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Trust in forecasts? Correlates with ridership forecast accuracy for fixed-guideway transit projects

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Abstract

The accuracy of ridership forecasts for fixed-guideway transit projects in the United States has improved in recent decades. A better understanding of the causes for this improvement can help decision makers, project evaluators, and other forecast users identify ridership forecasts that are most likely to be reliable. The analysis in this paper applies a series of linear regression models to evaluate the relationship between ridership forecast accuracy for 67 New Starts projects completed between 1983 and 2012 and four types of project characteristics: time between forecast and observation, local experience with the project mode, physical characteristics, and financial characteristics. The results indicate that local experience and financial characteristics (including the share of a project's costs funded by federal grants) are not significantly related to forecast accuracy, but there are differences by project mode, where forecasts for commuter rail projects are less accurate than those for other modes. The time until ridership observation does relate to forecast accuracy. However, not all of this elapsed time is important. The length of time required for project planning and development does not have a significant relationship with forecast error, nor does the total time between forecast preparation and ridership observation. However, the length of time required to construct the project is significantly associated with the accuracy of the ridership forecast. These results can help planners, policy makers, and other decision makers make judgments about the degree of trust they should place in transit ridership forecasts.

Keywords Public transit · Demand forecasting · Project planning · Ridership

Introduction

Over the past half-century, the number of cities with fixed-guideway transit systems—systems in which transit vehicles operate in dedicated right-of-way such as rail lines or dedicated bus routes—has increased dramatically. This growth has largely been driven by federal investment through the Federal Transit Administration's (FTA's) Capital Investment

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Program, more commonly referred to as New Starts. Early critics of the New Starts program argued that the projects it funded were justified based on unrealistically optimistic forecasts of project benefits. Indeed, the earliest study to empirically test the accuracy of ridership forecasts for federally funded transit projects included ten projects completed over the course of the 1980s and found that forecasts for ridership on these new rail systems exceeded actual ridership by an average of 65% (Pickrell 1989). Since that time, ridership forecast accuracy has improved. For the fifteen New Starts projects completed between 2008 and 2011, forecasts exceeded observed ridership by an average of 48% and observed ridership exceeded forecast ridership on four of those fifteen projects (Federal Transit Administration 2007–2018). Thus, optimistic forecast errors (those that overstate ridership) have decreased in both frequency and magnitude.

A better understanding of the causes for this improvement in forecast accuracy over time can assist decision makers, project evaluators, and other forecast users in identifying projects for which ridership forecasts are likely to be most reliable. This paper evaluates the relationship between ridership forecast accuracy for New Starts projects and four types of project characteristics: time between forecast and observation, local experience with the project mode, physical characteristics, and financial characteristics. The results indicate that the duration of time required to construct a project is an important predictor of the accuracy of the project's ridership forecasts. In addition, relative to forecasts for other fixed guideway modes, forecasts for commuter rail projects, people movers, and street cars have generally been the least accurate, while forecasts for light rail, intra-urban heavy rail, and bus projects have been the most accurate.

Prior research on transit ridership forecast accuracy

Beginning in the 1980s, many observers began to question the central federal role in transit funding. Some critics supported the Reagan Administration's New Federalism initiatives and argued that transit funding was one of many Federal programs that would be better funded and managed at the state and local levels (Davis 2015). Others further argued that urban rail transit was generally a bad investment—or a risky investment at least—and that the Federal government encouraged inappropriate risk-taking by placing the investment decision in the hands of local decision-makers while assuming a substantial portion of the risk at the Federal level (Gomez-Ibanez 1985a). It was in this political environment that the earliest studies of the accuracy of forecasts prepared for federally funded transit infrastructure projects were published.

Gomez-Ibanez (1985b) examines the performance of the first three modern (post-1950) light-rail systems to be constructed in North America, including two in Canada (Edmonton and Calgary) and one in the United States (San Diego), all of which were completed between 1978 and 1981. Rather than comparing project costs and performance to specific forecasts prepared for those projects, Gomez-Ibanez (1985b) compares performance to general claims light rail advocates had made about the benefits of light rail: that, for modestly higher capital costs than bus service, light rail can attract more transit passengers and serve those passengers at a lower operating cost per passenger mile. He finds neither increases in ridership nor reductions in operating costs, relative to his estimates of what the bus lines the new systems replaced would have achieved.

Kain (1990) presents a case study of ridership forecasts prepared for the first urban rail system in Dallas. Since the urban rail system had not yet opened for service and the forecasts were for the years 2000 and 2010, Kain's (1990) study could not directly measure forecast accuracy. Instead, Kain (1990) focused on the forecast methodology, with an emphasis on assumptions for inputs such as highway congestion, central business district employment levels, and parking costs. Kain (1990) finds these assumptions to be largely incorrect and points to evidence that the selection of input assumptions was politically motivated to produce inflated ridership forecasts. In his criticism of the ridership forecasts for the first urban rail lines in Los Angeles, Richmond (2005) took a similar approach to forecast evaluation, and goes on to claim that empirical tests of forecast accuracy are irrelevant since traditional methods of travel demand modeling are so inadequate that the accuracy of the forecasts they produce can only be coincidental.

Wachs (1990) describes how political pressure can lead forecasters to intentionally and unethically inflate ridership forecasts. After interviews with "public officials, consultants, and planners" in which many shared stories of being pressured to revise forecasts in support of politically popular projects, Wachs (1990) concludes,

> I am absolutely convinced that the cost overruns and patronage overestimates were not the result of technical errors, honest mistakes, or inadequate methods. …The forecasts had to be "cooked" in order to produce numbers which were dramatic enough to gain federal support for the projects whether or not they could be fully justified on technical grounds (144).

Kain (1990) refers to this practice as "strategic misrepresentation" and Flyvbjerg (2008) and is even more direct, calling it "strategic misrepresentation, that is, lying" (279).

As described above, the first study to empirically evaluate forecast accuracy for several urban rail transit projects in the United States was completed by Pickrell for the Urban Mass Transit Administration (UMTA) in 1989 and examined cost and ridership forecasts for four light-rail, four heavy-rail, and two downtown people mover projects that had been completed with UMTA funds between 1983 and 1987 (Pickrell 1989). Pickrell (1989) finds that forecasts for ridership on the new rail systems exceeded actual ridership by 28–85%, with an average of 65%.

A 2003 study by Spielberg et al. (2003) and a 2008 study by Lewis-Workman et al. (2008), both completed for for the FTA, follow up on Pickrell's (1989) study by comparing his findings with observations of projects that had been completed between 1990 and 2002 and between 2002 and 2006. Both studies found that the accuracy of cost estimates and ridership forecasts completed after Pickrell's (1989) study was better than that of the forecasts completed before the 1989 study. With regards to the accuracy of ridership forecasts, Spielberg et al. (2003) suggest four reasons for observed improvements: increases in experience, greater scrutiny, improved forecasting methods, and improvements in computing. They also find that ridership forecasts for initial lines of new systems have been less accurate than expansions of existing systems and that forecasts for transitways and downtown people movers were particularly inaccurate.

In spite of the gains documented by Spielberg et al. (2003), Lewis-Workman et al. (2008) did not find that the accuracy of cost estimates or ridership forecasts had continued to improve in the 5 years following Spielberg et al.'s (2003) study.

Both Spielberg et al. (2003) and Lewis-Workman et al. (2008) find that actual service levels have generally been well below those assumed when generating ridership forecasts, but note that it is not clear whether service was reduced in response to low ridership or ridership was lower than anticipated in response to lower-than-anticipated service.

Of the three studies discussed above (Lewis-Workman et al. 2008; Pickrell 1989; Spielberg et al. 2003), none included tests of the statistical significance of changes in the accuracy of ridership forecasts over time or the differences in accuracy by project characteristics. Such an analysis may not have been possible since, at the time each study was completed, too few federally funded transit projects had been constructed to allow for such an analysis to be meaningful or informative.

Subsequently, Button (2009) tested the hypothesis that the publication of Pickrell's (1989) finding that earlier forecasts had been inaccurate had been associated with a subsequent improvement in forecast accuracy. Button (2009) used a regression model to test the relationship between ridership forecast error and whether a forecast was prepared before or after the Pickrell report, with controls for project mode, station density, and whether the project was an expansion of an existing system. Button (2009) found that only the presence of an existing system and project mode were significant predictors of ridership forecast error at a 95-percent confidence level.

In 2000, the FTA introduced a new requirement that agencies receiving funding for projects through the New Starts program must prepare a Before and After Study for each funded project comparing forecast ridership to observed ridership measured 2 years after project opening (Federal Transit Administration 2000). These published case studies represent an important source of data on the accuracy of ridership forecasts for individual projects funded through the New Starts program (Federal Transit Administration 2007–2018).

Schmitt (2016) has compiled a database of forecast and observed ridership for transit projects (including both New Starts projects and those that did not use New Starts funds) in the United States that is intended for use by travel demand modelers who wish to apply the principles of reference-class forecasting suggested by Kahneman and Tversky (1979) and Flyvbjerg (2006). In order to define appropriate reference classes, Schmitt (2016) tests for differences in ridership forecast accuracy by project transportation mode; phase of project development (Alternatives Analysis, Preliminary Engineering, or Final Design); whether the project represents a new system, a new line, or an extension of an existing line; and year of construction (defined as either before or after 2007). He explains the significance of 2007 by the 2001 introduction of new analytical tools by the FTA, which increased model scrutiny, and the forecasts for many projects that opened after 2007 were prepared after the introduction of those tools. Schmitt (2016) found statistically significant differences only by project transportation mode (forecasts for light rail projects tended to be more accurate than those for projects of other modes) and by whether a project was constructed before or after 2007 (forecasts for older project tended to be less accurate).

