT LINK>>

6. Political Science Quantified? (Taylor et al. 2003)

Taylor, Miller, Iseki and Fink (2003) present "first-stage" modeling results that are remarkably consistent with the 1933-1936 Indiana experience described above, the strong correlations and other results reported by Neuzil (1975) and by Dargay and Hanly (2002), and the authors' exercise using data from Cox (2003), described above. Taylor et al. then proceed to "second-stage" modeling, during which the service supply variable is split into two parts, an "instrumental control variable" and a "residual policy variable." Results suggest a significantly weaker correlation between per-capita transit service supply and consumption. The authors question the techniques and findings of Taylor et al. The "instrumental control" and "residual policy" adjustments fail to convince. One conclusion in particular – that service increases do not generate ridership increases in proportion – appears to reiterate what has long been known among transit professionals. These issues are discussed separately.

Taylor et al. (2003) justify their use of separate "instrumental control" and "residual policy" variables in place of a single service-supply variable as follows:

> . . . Given the obvious simultaneity between transit supply (measured here as vehicle service hours) and transit service demand (measured as passenger boardings), interpreting the results of Model 1 is problematic. To address this issue, we use a simultaneous equations approach to first develop a model to predict transit service supply, and then to use the predicted service supply variable from the first model as an instrumental variable in a second model to predict transit service demand.
>
> Table 4 presents the second-stage results of the two sequential models. While a variety of models to predict total vehicle service hours were tested, we settled on a simple one variable

> model for the first stage using urbanized area population (lnpop) which explains about 80 percent (R^2=0.7968) of the variation in vehicle hours of service.

Taylor et al. (2003) go on to explain the "second stage" of their modeling procedure:

> . . . In addition to this predicted vehicle service hours variable, a second policy service hours variable (v31rsd) was created by subtracting the predicted level of service from the actual vehicle service hours in an urbanized area. The logic here is that, at the margin, metropolitan areas choose to provide more or less transit service than would be predicted by overall levels of transit demand. Some areas, like Honolulu, Hawaii, and Ithaca, New York, provide substantially more transit service than would be predicted by urbanized area population, while others, like Montgomery, Alabama, and Nashua, New Hampshire, provide substantially less transit service. Thus, this second variable can be interpreted as a policy variable which measures the effects of transit service supply on transit ridership at the margin . . .
>
> . . . Among urbanized areas with more transit than would be expected, many are dominated by large universities, which frequently have substantial transit systems designed to serve the university community. Others, like San Francisco, have urban densities conducive to transit and/or restricted parking. The cities with less transit than predicted tend to be relatively small metropolitan areas.

In their conclusions, Taylor et al. (2003) argue that the magnitude of transit usage in a given urban area is mainly a function of external factors outside the control of transit managers:

> . . . To conclude, we find that most of the variation in transit ridership between urbanized areas – in both absolute and relative terms–can be explained by (1) the size (both population and area) of the metropolitan area, (2) the vitality of the regional economy (measured in terms of median housing costs), and (3) the share of the population of with low levels of private vehicle access (measured in terms of zero-vehicle households. We find further that transit patronage is to a lesser, but still significant extent, explained by transit service levels and fares. The observed influence of fares on ridership is consistent with the literature. And, consistent with research on transit service elasticities, we find the relative influence of transit service levels on ridership to be greater than the relative influence of transit fares. Finally, separating the service supply variable into two parts – an instrumental control variable and a residual policy variable – makes clear that large changes in transit service–such as a doubling of service supply–will not result in a near doubling of patronage, as many of the models developed in earlier research would imply.

Many academics who write about transit topics, and various transit critics[8], share this view – as do many transit managers themselves (Yoh, Hass and Taylor 2003). However, widespread acceptance does not obviate problems associated with the methodology upon which such conclusions rest.

The desire to "estimate the complete supply-demand system" – that is, to incorporate all factors that influence transit supply and demand into one's modeling procedure – is understandable but fraught with difficulties. Given a scenario in which political decisions are made (more or less) as described by the "rational actor" model, various "decision factors" can be identified, quantified and incorporated into a model as variables. However, as recognized by Dargay and Hanly (2002), the "political process" does not necessarily operate according to the "rational actor" script. Political decisions can be, and are known to be, influenced by "non-rational" factors that may be difficult to identify and quantify. Thus, as Dargay and Hanly determined, it may be impossible to model such a decision-making process using statistical analysis, and attempts to do so may represent wasted time.

If Dargay and Hanly (2003) are correct, then it should be possible to find anomalous results that are not explained by the "instrumental control" and "residual policy" variables used by Taylor et al (2003) – but are explained by factors not incorporated into the analysis. Pitted against "Occam's Razor," the "instrumental control variable" proves to be particularly unconvincing.