Gomez-Ibanez (1985b), Pickrell (1989), Spielberg et al. (2003), Lewis-Workman et al. (2008), Button (2009), and Schmitt (2016) all take what Ascher (1979) describes as an "outsider's approach" to forecast evaluation: They compare forecast ridership to observed ridership and present explanations for error based on external factors rather than on the forecasting process or model form. Studies that apply Ascher's (1979) "insider's approach" to forecast evaluation by focusing on factors internal to the forecasting process and model form have generally been case studies of individual projects, such as those by Kain (1990) and Richmond (2005) and the Before and After Studies published by the FTA (2007–2018).

Flyvbjerg (2005) reports that some have argued that even comparing opening-year forecasts to opening-year observations is problematic because some degree of ridership "ramp-up" may be expected as ridership on a new line or system stabilizes in the first years after opening. Flyvbjerg (2005) responds to this criticism conceptually by arguing that opening year forecasts should incorporate expectations about pre-ramp-up conditions, but at that time, no empirical studies had documented the degree to which, and in what circumstances, ridership ramp-up should be expected. In a study of 55 rail transit projects that have opened in the United States since 1993, Shinn and Voulgaris (2019) have found that ridership can fluctuate dramatically in the initial years after project opening, but that the ramp-up period is relatively short and is complete by 2 years after project opening (which is consistent with the current requirement that Before and After Studies be based on ridership observations measured 2 years after project opening).

The research presented in this article builds on all of the previous work described above by testing the independent relationships between ridership forecast accuracy for federally funded fixed-guideway transit projects and four types of project characteristics:

Elapsed time

Spielberg et al. (2003) note that forecasters have more information about short-term changes in conditions that effect ridership than they do about long-term changes. Thus, forecast accuracy should improve as the length of time between forecast preparation and ridership observation decreases.

Financial characteristics

Early observers of modern fixed-guideway transit planning have suggested that reliance on outside funding sources creates incentives for biased forecasts (Kain 1990; Pickrell 1989; Richmond 2005). It might follow that low-cost, locally funded projects would be associated with more accurate forecasts than high-cost projects with high federal funding shares would be.

Physical characteristics

Schmitt (2016) has found that forecasts for light rail project have been more accurate than those for other modes. Spielberg et al. (2003) have suggested that forecasting models are less well suited for projects such as downtown people movers that are meant to serve passengers with very short trip lengths than for light rail projects. This could suggest that physical project characteristics such as length and mode would be associated with differences in forecast accuracy.

Local experience

One might also expect that local experience with transit projects of a particular mode would improve the accuracy of ridership forecasts. If this were the case, ridership forecasts for new lines or extensions of existing fixed-guideway transit systems would be more accurate than those for initial lines of new systems. Likewise, estimates for renovations of existing lines would be more accurate than those for the construction of new lines. While Button (2009) found this to be the case, Schmitt (2016) found no such relationship when using a larger and more recent sample, a different metric to describe forecast error, and a different analysis methodology.

This study follows Gomez-Ibanez (1985b), Pickrell (1989), Spielberg et al. (2003), Lewis-Workman et al. (2008), Button (2009), and Schmitt (2016) in taking Ascher's (1979) "outsider's approach" to forecast evaluation, so controls for the forecasting approach (e.g. activity-based models, four-stop models, or simplified approaches) are not included. Information on the modeling approach is not available for some projects in the sample, but most, if not all, of them are probably based on four-step regional travel demand models, given the time period in which they were prepared. The variables used to describe these four types of project characteristics are listed and discussed in the following section.

Data and methodology

The sample for this study comprises all federally funded fixed-guideway transit projects completed between 1983 and 2012 for which relevant ridership forecasts are available: a total of 67 projects. Data on the predicted and actual ridership on each project were compiled from Pickrell's report (1989) (nine of the 67 projects in the sample); two predicted-versus-actual studies published by the FTA (Lewis-Workman et al. 2008; Spielberg et al. 2003) (respectively 23 and 19 out of the 67 projects in the sample); and summaries of completed Before and After Studies published by the FTA (Federal Transit Administration 2007–2018) (16 of 67 the projects in the study sample). All of these sources report both predicted and observed ridership in terms of average weekday boardings, and all forecasts were prepared in connection with an application for a federal New Starts grant to support project construction. When these data sources report ridership observations for multiple years, I calculate the accuracy of ridership forecasts using the observed ridership for the year following project completion that is closest to the forecast horizon year. For the 16 projects for which data was drawn from FTA Before and After Studies (Federal Transit Administration 2007–2018), this is generally two years after project opening.

Data on the federal funding share for each project were compiled from Pickrell's report (Pickrell 1989) and from annual reports to Congress on New Starts funding (Federal Transit Administration 1993–1994; Federal Transit Administration 1996–2016; Urban Mass Transportation Administration 1990–1991).

The study sample includes projects in 35 different cities across the United States. In all, 26 states have had at least one project in the sample, including District of Columbia and Puerto Rico.

The sample is not only diverse geographically, but with respect to project mode as well; it includes 38 light rail projects, 12 heavy rail projects, seven commuter rail projects, four people mover projects, three transitway projects (exclusive bus lanes), two bus rapid transit projects, and one streetcar project. Thirty-one projects in the sample were initial lines of a new (single-mode) transit system; 29 were expansions lines or extensions for existing systems; and six were renovations of existing lines (for example, double-tracking and station renovations). All transitway projects are categorized as renovations of existing lines.

Measuring error

Shinn and Voulgaris (2019) describes several possible metrics that can be used to describe forecast error. Of these two of the most common are mean absolute percent error (MAPE), which is the difference between the forecast and observed values divided by the observed value, and mean magnitude of error relative to the estimate (MMRE), which is the difference between the forecast and observed values divided by the forecast value. A major weakness of both of these measures is that they are asymmetrical or biased in favor of errors in a particular direction. MAPE imposes a greater penalty for overestimates than for underestimates, while MMER imposes a greater penalty for underestimates than for overestimates. For this study, ridership forecast error is calculated as symmetrical percent error, as shown in Eq. 1, where e is the estimated ridership and o is the observed ridership. Symmetrical percent error is recommended by Armstrong (1978) because it is dimensionless

Table 1 Variables tested for relationship with forecast error

Time of forecast	Year	
	Legislation	
Project characteristics	Elapsed time	Project development
		Project construction
		Forecast horizon
	Financial characteristics	Total project cost
		Federal funding share
	Physical characteristics	Project length (log-transformed)
		Project mode
	Local experience	System mileage share
		Project sequence
External factors	Change in fuel price	
	Change in unemployment	
	Change in population	
	Forecast horizon year minus observation year	
	Forecast-year unemployment	
	Forecast-year population (log-transformed)	

(it is scaled to allow comparisons of estimate accuracy for projects of different magnitudes) and symmetrical (it has the same range of possible values for underestimates as for overestimates)

$$\frac{(e-o)}{\left(\frac{1}{2}\right)(e+o)}. \tag{1}$$

For individual observations, symmetrical percent error will be positive for overestimates and negative for underestimates. When symmetrical percent errors are averaged across observations, the resulting symmetrical mean percent error (SMPE) represents the average *bias* of the set of estimates, but can overstate the average *accuracy* of the estimates, since any underestimates can mitigate the impact of overestimates (and vice versa) on the average value. Symmetrical mean absolute percent error (SMAPE) can better represent the average inaccuracy of a set of observations by taking the average of the absolute value of the percent error for each observation. However, SMAPE does not indicate the direction of the error. Since underestimates and overestimates have different practical consequences in the case of ridership forecasts, this paper primarily focuses on SMPE rather than SMAPE.

Time, project characteristics, and control variables

This paper evaluates the relationship between ridership forecast error and variables describing the time at which the forecast was prepared, characteristics of the project, and external factors. These variables are listed in Table 1.

Two different variables describe the time at which a forecast was prepared. The year a forecast was published as a continuous variable that can capture for constant changes in a consistent direction over time.

Federal legislation has varied the relative influence that ridership forecasts have had on a project's eligibility for federal grant funding over the years. If, as Wachs (1990) and Flyvbjerg et al. (2005) have suggested, inaccurate forecasts represent an intentional attempt to misrepresent anticipated ridership in order to secure funding, one might expect forecast accuracy to change as the laws governing the eligibility for funding have changed. To account for this possibility, a categorical time-period variable indicating which of five federal laws authorized capital funding for transit projects at the time the forecast was made[1] is also useful to determine whether discrete changes in forecast accuracy have been associated with differences in legislation.

The time between forecasts and measurements of actual values can be divided into three components: the time between the forecast and the beginning of construction (project development); time between the beginning of construction and project opening (project construction); and the time between the project opening and the year in which an actual value is observed. Variables for project development duration, project construction duration, and forecast horizon (time from the year the forecast was made to the forecast horizon year) describe each of these three components.

Two variables describe the financial characteristics of each project: total project cost, and the share of total project costs that are funded through federal programs (primarily, but not exclusively, the New Starts program). The latter value is calculated as the final value of the grant awarded to the project divided by the actual project cost.

Two variables describe the physical characteristics of the project: project length and project mode. Project length is determined as the number miles the project covers in a single direction. Project mode classifies projects into one of six possible modes: Light rail, heavy rail, commuter rail, transitway, downtown people mover, and bus rapid transit. Transitways are defined as projects that create a dedicated right-of-way for transit without adding new transit service or transit vehicles. All transitways in the sample are bus lanes or bus tunnels. Bus rapid transit projects generally include the construction of bus lanes, but they are distinct from transitway projects in that they also add new rapid bus service.

Two variables indicate the prior experience of the project sponsor with respect to transit planning and forecasting. The first is an indicator variable for whether the project represents an initial line for a new transit system, an expansion of an existing system, or a renovation of an existing line. The second is share of the planned system mileage the project represents. For expansions of existing systems, this value is calculated as the project length divided by the sum of the project length and the total system mileage at the time the forecast was made. This value is always 100% for initial lines (since the total system mileage is zero before project opening) and zero for renovation projects (since these projects do not add mileage to the system).

External conditions, such as economic or demographic characteristics of the community a project is intended to serve, might influence the accuracy of ridership forecasts, since these are important inputs to many forecast models. For example, forecasts prepared at

[1] The five acts that authorized capital funding for rapid transit projects during the period of this study were the Urban Mass Transportation Act (1964–1987); the Surface Transportation and Uniform Relocation Assistance Act (STURAA) (1987–1991); the Intermodal Surface Transportation Efficiency Act (ISTEA) (1991–1997); the Transportation Equity Act for the 21st Century (TEA-21) (1997–2005); and the Safe Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) (2005–2012). Since the sample is limited to projects that were completed before 2012, no forecasts completed under Moving Ahead for Progress in the 21st Century (MAP-21) (2012–2015) and the Fixing America's Surface Transportation Act (FAST-Act) (2015 to present) are included in the analysis.

times of particularly high or low unemployment rates, or forecasts for which the unemployment rate changed dramatically between the time the forecast was made and the time at which ridership was observed, might have greater errors because forecasters failed to anticipate these changes. Moreover, project sponsors serving larger populations may have greater resources to devote to preparing rigorous forecasts. They may also answer to a wider variety of stakeholders, which could influence the incentives for promoting a particular project through optimistic forecasts. To account for some of these effects, this analysis controls for the population of the primary county served by the project sponsor; the unemployment rate in the central city of the projects sponsor's service area in the year the forecast was made; and three additional variables representing the percent change between the year a forecast was made and the year ridership was observed: change in the average price of gasoline within the state where the project is located, change in the central city unemployment rate, and change in the county population.

In many cases, observed ridership data were not available for the ridership forecast horizon year because the project was not completed until after the forecast horizon year, the forecast horizon year is still in the future at the time of this writing, or because the system had expanded further by the time the horizon year was reached, and route or sub-route level ridership data were not available in the forecast horizon year. When ridership observations are from a year other than the forecast horizon year, ridership observations from the closest available year were used. To account for discrepancies between forecast horizon years and observation years, a control variable to indicate the number of years between the ridership forecast horizon year and the year in which ridership was observed.

Modeling forecast error

A series of linear regression models tests the degree to which project characteristics may have influenced the accuracy of ridership forecasts. First, a constant model with no independent variables and a control model including only the external control variables shown in Table 1 offer a basis for comparison with a model including the project characteristics described above. The change in model fit between the control model and a full model including all of the variables listed in Table 1 indicates whether (and the degree to which) the full set of project characteristics help explain variation in forecast accuracy. Several of the variables included in the full model are highly correlated with one another, which introduces multi-collinearity to the model, violating one of the key assumptions of multiple linear regression. Generalized variance inflation factors (GVIF) indicate which variables in a linear regression model contribute to multi-collinearity (Fox and Monette 1992). A final model was estimated by removing variables with high GVIF values from the full model.

Results

Figure 1 illustrates the relationship between forecast error and the year in which the forecast was prepared and shows a trend of improved forecast accuracy over time. A LOESS (local polynomial regression) curve with a shaded band indicating a 95-percent confidence interval is shown to illustrate the overall trend in the data. The correlation between the year of forecast publication and forecast error is significant with a 95-percent confidence between -0.58 and -0.17, which indicates that forecast accuracy has improved steadily over time. The y-axis in Fig. 1 indicates SMPE, which is the difference between the

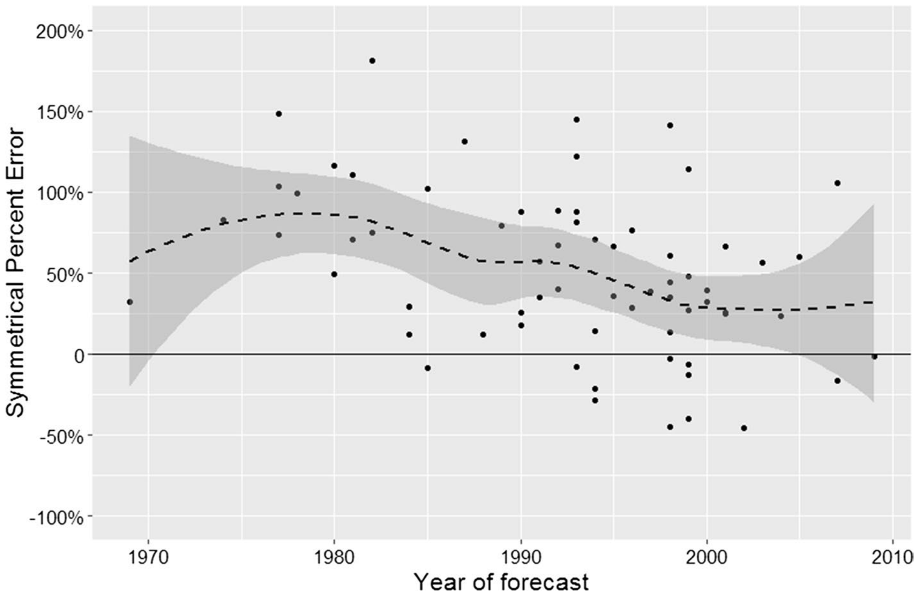

Fig. 1 Variation in ridership forecast accuracy over time

forecast and observed ridership divided by the average of the forecast and observed ridership (as shown in Eq. 1). A positive SMPE value of 100% corresponds to a MAPE value of 200% (i.e. forecast values are 200% higher than observed values) and an MMRE value of 67% (i.e. observed values are 67% lower than forecast values.

Table 2 shows the 95-percent confidence intervals for correlations between each of the variables in Table 1 and the year in which a project's ridership forecast was prepared, as well as the error associated with the project's ridership forecast. Correlation is a measure of the strength and direction of a linear relationship between two variables. A correlation of one indicates a perfectly linear positive relationship, where an increase in one variable perfectly corresponds to a constant increase in the other; a correlation of negative one indicates a perfectly linear negative relationship, where an increase in one variable perfectly corresponds to a constant decrease in the other; and a correlation of zero indicates that there is not a linear relationship between the two variables. If the 95-percent confidence interval for the correlation between two variables includes zero, we cannot conclude with 95% confidence that there is a linear relationship between those two variables.

The "Project construction" row in Table 2 shows that the 95-percent confidence interval for the correlation between the duration of the time required to construct the project and the year in which the forecast was prepared ranges from −0.66 to −0.30. Since this entire interval is negative, we can be 95-percent confident that there is a (mild to moderate) negative linear relationship between the year of a forecast and the time required to construct a project. In other words, there has been a trend towards shorter construction durations over time. The "Project construction" row also shows that the 95-percent confidence interval for the correlation between the duration of time required to construct the project and the error of the forecast ranges from 0.16 to 0.57. Since this entire range is positive, we can be 95-percent confident that there is a (mild to moderate) positive linear relationship between construction duration and forecast error. In other words, longer construction durations are associated with less accurate ridership forecasts.

Table 2 Correlations with time and with forecast error

Variable	95-percent confidence interval for correlation…	
	…with the year in which the forecast was prepared	…with forecast error
Time of forecast		
Year	**1.00**	**−0.58 to −0.17**
Project characteristics		
Elapsed time		
Project development	−0.22 to 0.25	−0.21 to 0.27
Project construction	**−0.66 to −0.30**	**0.16 to 0.57**
Forecast horizon	−0.13 to 0.34	−0.36 to 0.11
Financial characteristics		
Total project cost	−0.44 to 0.01	−0.23 to 0.25
Federal funding share	−0.32 to 0.15	−0.27 to 0.21
Physical characteristics		
Project length	−0.33 to 0.14	−0.29 to 0.19
Local experience		
System mileage share	−0.42 to 0.03	−0.26 to 0.22
External control variables		
Change in fuel price		−0.42 to 0.06
Change in unemployment		**−0.63 to −0.23**
Change in population		−0.19 to 0.30
Forecast-year unemployment		**0.11 to 0.55**
Forecast-year population		−0.24 to 0.25

Bold text indicates significance at 95-percent confidence level

None of the other continuous variables describing project characteristics have a statistically significant relationship with the year in which the forecast was prepared or with forecast error. Of the external control variables, two are significantly correlated with forecast error. The unemployment level at the time the forecast was prepared was positively correlated with forecast error (i.e. forecasts prepared during times of high unemployment have greater errors). The change in unemployment between the time the forecast was prepared and the time ridership was observed is negatively correlated with forecast error. These two variables are also highly correlated with one another (the 95-percent confidence interval for the correlation is between −0.77 and −0.47). This reflects the phenomenon of "regression to the mean" (Healy and Goldstein 1978): When the unemployment rate is high (higher than about 5.5%) at the time a ridership forecast is made, it will generally decrease by the time ridership is observed. Conversely, when the unemployment rate is low, it is likely to increase by the time ridership is observed.