Table 4. San Francisco, CA Compared to Atlanta, GA

Urbanized Area	Annual Place Miles Per Capita	Annual Passenger MIles Per Capita	Load Factor
San Francisco-Oakland	2,308	392	17.0%
Atlanta (MARTA Service Area)	1,217	212	17.4%

As described by Taylor et al. (2003), the San Francisco urbanized area had a transit work share of 19 percent, while the similarly sized Atlanta urbanized area had a share of only 4 percent. The authors wondered why. As shown in Table 4 (above), the San Francisco - Oakland urbanized area in 2001 had approximately twice the transit service per capita as provided by the Metropolitan Atlanta Rapid Transit Authority (MARTA) within its service area. – which includes only about 40 percent of the population of the Atlanta region. This reflects a bevy of cultural and political factors, many related to the history of Georgia's race relations – and suggests a 10 percent transit commute share within the MARTA service area. This commute share is about

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[8] e.g. Cox, O'Toole.

half that of San Francisco, which has almost twice as much transit service per capita as the "MARTA Service Area" Moreover, the urban population density of San Francisco is roughly triple that of Atlanta.

Planning studies indicate that the Atlanta region has a number of productive, cost-effective "potential" transit expansions – heavy rail and otherwise – mainly outside the MARTA service area (e.g. northwest into Cobb County toward Marietta). However, in the current climate of Georgia politics (and race relations), these extensions are not likely to receive funding. Under the previous (Democratic) governor, the state went so far as to establish a regional rail authority for Atlanta, with no organizational connection to MARTA, perhaps to ensure that better transit would not be "tainted" politically in Atlanta's vast suburbs by association with MARTA.

Certain "policy" (sic) variables pertaining to the state of transit in various "Old South" cities such as Montgomery, Alabama would be difficult to identify and quantify. Taylor et al. (2003) make no attempt to do so, but the influence of such factors is clear. The leading role played by Montgomery's transit system (then under private ownership) during the Civil Rights Movement gave way in time to a long period of decline under public ownership, a virtual backlash. Service was reduced gradually to a very low level, leading to discontinuance of all fixed-route service in favor of paratransit in 1997. This situation is currently reversing, if slowly, as Montgomery decision-makers discover the very high cost of providing paratransit to the general public.

Taylor et al. (2003) also failed to note (or quantify) the political and cultural factors that can exert major influence on level of transit service provided in large cities. For example, metropolitan Detroit and Houston both are in the population range of 4.5 – 5.0 million, and are the home to the automobile and oil industries, respectively.

Table 5. Detroit, MI Urbanized Area vs. Houston, TX Urbanized Area

Urbanized Area	Annual Place Miles Per Capita	Annual Passenger MIles Per Capita	Load Factor
Detroit	441	56	12.7%
Houston	614	126	20.5%

Houston provides about 40 percent more transit service per capita than Detroit, and generates slightly more than double the annual passenger miles per capita (Table 5, above). Houston's transit load factor is among the highest of any U.S. city despite its relatively low density of development. On the other hand, Detroit's load factor is one of the lowest for such a large urban region, comparable to smaller, second tier cities in the South and Midwest. In Houston, a new

7.5 mile light rail transit (LRT) line – which has among the highest ridership per line mile of any new LRT system in the United States – opened in late 2003 to extensive controversy.

In Detroit, little progress has been made towards establishing a regional transit system (using any mode), despite a rather extensive network of existing railroad rights-of-way in the region. Most transit service in Detroit is provided within the central city proper, a system threatened by the City of Detroit's ongoing financial crisis. Major political and cultural factors are at work in both Houston and Detroit, "policy variables" that are difficult, if not impossible, to capture in a quantitative model.

Many studies relate usefully to transit planning and management issues. Racca (2004), for example, establishes "service classifications" for transit-based factors such as "ratio of established transit trip time to car drive time" and "direct" or "indirect" service. Model results (transit mode share) therefore relate to factors within the control of transit management. Other studies relate specifically to management strategies and factors identified by managers as having significant influence on ridership. One pertinent example of successful transit planning and management is outlined in succinct fashion by Yoh, Haas, and Taylor (2003). Describing the Milwaukee, WI County Transit System, these authors write:

> ...The system makes an ongoing effort to match service levels to demand. This is not achieved by mathematical formula; instead changes in demand are consistently monitored and incremental adjustments made on the basis of experienced judgment and past experience.

In contrast, the authors believe that the two-step modeling procedure used by Taylor et al. (2003) may be best interpreted in political science terms, providing technical support for public policy decisions, e.g. how much additional transit service can a regional afford to provide, and what are the likely results in terms of increased ridership. The findings of Taylor et al. bear little apparent relationship to management and planning issues, e.g., how "increments" of added service should be configured, staged and deployed.