Independent relationships between project characteristics and ridership forecast accuracy

As the left side of Table 3 shows, when all variables described in this paper are included in a model predicting ridership forecast accuracy, high GVIF values suggest excessive multicollinearity for several variables, where a GVIF is determined to be too high if it exceeds 2.0 when raised to the inverse power of twice the variable's degrees of freedom. Based on

Table 3 Generalized variance inflation factor analysis for ridership error models

	Full model			Final model		
	GVIF	*df*	$GVIF^{(1/(2\times df))}$	GVIF	*df*	$GVIF^{(1/(2\times df))}$
Time of forecast						
Year	24.7	1	5.0	3.5	1	1.9
Legislation	304.2	4	2.0	–	–	–
Project characteristics						
Elapsed time						
Project development	4.1	1	2.0	1.6	1	1.3
Project construction	3.5	1	1.9	2.0	1	1.4
Forecast horizon	29.0	1	5.4	2.1	1	1.5
Financial characteristics						
Total project cost (log-transformed)	4.1	1	2.0	3.1	1	1.8
Federal funding share	1.8	1	1.3	1.6	1	1.3
Physical characteristics						
Project length (log-transformed)	3.4	1	1.9	–	–	–
Project mode	176.3	6	1.5	12.9	5	1.2
Local experience						
System mileage share	8.2	1	2.9	2.8	1	1.7
Project sequence	19.7	2	2.1	–	–	–
External control variables						
Change in fuel price	4.7	1	2.2	2.5	1	1.6
Change in unemployment	6.7	1	2.6	–	–	–
Change in population	1.9	1	1.4	1.4	1	1.2
Forecast horizon year minus observation year	27.3	1	5.2	–	–	–
Forecast-year unemployment	4.0	1	2.0	1.6	1	1.3
Forecast-year population (log-transformed)	2.3	1	1.5	1.8	1	1.3

this result, the final model excludes five variables (authorizing legislation, project length, project sequence, change in unemployment, and the difference between the forecast horizon year and the ridership observation year) from the model. Authorizing legislation and project sequence are both categorical variables that are perfectly predicted by continuous variables that remain in the final model. Project length is highly correlated ($r = 0.46$) with project cost; and change in unemployment is highly correlated ($r = -0.64$) with forecast year unemployment. As the right side of Table 3 shows, these changes result in acceptable GVIF values.

Figure 2 compares the fit of four different models predicting ridership forecast error, with two different measures to describe model fit: the Akaike information criterion (AIC) and adjusted R^2. Both measures are designed to avoid over-fitting a model to the data by penalizing model complexity and rewarding parsimony. The constant model predicts no variation in forecast error, and thus predicts none of the observed variation in forecast error, resulting in an adjusted R^2 value of zero. The control model includes only the time-of-forecast and external control variables listed in Table 1; the full model includes all of the variables listed in Table 1; and the final model omits variables that introduce multicollinearity, as described above.

The control model fits the data better than the constant model, and the full model fits the data better than the control model. This result indicates that the set of control variables and

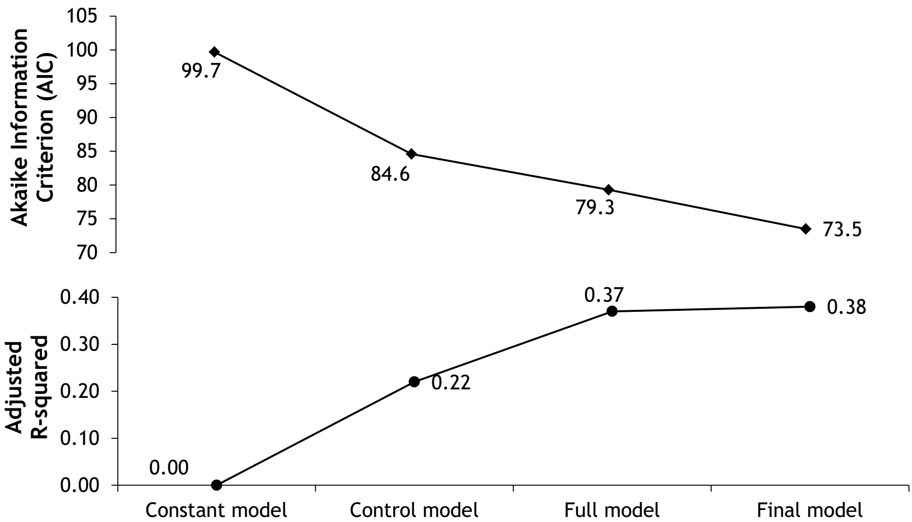

Fig. 2 Model fit comparison

the set of variables representing project characteristics each contributes to explaining the variation in ridership forecast error. The final model offers the best model fit.

Table 4 shows the variable coefficient estimates and *p*-values for the final model. As shown, the direction of the relationship with ridership forecast error can only be determined with 95-percent confidence for three variables: the year in which the forecast was prepared, construction duration, and mode. On average, and controlling for other factors, forecast error improved by about two percentage points each year. Each additional year of project construction is associated with an additional seven percentage points of ridership forecast error. Ridership forecasts for commuter rail projects have errors that are about 42 percentage points greater than those for light rail projects, and the error associated with the ridership forecast for the only streetcar project in the sample was more than double that of the rest of the sample.

Discussion

What can planners, policy makers, and decision makers do with these results? A primary contribution of this work is to identify which project characteristics are associated with variation in forecast accuracy, and perhaps just as importantly, which are not. This can guide decision makers and other forecast users as they evaluate the degree to which they can trust the ridership forecasts associated with a proposed project.

For example, Pickrell (1989) has suggested that when a larger share of a project's total capital costs is subsidized by federal grants (such as New Starts grants), there is a greater incentive to inflate ridership forecasts to win access to federal funding (one anonymous reviewer of this paper related that he or she had observed this dynamic at play more recently in the preparation of forecasts for the Tren Urbano project in Puerto Rico). However, the analysis presented here finds no statistically significant relationship between the share of a project's funding that comes from federal grants and the accuracy of the ridership forecasts

Table 4 Final model results for ridership forecast error

	Estimate	Standard error	*p*-value
Time of forecast			
Year	**−0.023**	**0.011**	**0.050**
Project characteristics			
Elapsed time			
Project development (years)	*0.031*	*0.033*	*0.360*
Project construction (years)	**0.080**	**0.029**	**0.008**
Forecast horizon (years)	*−0.014*	*0.011*	*0.227*
Financial characteristics			
Total project cost (log-transformed)	*−0.260*	*0.208*	*0.219*
Federal funding share	*0.592*	*0.394*	*0.140*
Physical characteristics			
Project mode			
Base: Light rail (38 projects)			
Heavy rail (12 projects)	*0.149*	*0.188*	*0.433*
Commuter Rail (7 projects)	**0.419**	**0.200**	**0.042**
People mover (4 projects)	0.447	0.258	0.091
Bus rapid transit (2 projects)	*−0.225*	*0.404*	*0.580*
Transitway (3 projects)	*0.241*	*0.285*	*0.402*
Streetcar (1 project)	**1.179**	**0.466**	**0.015**
Local experience			
System mileage share	*−0.043*	*0.189*	*0.822*
External control variables			
Change in fuel price	*0.335*	*0.231*	*0.107*
Change in population	*0.716*	*0.512*	*0.128*
Forecast-year unemployment	*0.018*	*0.030*	*0.573*
Forecast-year population (log-transformed)	*−0.021*	*0.177*	*0.905*

Bold text indicates significance at a 95-percent confidence level; Bolditalic text indicates significance at a 90-percent confidence level; Italic text indicates non-significance

for that project. There is no strong evidence that reducing the role of the federal government in funding transportation infrastructure would result in more accurate forecasts. Likewise, there is no evidence-based support for decision makers and other forecast users to have any more confidence in forecasts for fully-locally-funded projects than they have in forecasts for projects that are partially or primarily funded through federal grants. Indeed, it is just as likely that federal participation in transit funding has led to greater oversight that has served to increase forecast accuracy. It was not possible to control for the frequent changes in federal policy and oversight that have occurred over the course of the study period. A qualitative study on the behavioral responses of modelers and forecasters to changes in federal policy could further illuminate the relationship between forecast accuracy and federal oversight.

This is not to say that unethical, intentional bias (as documented or suggested by Flyvbjerg (2005), Wachs (1990), Richmond (2005), and Kain (1990)) does not at least partially explain forecast error, but it may suggest that the incentive for biased forecasts is just as great when project advocates seek local funding as when they seek federal funding. Notably, Richmond's (2005) and Kain's (1990) case studies of unethical forecasting practices are both of projects that were constructed without federal funds. The results of this study do not support (nor do they definitively refute) the suggestion that policy makers should seek to reduce the federal funding share for transit infrastructure for purposes of improving forecast accuracy and reducing strategic misrepresentation on the part of forecasters (although there may be other reasons for pursuing those policies).

Based on the results of this study, it does appear that, as suggested by Spielberg et al. (2003), the time until ridership is observed does relate to forecast accuracy. In some respects, this result is quite intuitive: it is more difficult to predict the distant future than the immediate future. However, not all of this elapsed time is related to forecast accuracy. The length of time required for project planning and development does not have a significant relationship with forecast error, nor does the total time between forecast preparation and ridership observation. In contrast, the length of time required to construct the project is significantly associated with the accuracy of the ridership forecast. This may indicate that additional time spent on project planning and development can increase the likelihood that actual ridership will meet forecast values if that additional time is effective in reducing the length of time that would be required to construct the project. In the specific instances when this is likely to be the case, project managers should be less concerned about project delays before the beginning of project construction than those that occur after construction begins.

This study does not evaluate the question of whether more time spent on project planning leads to shorter construction durations in general. Within the study sample there is a negative correlation (−0.22) between the project development duration and the construction duration, with a p value of 0.06, indicating significance at the 90th, but not at the 95th confidence level. This may suggest that more time spend on project planning can reduce the time required for construction, and by extension, the accuracy of ridership forecasts. Further research is needed on this topic.

In defining construction duration, this analysis does not differentiate between long construction durations that result from unanticipated delays and those that do not. Given the importance of construction duration demonstrated by this analysis, such differentiation warrants further research. To the extent that long construction durations may be associated with unexpected delays that lead to cost overruns, the relationship described here between construction duration and ridership forecast error is consistent with Flyvbjerg's (2016) finding that infrastructure projects for which actual cost exceed predicted costs also have benefits that fall short of predicted benefits by an even greater degree.

Transit agencies would be well advised to view construction delays as potentially symptomatic of additional problems that might also lead to lower-than-anticipated ridership and to take proactive steps to increase ridership, for example, through changes in fare policy, marketing, and cooperation with partners to protect and promote transit-supportive development patterns.

Finally, the finding that forecasts for street car, people mover, and commuter rail projects have been significantly less accurate than those for light rail, heavy rail, bus rapid transit, and transitway projects suggests that decision makers and other forecast users should be particularly skeptical of forecasts for novel transit modes. Street car and people mover projects are generally more suited to shorter trips than are typical on other transit modes, while commuter rail projects are more suited to longer trips than are typical on other transit modes. These types of differences likely weaken the ability of regional travel demand models developed for and calibrated more common transit modes to accurately model traveler decisions.

As described at the outset of this paper, this study follows Gomez-Ibanez (1985b), Pickrell (1989), Spielberg et al. (2003), Lewis-Workman et al. (2008), Button (2009), and

Schmitt (2016) in taking Ascher's (1979) "outsider's approach" to forecast evaluation, so controls for the forecasting approach (e.g. activity-based models, four-stop models, or simplified approaches) and an analysis of the appropriateness of model input assumptions including those describing land use, fare policy, are not included. However, the results of this study can assist forecast users in determining which projects' ridership forecasts warrant a higher degree of scrutiny with regard to the appropriateness of the forecasting approach and input assumptions.

Conclusion

On the whole, there is good reason to be optimistic about optimism bias in ridership forecasts. Optimistic forecast error (e.g. error that overestimates project ridership) has decreased steadily over time, by an average of about 2% per year since the late 1960s, controlling for other factors. However, this improvement speaks more to the very high errors that were common in the early years of transit ridership forecasting than to a satisfactory level of accuracy today. Some of this observed improvement can be explained by the reduction in project construction durations, since project construction durations have decreased over time and, controlling for other factors, shorter construction durations are associated with more accurate ridership forecasts.

All of the projects in this sample relied on funding from New Starts grants for capital costs, but the share of capital costs provided by federal funding varied from project to project, and there was no statistically significant relationship between the federal funding share and the accuracy of ridership forecasts. There is a significant relationship between ridership forecast accuracy and project mode, with less accurate forecasts associated with novel modes (people movers, street cars, and commuter rail) that are best suited to serve trips of a different trip length (longer or shorter) than more common transit modes do.

Although the final model presented in this paper explains 38% of the observed variation in ridership forecast accuracy, there are many other factors that influence ridership forecast accuracy that could not be included in this study. Detailed analysis of unanticipated land use changes, for example, cannot be included in an analysis of a large sample of projects, but these changes can have important impacts on the accuracy of ridership forecasts. In-depth case studies of individual projects, including an analysis of contemporary documents and interviews with forecasters and project stakeholders, can play an important role in uncovering the effects of these case-specific factors, and there is a need for this type of work to supplement quantitative analysis of changes in forecast accuracy over time. Nevertheless, this study offers important insights that can assist policy makers, decision makers, and other forecast users in determining the degree of trust they should place in transit ridership forecasts.

Compliance with ethical standards

Conflict of interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

Appendix

See Tables 5, 6, 7, 8, 9, 10, 11 and 12.

Table 5 Time variables for projects in study sample (a) (1/3), (b) (2/3) and (c) (3/3)

Project name	Year of…					Surface transportation bill in place at the time of the ridership forecast
	Ridership forecast	Construction start	Project opening	Ridership forecast horizon	Observed ridership	
(a)						
Heavy Rail (Baltimore, MD)	1974	1976	1983	1980	1987	UMTA
Heavy Rail (Washington, DC)	1969	1969	1985	1977	1986	UMTA
Heavy Rail (Miami, FL)	1977	1980	1985	1985	1988	UMTA
Light Rail (Buffalo, NY)	1977	1979	1986	1995	1989	UMTA
Metromover (Miami, FL)	1980	1983	1986	1985	1988	UMTA
Banfield Transitway (Portland, OR)	1977	1982	1986	1990	1989	UMTA
Light Rail (Pittsburgh, PA)	1978	1980	1987	1985	1989	UMTA
People Mover (Detroit, MI)	1980	1983	1987	1985	1988	UMTA
Light Rail (Sacramento, CA)	1981	1984	1987	2000	1989	UMTA
El Cajon Extension (San Diego, CA)	1985	1987	1989	2000	2000	UMTA
Guadalupe (San Jose, CA)	1981	1986	1991	1990	1992	UMTA
Orange Line (Chicago, IL)	1982	1987	1993	2000	2000	UMTA
SW Transitway (Houston, TX)	1985	1987	1993	2005	2002	UMTA
Metrolink (St Louis, MO)	1984	1990	1994	1995	1995	UMTA
Metromover Extensions (Miami, FL)	1987	1991	1994	2000	2000	UMTA
Metro Extension (Baltimore, MD)	1984	1988	1995	2005	2001	UMTA
Colma station (San Francisco, CA)	1988	1993	1996	2000	2000	STURAA
South Oak Cliff (Dallas, TX)	1990	1993	1997	2005	2002	STURAA
LRT Extensions (Baltimore, MD)	1991	1994	1997	2005	2001	STURAA
Hillsboro Extension (Portland, OR)	1993	1994	1998	2005	2002	STURAA
N/S LRT (Salt Lake City, UT)	1990	1995	1999	2010	2002	STURAA
Tasman West LRT (San Jose, CA)	1991	1996	1999	2005	2002	STURAA
Skyway Express (Jacksonville, FL)	1982	1987	2000	1995	2000	UMTA
Red Line (Los Angeles, CA)	1989	1986	2000	2000	2001	STURAA

Table 5 (continued)

Project name	Year of…					Surface transportation bill in place at the time of the ridership forecast
	Ridership forecast	Construction start	Project opening	Ridership forecast horizon	Observed ridership	
(b)						
North Line Extension (Atlanta, GA)	1990	1995	2000	2005	2003	STURAA
Airport Busway (Pittsburgh, PA)	1992	1994	2000	2005	2002	ISTEA
Southwest Light Rail (Denver, CO)	1994	1999	2000	2015	2002	ISTEA
University Ext (Salt Lake City, UT)	1999	2000	2001	2020	2005	TEA-21
St Clair Extension (St Louis, MO)	1994	1996	2001	2010	2002	ISTEA
North Central Ext (Dallas, TX)	1994	1999	2002	2020	2007	ISTEA
BART to SFO (San Francisco, CA)	1993	1999	2003	2010	2007	ISTEA
Med Center Ext (Salt Lake City, UT)	1999	2002	2003	2020	2005	TEA-21
South LRT (Sacramento, CA)	1995	1997	2003	2015	2007	ISTEA
Piers Transitway (Boston, MA)	1993	1994	2004	2010	2007	ISTEA
Largo Extension (Washington, DC)	1996	2001	2004	2020	2007	ISTEA
Interstate MAX (Portland, OR)	1996	2000	2004	2015	2007	ISTEA
Hiawatha (Minneapolis, MN)	1999	2001	2004	2020	2007	NA
Med Center Ext (Memphis, TN)	1998	2001	2004	2020	2007	ISTEA
Tren Urbano (San Juan, PR)	1993	1999	2005	2010	2007	ISTEA
Reconstruction II (Pittsburgh, PA)	1994	2001	2005	2010	2007	ISTEA
Mission Valley East (San Diego, CA)	1998	2000	2005	2015	2007	ISTEA
Douglas Reconstr. (Chicago, IL)	1999	2001	2005	2020	2007	TEA-21
Elizabeth Link (Newark, NJ)	1993	2000	2006	2015	2008	ISTEA
Hudson Bergen I (Jersey City, NJ)	1992	1996	2002	2010	2008	ISTEA
Hudson Bergen II (Jersey City, NJ)	1992	2000	2006	2010	2008	ISTEA
North Central (Chicago, IL)	1998	2001	2006	2020	2006	ISTEA

Table 5 (continued)

Project name	Year of…					Surface transportation bill in place at the time of the ridership forecast
	Ridership forecast	Construction start	Project opening	Ridership forecast horizon	Observed ridership	
Southwest (Chicago, IL)	1998	2001	2006	2020	2006	ISTEA
UP West Ext (Chicago, IL)	1998	2001	2006	2020	2006	ISTEA
(c)						
Southeast Corridor (Denver, CO)	1998	2000	2006	2020	2007	ISTEA
Central Double Track (Baltimore)	1999	2001	2006	2020	2008	TEA-21
Ft Lauderdale Dbl-Track (Miami)	1999	2000	2007	2015	2007	TEA-21
South Corridor (Charlotte, NC)	1998	2005	2007	2025	2009	TEA-21
Sprinter light rail (Oceanside, CA)	1995	2002	2008	2015	2010	ISTEA
Euclid Corridor (Cleveland, OH)	1997	2004	2008	2010	2010	ISTEA
East Valley (Phoenix, AZ)	1998	2005	2008	2020	2011	ISTEA
Frontrunner N (Salt Lake City, UT)	2003	2006	2008	2008	2009	TEA-21
Gold Line Ext. (Los Angeles, CA)	2000	2004	2009	2020	2011	TEA-21
Central, Airport Links (Seattle)	2000	2003	2009	2009	2011	TEA-21
Westside Express (Portland, OR)	2001	2006	2009	2009	2009	TEA-21
Green Line (Portland, OR)	2004	2007	2009	2009	2011	TEA-21
Northstar (Minneapolis, MN)	2005	2007	2009	2009	2011	TEA-21
NW–SE Line (Dallas, TX)	2001	2006	2010	2010	2012	TEA-21
The Tide (Norfolk, VA)	2002	2008	2011	2011	2013	TEA-21
Mountainlink (Flagstaff, AZ)	2009	2011	2011	2011	2013	SAFETEA

Table 6 Sources of time variables for project in study sample (a) (1/3), (b) (2/3) and (c) (3/3)