7. "Doesn't Everybody Know That?" (Taylor et al. 2003)

> . . . Finally, separating the service supply variable into two parts – an instrumental control variable and a residual policy variable – makes clear that large changes in transit service–such as a doubling of service supply – will not result in a near doubling of patronage, as many of the models developed in earlier research would imply (Taylor, Miller, Iseki and Fink 2003).

The authors, as transit professionals, find the above conclusion puzzling. Taylor et al. (2003) are of course correct – but the stated fact has long been known in the practical world of transit planning, operation and management. Large increases in transit service generally do not attract short-term or medium-term ridership increases "in proportion." Although this does occur, examples are rare and are regarded as "exceptional" by transit professionals – who typically expect explanations[9]. The fact "uncovered" by Taylor et al. (2003) does not differ from that implied by many of the models developed during earlier research. The need for reiteration – whether or not supported by sophisticated mathematical modeling procedures – is not clear.

Half a century ago in St. Louis, the transit company doubled service on three routes, each with different levels of service and ridership. The service changes were accompanied by extensive marketing. Subsequent ridership increases ranged from 10 to 50 percent. The route with the largest gain in ridership was that with the least service (every 30 minutes improved to every 15 minutes). This trial, remembered today as a classic experiment, demonstrated three important points (Tennyson 2004):

1. Service increases did not produce commensurate increases in ridership – nor, of vital importance at the time, in revenues.
2. No uniform "elasticity" of ridership with respect to service was apparent. The uniform 100 percent increase in service (vehicle miles) resulted in a wide range of ridership ("revenue passenger") increases.
3. The apparent relationship between service frequency and ridership: a one-minute reduction in "average wait time" (i.e., one-half the headway) produced a 3 percent increase in ridership. In other words, a reduction of "average wait time" by 10 minutes (e.g. from 30-minute to 10-minute headway) would produce a 30 percent ridership increase.

Following this experiment, the St. Louis Public Service Company was not able to continue the increased service on any of the three lines because marginal increases in operating expense were not offset by the (lower) marginal increases in fare revenue. However, results did suggest that other service improvements might prove "sustainable" given a sufficient reduction of "average wait time." For example, a reduction in headway from 150 minutes to 75 minutes implies a

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[9] As described above, interurban electric railways in Indiana increased service (annual passenger car-miles) by 35 percent during 1933-1936; annual passenger traffic increased by 77 percent and annual passenger revenue increased by 35 percent. The authors emphasize that this occurred during a period of economic recovery from a recession of unparalleled duration (1929-1933) and severity. The service, ridership and revenue changes should not be considered in isolation from "background" economic factors.

ridership – and revenue – increase of about 110 percent. Therefore, although unsuccessful, the St. Louis experiment did provide useful information for planning and management.

Other research and data – from the U.S. and other countries – reinforce the point above. Tegnér and Jarlebring (2004), for example, found that transit ridership increased at a lower rate than supply (annual vehicle-km) from 1985 to 2002 in Sweden. With reference to supply, summary findings from six time-series models include elasticities of ridership with respect to supply (vehicle-km) in the range of 0.1–0.7.

With reference to individual operators and corridors, the pattern is similar – and clear. In Ottawa, from 1972 to 1982, service systemwide was increased by 160 percent on a per-capita basis (bus-km per capita). Ridership per capita increased by 76 percent, and weekday peak-period ridership per capita increased by 42 percent. Total operating expense per capita increased by 140 percent (See

http://www.carquinezassociates.com/ptlibrary/specialreports/sr8.OttawaTransit.pdf

In Portland from 1998 to 2001, capacity systemwide was increased by 41 percent, adjusting for relative vehicle size. This generated a 28 percent increase in annual boardings and a 27 percent increase in annual passenger miles. Because operating costs did not increase out of proportion to ridership, unit operating costs remained stable. (See

http://www.carquinezassociates.com/ptlibrary/specialreports/sr6.PortlandvsSeattle.htm

Monterey-Salinas Transit, a medium-sized operator serving Monterey and Salinas, California, implemented a “Service Improvement Plan” during 1998-2001. Service systemwide (annual revenue vehicle hours) was increased 34 percent, exclusive of paratransit. This increase generated a 20 percent increase in ridership (annual boardings). The number of boardings per hour declined by 11 percent and the cost recovery ratio fell by 25 percent, the latter reflecting in part the fact that fares were not increased. However, cost recovery remained strong by comparison with similar systems. The community viewed the overall net change, including restructuring of routes to better serve demand and overall increased service, as positive.