Project name	Year of…				
	Ridership forecast	Construction start	Project opening	Ridership forecast horizon	Observed ridership
(a)					
Heavy Rail (Baltimore, MD)	(1)	(2)	(1)	(1)	(1)
Heavy Rail (Washington, DC)	(1)	(3)	(1)	(1)	(1)
Heavy Rail (Miami, FL)	(1)	(4)	(1)	(1)	(1)
Light Rail (Buffalo, NY)	(1)	(6)	(1)	(1)	(1)
People Mover (Miami, FL)	(1)	(7)	(1)	(1)	(1)
Benfield Transitway (Portland, OR)	(1)	(8)	(1)	(1)	(1)
Light Rail (Pittsburgh, PA)	(1)	(9)	(1)	(1)	(1)
People Mover (Detroit, MI)	(1)	(10)	(1)	(1)	(1)
Light Rail (Sacramento, CA)	(1)	(11)	(1)	(1)	(1)
El Cajon Extension (San Diego, CA)	(7)	(7)	(7)	(7)	(7)
Guadalupe (San Jose, CA)	(7)	(7)	(7)	(7)	(7)
Orange Line (Chicago, IL)	(7)	(7)	(7)	(7)	(7)
SW Transitway (Houston, TX)	(7)	(7)	(7)	(7)	(7)
Metrolink (St Louis, MO)	(7)	(7)	(7)	(7)	(7)
Metromover Extensions (Miami, FL)	(7)	(7)	(7)	(7)	(7)
I-25 Transitway (Denver, CO)	(7)	(7)	(7)	(7)	(7)
Metro Extension (Baltimore, MD)	(7)	(7)	(7)	(7)	(7)
Colma station (San Francisco, CA)	(7)	(7)	(7)	(7)	(7)
South Oak Cliff (Dallas, TX)	(7)	(7)	(7)	(7)	(7)
LRT Extensions (Baltimore, MD)	(7)	(7)	(7)	(7)	(7)
Hillsboro Extension (Portland, OR)	(7)	(7)	(7)	(7)	(7)
N/S LRT (Salt Lake City, UT)	(7)	(7)	(7)	(7)	(7)
Tasman West LRT (San Jose, CA)	(7)	(7)	(7)	(7)	(7)
Skyway Express (Jacksonville, FL)	(7)	(7)	(7)	(7)	(7)
Red Line (Los Angeles, CA)	(7)	(7)	(7)	(7)	(7)
(b)					
North Line Extension (Atlanta, GA)	(7)	(7)	(7)	(7)	(7)
Airport Busway (Pittsburgh, PA)	(7)	(7)	(7)	(7)	(7)
Southwest Light Rail (Denver, CO)	(7)	(7)	(7)	(7)	(7)
University Ext (Salt Lake City, UT)	(14)	(14)	(14)	(14)	(14)
St Clair Extension (St Louis, MO)	(7)	(7)	(7)	(7)	(7)
North Central Ext (Dallas, TX)	(12)	(12)	(12)	(12)	(12)
BART to SFO (San Francisco, CA)	(12)	(12)	(12)	(12)	(12)
Med Center Ext (Salt Lake City, UT)	(12)	(12)	(12)	(12)	(12)
South LRT (Sacramento, CA)	(12)	(12)	(12)	(12)	(12)
Piers Transitway (Boston, MA)	(12)	(12)	(12)	(12)	(12)
Largo Extension (Washington, DC)	(12)	(12)	(12)	(12)	(12)
Interstate MAX (Portland, OR)	(12)	(12)	(12)	(12)	(12)
Hiawatha (Minneapolis, MN)	(12)	(12)	(12)	(12)	(12)
Med Center Ext (Memphis, TN)	(12)	(12)	(12)	(12)	(12)
Tren Urbano (San Juan, PR)	(12)	(12)	(12)	(12)	(12)

Table 6 (continued)

Project name	Year of…				
	Ridership forecast	Construction start	Project opening	Ridership forecast horizon	Observed ridership
Reconstruction II (Pittsburgh, PA)	(12)	(12)	(12)	(12)	(12)
Mission Valley East (San Diego, CA)	(12)	(12)	(12)	(12)	(12)
Douglas Reconstr. (Chicago, IL)	(12)	(12)	(12)	(12)	(12)
Elizabeth Link (Newark, NJ)	(12)	(12)	(12)	(12)	(12)
Hudson Bergen I (Jersey City, NJ)	(12)	(12)	(12)	(12)	(12)
Hudson Bergen II (Jersey City, NJ)	(12)	(12)	(12)	(12)	(12)
North Central (Chicago, IL)	(12)	(12)	(12)	(12)	(12)
Southwest (Chicago, IL)	(12)	(12)	(12)	(12)	(12)
UP West Ext (Chicago, IL)	(12)	(12)	(12)	(12)	(12)
(c)					
Southeast Corridor (Denver, CO)	(12)	(12)	(12)	(12)	(12)
Central Double Track (Baltimore)	(12)	(12)	(12)	(12)	(12)
Ft Lauderdale Dbl-Track (Miami)	(12)	(12)	(12)	(12)	(12)
South Corridor (Charlotte, NC)	(13)	(13)	(13)	(13)	(13)
Sprinter light rail (Oceanside, CA)	(13)	(13)	(13)	(13)	(13)
Euclid Corridor (Cleveland, OH)	(14)	(14)	(14)	(14)	(14)
East Valley (Phoenix, AZ)	(15)	(15)	(15)	(15)	(15)
Frontrunner N (Salt Lake City, UT)	(15)	(15)	(15)	(15)	(15)
Gold Line Ext. (Los Angeles, CA)	(15)	(15)	(15)	(15)	(15)
Central, Airport Links (Seattle)	(15)	(15)	(15)	(15)	(15)
Westside Express (Portland, OR)	(15)	(15)	(15)	(15)	(15)
Green Line (Portland, OR)	(16)	(16)	(16)	(16)	(16)
Northstar (Minneapolis, MN)	(15)	(15)	(15)	(15)	(15)
NW–SE Line (Dallas, TX)	(16)	(16)	(16)	(16)	(16)
The Tide (Norfolk, VA)	(17)	(17)	(17)	(17)	(17)
Mountainlink (Flagstaff, AZ)	(16)	(16)	(16)	(16)	(16)

Table 7 Accuracy variables for projects in study sample (1/3) (a) (1/3), (b) (2/3) and (c) (3/3)

Project name	Ridership (average weekday boardings)	
	Forecast	Actual
(a)		
Heavy Rail (Baltimore, MD)	103,000	42,600
Heavy Rail (Washington, DC)	569,600	411,600
Heavy Rail (Miami, FL)	239,900	35,400
Light Rail (Buffalo, NY)	92,000	29,200
People Mover (Miami, FL)	41,000	10,800
Benfield Transitway (Portland, OR)	42,500	19,700
Light Rail (Pittsburgh, PA)	90,500	30,600
People Mover (Detroit, MI)	67,700	41,000
Light Rail (Sacramento, CA)	50,000	14,400
El Cajon Extension (San Diego, CA)	21,600	23,478
Guadalupe (San Jose, CA)	41,200	19,738
Orange Line (Chicago, IL)	118,760	54,042
SW Transitway (Houston, TX)	27,280	8875
Metrolink (St Louis, MO)	41,800	37,045
Metromover Extensions (Miami, FL)	20,404	4209
Metro Extension (Baltimore, MD)	13,600	10,128
Colma station (San Francisco, CA)	15,200	13,482
South Oak Cliff (Dallas, TX)	34,800	26,884
LRT Extensions (Baltimore, MD)	11,804	8272
Hillsboro Extension (Portland, OR)	40,514	43,876
N/S LRT (Salt Lake City, UT)	26,500	22,100
Tasman West LRT (San Jose, CA)	14,875	8244
Skyway Express (Jacksonville, FL)	42,472	2054
Red Line (Los Angeles, CA)	297,733	128,659
(b)		
North Line Extension (Atlanta, GA)	57,120	22,328
Airport Busway (Pittsburgh, PA)	23,369	9000
Southwest Light Rail (Denver, CO)	22,000	19,083
University Ext (Salt Lake City, UT)	7577	11,359
St Clair Extension (St Louis, MO)	11,960	15,976
North Central Ext (Dallas, TX)	11,000	13,581
BART to SFO (San Francisco, CA)	67,400	26,284
Med Center Ext (Salt Lake City, UT)	2473	2640
South LRT (Sacramento, CA)	12,550	8734
Piers Transitway (Boston, MA)	29,700	12,500
Largo Extension (Washington, DC)	14,270	6361
Interstate MAX (Portland, OR)	17,030	12,785
Hiawatha (Minneapolis, MN)	24,600	27,871
Med Center Ext (Memphis, TN)	4200	720
Tren Urbano (San Juan, PR)	113,643	27,567
Reconstruction II (Pittsburgh, PA)	49,000	23,411
Mission Valley East (San Diego, CA)	10,795	7572

Table 7 (continued)

Project name	Ridership (average weekday boardings)	
	Forecast	Actual
Douglas Reconstr. (Chicago, IL)	33,000	25,106
Elizabeth Link (Newark, NJ)	12,500	2000
Hudson Bergen I (Jersey City, NJ)	31,300	20,868
Hudson Bergen II (Jersey City, NJ)	34,860	17,322
North Central (Chicago, IL)	8400	5338
Southwest (Chicago, IL)	13,800	8811
UP West Ext (Chicago, IL)	3900	2078
Southeast Corridor (Denver, CO)	30,000	26,192
Central Double Track (Baltimore) (c)	44,000	26,987
Ft Lauderdale Dbl-Track (Miami)	42,100	11,503
South Corridor (Charlotte, NC)	14,000	14,370
Sprinter light rail (Oceanside, CA)	15,100	7569
Euclid Corridor (Cleveland, OH)	21,100	14,300
East Valley (Phoenix, AZ)	25,800	40,700
Frontrunner N (Salt Lake City, UT)	8400	4700
Gold Line Ext. (Los Angeles, CA)	18,000	13,000
Central, Airport Links (Seattle)	34,900	23,400
Westside Express (Portland, OR)	2400	1200
Green Line (Portland, OR)	30,400	24,000
Northstar (Minneapolis, MN)	4100	2200
NW–SE Line (Dallas, TX)	40,300	31,000
The Tide (Norfolk, VA)	2900	4600
Mountainlink (Flagstaff, AZ)	4150	4200

Table 8 Sources of accuracy variables for projects in study sample (a) (1/3), (b) (2/3) and (c) (3/3)

Project name	Ridership (average weekday boardings)	
	Forecast	Actual
(a)		
Heavy Rail (Baltimore, MD)	(1)	(1)
Heavy Rail (Washington, DC)	(1)	(1)
Heavy Rail (Miami, FL)	(1)	(1)
Light Rail (Buffalo, NY)	(1)	(1)
People Mover (Miami, FL)	(1)	(1)
Benfield Transitway (Portland, OR)	(1)	(1)
Light Rail (Pittsburgh, PA)	(1)	(1)
People Mover (Detroit, MI)	(1)	(1)
Light Rail (Sacramento, CA)	(1)	(1)
El Cajon Extension (San Diego, CA)	(7)	(7)
Guadalupe (San Jose, CA)	(7)	(7)
Orange Line (Chicago, IL)	(7)	(7)
SW Transitway (Houston, TX)	(7)	(7)
Metrolink (St Louis, MO)	(7)	(7)
Metromover Extensions (Miami, FL)	(7)	(7)
Metro Extension (Baltimore, MD)	(7)	(7)
Colma station (San Francisco, CA)	(7)	(7)
South Oak Cliff (Dallas, TX)	(7)	(7)
LRT Extensions (Baltimore, MD)	(7)	(7)
Hillsboro Extension (Portland, OR)	(7)	(7)
N/S LRT (Salt Lake City, UT)	(7)	(7)
Tasman West LRT (San Jose, CA)	(7)	(7)
Skyway Express (Jacksonville, FL)	(7)	(7)
Red Line (Los Angeles, CA)	(7)	(7)
(b)		
North Line Extension (Atlanta, GA)	(7)	(7)
Airport Busway (Pittsburgh, PA)	(7)	(7)
Southwest Light Rail (Denver, CO)	(7)	(7)
University Ext (Salt Lake City, UT)	(12)	(12)
St Clair Extension (St Louis, MO)	(7)	(7)
North Central Ext (Dallas, TX)	(12)	(12)
BART to SFO (San Francisco, CA)	(12)	(12)
Med Center Ext (Salt Lake City, UT)	(12)	(12)
South LRT (Sacramento, CA)	(12)	(12)
Piers Transitway (Boston, MA)	(12)	(12)
Largo Extension (Washington, DC)	(12)	(12)
Interstate MAX (Portland, OR)	(12)	(12)
Hiawatha (Minneapolis, MN)	(12)	(12)
Med Center Ext (Memphis, TN)	(12)	(12)
Tren Urbano (San Juan, PR)	(12)	(12)
Reconstruction II (Pittsburgh, PA)	(12)	(12)
Mission Valley East (San Diego, CA)	(12)	(12)

Table 8 (continued)

Project name	Ridership (average weekday boardings)	
	Forecast	Actual
Douglas Reconstr. (Chicago, IL)	(12)	(12)
Elizabeth Link (Newark, NJ)	(12)	(12)
Hudson Bergen I (Jersey City, NJ)	(12)	(12)
Hudson Bergen II (Jersey City, NJ)	(12)	(12)
North Central (Chicago, IL)	(12)	(12)
Southwest (Chicago, IL)	(12)	(12)
UP West Ext (Chicago, IL)	(12)	(12)
Southeast Corridor (Denver, CO)	(12)	(12)
Central Double Track (Baltimore) (c)	(12)	(12)
Ft Lauderdale Dbl-Track (Miami)	(12)	(12)
South Corridor (Charlotte, NC)	(13)	(13)
Sprinter light rail (Oceanside, CA)	(13)	(13)
Euclid Corridor (Cleveland, OH)	(14)	(14)
East Valley (Phoenix, AZ)	(15)	(15)
Frontrunner N (Salt Lake City, UT)	(15)	(15)
Gold Line Ext. (Los Angeles, CA)	(15)	(15)
Central, Airport Links (Seattle)	(15)	(15)
Westside Express (Portland, OR)	(15)	(15)
Green Line (Portland, OR)	(16)	(16)
Northstar (Minneapolis, MN)	(15)	(15)
NW–SE Line (Dallas, TX)	(16)	(16)
The Tide (Norfolk, VA)	(17)	(17)
Mountainlink (Flagstaff, AZ)	(16)	(16)

Table 9 Funding, scale, and experience variables for projects in study sample (a) (1/3), (b) (2/3) and (c) (3/3)

Project name	Federal funding share (%)	Project sequence	Project length (miles)	Transit mode	System mileage at time of ridership forecast	Project capital cost (millions)
(a)						
Heavy Rail (Baltimore, MD)	79	Initial line	7.6	Heavy rail	0	$790
Heavy Rail (Washington, DC)	67	Initial line	60.5	Heavy rail	0	$4375
Light Rail (Buffalo, NY)	79	Initial line	6.4	Light rail	0	$536
People Mover (Miami, FL)	53	Initial line	2.0	People mover	0	$153
Benfield Transitway (Portland, OR)	83	Initial line	2.9	Light rail	0	$240
Light Rail (Pittsburgh, PA)	80	Initial line	15.1	Light rail	0	$537
People Mover (Detroit, MI)	79	Initial line	10.5	People mover	0	$197
Light Rail (Sacramento, CA)	59	Initial line	18.3	Light rail	0	$172
El Cajon Extension (San Diego, CA)	61	Expansion	11.1	Light rail	15.9	$103
Guadalupe (San Jose, CA)	68	Initial line	20.0	Light rail	0	$380
Orange Line (Chicago, IL)	67	Expansion	9.0	Heavy rail	112	$522
SW Transitway (Houston, TX)	63	Renovation	9.7	Transitway	NA	$98
Metrolink (St Louis, MO)	75	Initial line	18.0	Light rail	0	$464
Metromover Extensions (Miami, FL)	59	Expansion	2.5	People mover	1.9	$228
Metro Extension (Baltimore, MD)	78	Expansion	1.5	Heavy rail	14	$353
Colma station (San Francisco, CA)	60	Expansion	0.9	Heavy rail	98.3	$180
South Oak Cliff (Dallas, TX)	44	Initial line	9.6	Light rail	0	$360
LRT Extensions (Baltimore, MD)	73	Expansion	7.3	Light rail	22	$116
Hillsboro Extension (Portland, OR)	73	Expansion	17.1	Light rail	15.1	$964
N/S LRT (Salt Lake City, UT)	82	Initial line	15	Light rail	0	$299
Tasman West LRT (San Jose, CA)	75	Initial line	7.6	Light rail	0	$325
Skyway Express (Jacksonville, FL)	50	Initial line	2.5	People mover	0	$137
Red Line (Los Angeles, CA)	NA	Initial line	17.0	Heavy rail	0	NA
(b)						
Airport Busway (Pittsburgh, PA)	80	Renovation	6.1	Transitway	NA	$322

Table 9 (continued)

Project name	Federal funding share (%)	Project sequence	Project length (miles)	Transit mode	System mileage at time of ridership forecast	Project capital cost (millions)
Southwest Light Rail (Denver, CO)	68	Expansion	8.7	Light rail	0	$178
University Ext (Salt Lake City, UT)	90	Expansion	2.5	Light rail	NA	$108
St Clair Extension (St Louis, MO)	72	Expansion	17.0	Light rail	0	$339
North Central Ext (Dallas, TX)	76	Expansion	12.5	Light rail	0	$437
BART to SFO (San Francisco, CA)	48	Expansion	8.7	Heavy rail	98.3	$1552
Med Center Ext (Salt Lake City, UT)	63	Expansion	1.5	Light rail	NA	$85
South LRT (Sacramento, CA)	52	Expansion	6.3	Light rail	18.3	$219
Piers Transitway (Boston, MA)	55	Renovation	1.0	Transitway	NA	$600
Largo Extension (Washington, DC)	85	Expansion	3.1	Heavy rail	89.0	$426
Interstate MAX (Portland, OR)	87	Expansion	5.8	Light rail	15.1	$324
Hiawatha (Minneapolis, MN)	55	Initial line	11.6	Light rail	0	$697
Med Center Ext (Memphis, TN)	103	Expansion	2.0	Light rail	5.0	$58
Tren Urbano (San Juan, PR)	32	Initial line	10.7	Heavy rail	0	$2228
Reconstruction II (Pittsburgh, PA)	61	Expansion	13	Light rail	12.0	$385
Mission Valley East (San Diego, CA)	68	Expansion	5.9	Light rail	27.0	$506
Douglas Reconstr. (Chicago, IL)	87	Renovation	6.6	Heavy rail	NA	$441
Elizabeth Link (Newark, NJ)	81	Initial line	1.0	Light rail	0	$208
Hudson Bergen I (Jersey City, NJ)	69	Initial line	9.3	Light rail	0	$860
Hudson Bergen II (Jersey City, NJ)	74	Expansion	6.1	Light rail	0	$886
North Central (Chicago, IL)	62	Renovation	6.3	Commuter rail	NA	$217
Southwest (Chicago, IL)	56	Expansion	11	Commuter rail	468	$185
UP West Ext (Chicago, IL)	88	Expansion	8.5	Commuter rail	468	$106
Southeast Corridor (Denver, CO)	62	Expansion	19.1	Light rail	5.3	$851
Central Double Track (Baltimore)	81	Renovation	9.4	Light rail	NA	$152

Table 9 (continued)