In Los Angeles, weekday service supply (vehicle miles) in the Blue Line light rail corridor was increased by 65 percent from 1990 to 1993 (adjusted for differences in vehicle size, and considering all north-south lines within two miles of the rail corridor which opened during fiscal year 1991). Weekday ridership (boardings) increased by nearly 26 percent and weekday travel (passenger miles) increased by more than 45 percent.

In Table 6 below, the column heading “Proportional Ridership Increase” refers to short-term or medium-term ridership increases in proportion to service increases (or exceeding the percentage change of same). A table entry of “Yes” indicates that “proportional ridership increase” was reported, implied or postulated.

Table 6. Summary of Findings re. Service Supply and Consumption

Case or Study	Proportional Ridership Increase
Carstens and Csanyi (1968)	No
Gordon and Willson (1984 and 1985)	No
Indiana interurbans, 1933-1936	Yes
Los Angeles, Blue Line corridor, 1990-1993	No
Mees (2000)	No
Meyer and Miller (1984)	No
Monterey-Salinas Transit, 1998-2001	No
Neuzil (1975)	No
Ottawa (OC Transpo), 1972-1982	No
Portland (Tri-Met), 1998-2001	No
Racca (2004)	No
St. Louis Public Service	No
Taylor et al. (2003)	No
Tegner (2004)	No
Yoh et al. (2003)	No

With the exception of the Indiana interurban electric railways during 1933-1936, proportional ridership increases are not associated with the cases and studies tabulated above.

Selected factors that encourage or influence transit ridership are listed in Table 7 below, together with time frame and policy influence.

Table 7. Some Factors Influencing Transit Ridership

Factor	Time Frame for Changes	Influenced By	
		Local Government?	Transit Operator?
Land Use - Residential Density	Long-Term	Moderate	
Land Use - "Mixed Use"	Long-Term	Moderate	
Land Use - "Transit-Oriented Development"	Long-Term	Moderate	
Land Use - Pedestrian Amenities	Medium-Term	Moderate	
Private Automobile Ownership Per Capita	Medium-Term	Small	
High-Occupancy Vehicle Priority	Medium- to Long	Moderate	
Bus Lanes and Traffic Signal Priority	Short- to Medium	Strong	
Parking - Supply and Cost	Medium-Term	Moderate	
Transit Service Quality - Comfort	Short- to Medium		Large
Transit Service Quality - User Information	Short		Large
Transit Service Quality - Marketing	Short		Large
Transit Service Pricing	Short		Moderate
Transit Service Quantity, Location and Scheduling	Short		Large

The authors reiterate that Taylor et al. (2003) are correct: "large changes in transit service – such as a doubling of service supply – will not result in a near doubling of patronage." That, however, begs the obvious question: "Doesn't everybody know that?"

8. Conclusions

The findings above are perhaps most usefully summarized with reference to "Anytown," a fictional U.S. urban region with a population of 500,000 and a transit "riding habit" of 20 annual boardings per capita. "Anytown" decision-makers, with the firm support of local residents and businesses, have adopted a policy that transit usage should be doubled, to 40 annual boardings per capita, over a 20-year period.

(In Madison, Wisconsin, Madison Metro Transit served a population of about 220,000 and carried 50 boardings per capita at 2003. This is considered an exceptional performance by transit in a U.S. city of this size.)

Although service details would need to be determined with reference to “site-specific” conditions, ”Anytown” would need to plan for phased service increases to levels commensurate with 40 annual boardings per capita (Madison Metro Transit operated 28 vehicle-miles per capita at 2003). Because this service level (e.g. annual vehicle-miles per capita) is likely to be much greater than “currently” operated (at least two times greater, perhaps more), “Anytown” would be wise to begin by identifying the funding sources – capital and operating – that would eventually be required. Neuzil (1975), Carstens and Csanyi (1968), Dargay and Hanley (2002) and the authors’ analysis presented above all make clear that large-scale increase in transit usage per capita is not likely without large-scale expansion of service offered per capita. Taylor et al.(2003) relate most clearly to a point long known by transit managers – that short-term and medium-term ridership increases will not keep pace with service changes. Successive increments of service expansion would be implemented with reference to service productivity (boardings per revenue service hour), cost recovery, and other targets established by decision-makers, and with reference to regional goals as outlined in the adopted regional plan. The findings of Dargay and Hanley suggest that, over time, transit usage may grow sufficiently to raise service productivity to “current” levels.

One could summarize this knowledge as follows:

> If you operate it, they will ride . . . but don’t expect sellout crowds at once.

The various factors outlined by Mees (2000) can have significant impact as in Toronto – but these require time, as measured by the decade. In the face of “peak oil,” (see for example, (*www.peakoil.net*), Mees’ advice for improving transit appears wise and prescient.

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