Project name	Federal funding share (%)	Project sequence	Project length (miles)	Transit mode	System mileage at time of ridership forecast	Project capital cost (millions)
(c)						
Ft Lauderdale Dbl-Track (Miami)	58	Renovation	43.6	Commuter rail	NA	$346
Blue line (Charlotte, NC)	43	Initial line	9.6	Light rail	0	$463
Sprinter light rail (Oceanside, CA)	32	Initial line	22.0	Light rail	0	$478
Euclid Corridor (Cleveland, OH)	85	Initial line	7.1	Rapid bus	0	$168
East Valley (Phoenix, AZ)	46	Initial line	19.7	Light rail	0	$1405
Frontrunner N (Salt Lake City, UT)	80	Initial line	44.0	Commuter rail	0	$614
Gold Line Ext. (Los Angeles, CA)	78	Expansion	6.0	Light rail	42.0	$899
Central, Airport Links (Seattle)	20	Initial line	15.6	Light rail	0	$2558
Westside Express (Portland, OR)	43	Initial line	14.7	Commuter rail	0	$162
Green Line (Portland, OR)	76	Expansion	14.5	Light rail	32.2	$576
Northstar (Minneapolis, MN)	53	Initial line	40	Commuter rail	0	$309
NW–SE Line (Dallas, TX)	50	Expansion	20.9	Light rail	20	$1406
The Tide (Norfolk, VA)	53	Initial line	7.3	Light rail	0	$315
Mountainlink (Flagstaff, AZ)	76	Initial line	4.0	Rapid bus	0	$8

Table 10 Sources of funding, scale, and experience variables for projects in study sample (a) (1/3), (b) (2/3) and (c) (3/3)

Project name	Federal funding share	Project sequence	Project length (miles)	Transit mode	System mileage at time of ridership forecast	Project capital cost (millions)
(a)						
Heavy Rail (Baltimore, MD)	(1)	(1)	(1)	(1)	(1)	(1)
Heavy Rail (Washington, DC)	(1)	(1)	(1)	(1)	(1)	(1)
Heavy Rail (Miami, FL)	(1)	(1)	(1)	(1)	(1)	(1)
Light Rail (Buffalo, NY)	(1)	(1)	(1)	(1)	(1)	(1)
People Mover (Miami, FL)	(1)	(1)	(1)	(1)	(1)	(1)
Benfield Transitway (Portland, OR)	(1)	(1)	(1)	(1)	(1)	(1)
Light Rail (Pittsburgh, PA)	(1)	(1)	(1)	(1)	(1)	(1)
People Mover (Detroit, MI)	(1)	(1)	(1)	(1)	(1)	(1)
Light Rail (Sacramento, CA)	(1)	(1)	(1)	(1)	(1)	(1)
El Cajon Extension (San Diego, CA)	(20)	(7)	(7)	(7)	(21)	(7)
Guadalupe (San Jose, CA)	(20)	(7)	(7)	(7)	(7)	(7)
Orange Line (Chicago, IL)	(20)	(7)	(7)	(7)	(22)	(7)
SW Transitway (Houston, TX)	(20)	(7)	(7)	(7)	NA	(7)
Metrolink (St Louis, MO)	(23)	(7)	(7)	(7)	(7)	(7)
Metromover Extensions (Miami, FL)	(24)	(7)	(7)	(7)	(7)	(7)
Metro Extension (Baltimore, MD)	(20)	(7)	(7)	(7)	(2)	(7)
Colma station (San Francisco, CA)	(25)	(7)	(7)	(7)	(22)	(7)
South Oak Cliff (Dallas, TX)	(26)	(7)	(7)	(7)	(7)	(7)
LRT Extensions (Baltimore, MD)	(26)	(7)	(7)	(7)	(7)	(7)
Hillsboro Extension (Portland, OR)	(26)	(7)	(7)	(7)	(1)	(7)
N/S LRT (Salt Lake City, UT)	(27)	(7)	(7)	(7)	(7)	(7)
Tasman West LRT (San Jose, CA)	(27)	(7)	(7)	(7)	(7)	(7)
Skyway Express (Jacksonville, FL)	(28)	(7)	(7)	(7)	(7)	(7)
Red Line (Los Angeles, CA)	NA	(7)	(7)	(7)	(7)	NA

Table 10 (continued)

Project name	Federal funding share	Project sequence	Project length (miles)	Transit mode	System mileage at time of ridership forecast	Project capital cost (millions)
(b)						
Airport Busway (Pittsburgh, PA)	(28)	(7)	(7)	(7)	NA	(7)
Southwest Light Rail (Denver, CO)	(27)	(7)	(7)	(7)	(30)	(7)
University Ext (Salt Lake City, UT)	(27)	(12)	(12)	(12)	(7)	(12)
St Clair Extension (St Louis, MO)	(29)	(7)	(7)	(7)	(7)	(7)
North Central Ext (Dallas, TX)	(29)	(12)	(12)	(12)	(12)	(12)
BART to SFO (San Francisco, CA)	(31)	(12)	(12)	(12)	(12)	(12)
Med Center Ext (Salt Lake City, UT)	(32)	(12)	(12)	(12)	NA	(12)
South LRT (Sacramento, CA)	(27)	(12)	(12)	(12)	(1)	(12)
Piers Transitway (Boston, MA)	(33)	(12)	(12)	(12)	NA	(12)
Largo Extension (Washington, DC)	(34)	(12)	(12)	(12)	(35)	(12)
Interstate MAX (Portland, OR)	(31)	(12)	(12)	(12)	(1)	(12)
Hiawatha (Minneapolis, MN)	(27)	(12)	(12)	(12)	(12)	(12)
Med Center Ext (Memphis, TN)	(27)	(12)	(12)	(12)	(36)	(12)
Tren Urbano (San Juan, PR)	(31)	(12)	(12)	(12)	(12)	(12)
Reconstruction II (Pittsburgh, PA)	(27)	(12)	(12)	(12)	(12)	(12)
Mission Valley East (San Diego, CA)	(31)	(12)	(12)	(12)	(7, 21)	(12)
Douglas Reconstr. (Chicago, IL)	(31)	(12)	(12)	(12)	NA	(12)
Elizabeth Link (Newark, NJ)	(27)	(12)	(12)	(12)	(12)	(12)
Hudson Bergen I (Jersey City, NJ)	(32)	(12)	(12)	(12)	(12)	(12)
Hudson Bergen II (Jersey City, NJ)	(31)	(12)	(12)	(12)	(12)	(12)
North Central (Chicago, IL)	(37)	(12)	(12)	(12)	NA	(12)
Southwest (Chicago, IL)	(37)	(12)	(12)	(12)	(38)	(12)
UP West Ext (Chicago, IL)	(37)	(12)	(12)	(12)	(38)	(12)

Table 10 (continued)

Project name	Federal funding share	Project sequence	Project length (miles)	Transit mode	System mileage at time of ridership forecast	Project capital cost (millions)
Southeast Corridor (Denver, CO)	(31)	(12)	(12)	(12)	(30)	(12)
Central Double Track (Baltimore)	(31)	(12)	(12)	(12)	NA	(12)
(c)						
Ft Lauderdale Dbl-Track (Miami)	(33)	(12)	(12)	(12)	NA	$346
South Corridor (Charlotte, NC)	(31)	(13)	(13)	(13)	(13)	$463
Sprinter light rail (Oceanside, CA)	(31)	(13)	(13)	(13)	(13)	$478
Euclid Corridor (Cleveland, OH)	(31)	(14)	(14)	(14)	(14)	$168
East Valley (Phoenix, AZ)	(34)	(15)	(15)	(15)	(15)	$1405
Frontrunner N (Salt Lake City, UT)	(34)	(15)	(15)	(15)	(15)	$614
Gold Line Ext. (Los Angeles, CA)	(34)	(15)	(15)	(15)	(39)	$899
Central, Airport Links (Seattle)	(34)	(15)	(15)	(15)	(15)	$2558
Westside Express (Portland, OR)	(31)	(15)	(15)	(15)	(15)	$162
Green Line (Portland, OR)	(34)	(16)	(16)	(16)	(1, 7)	$576
Northstar (Minneapolis, MN)	(34)	(15)	(15)	(15)	(15)	$309
NW–SE Line (Dallas, TX)	(34)	(16)	(16)	(16)	(40)	$1406
The Tide (Norfolk, VA)	(34)	(17)	(17)	(17)	(17)	$315
Mountainlink (Flagstaff, AZ)	(34)	(16)	(16)	(16)	(16)	$8

Table 11 External control variables for projects in study sample (a) (1/3), (b) (2/3) and (c) (3/3)

Project name	State average price per gallon of gasoline at time of…		County population (thousands) at time of…		State unemployment rate (June, seasonally adjusted) at time of…	
	Ridership forecast	Observed ridership	Ridership forecast	Observed ridership	Ridership forecast	Observed ridership
(a)						
Heavy Rail (Baltimore, MD)	0.54	0.97	887	751	NA	4.3
Heavy Rail (Washington, DC)	NA	0.99	762	638	NA	7.7
Heavy Rail (Miami, FL)	0.57	0.86	1518	1875	8.3	5.0
Light Rail (Buffalo, NY)	0.63	0.94	1045	973	9.1	4.9
People Mover (Miami, FL)	1.18	0.86	1626	1875	6.2	5.0
Benfield Transitway (Portland, OR)	0.59	1.02	560	582	7.5	5.4
Light Rail (Pittsburgh, PA)	0.62	0.94	1481	1348	6.8	4.6
People Mover (Detroit, MI)	1.21	0.86	2338	2157	13.5	7.4
Light Rail (Sacramento, CA)	1.36	0.92	809	1015	7.1	5.1
El Cajon Extension (San Diego, CA)	1.05	1.51	2180	2825	7.3	5.0
Guadalupe (San Jose, CA)	1.36	1.11	1315	1532	7.1	9.3
Orange Line (Chicago, IL)	1.24	1.48	5224	5377	11.3	4.3
SW Transitway (Houston, TX)	1.06	1.24	2614	3558	7.1	6.4
Metrolink (St Louis, MO)	1.02	1.01	429	369	6.9	4.9
Metromover Extensions (Miami, FL)	0.86	1.33	1844	2259	5.2	3.8
Metro Extension (Baltimore, MD)	1.08	1.40	768	645	5.4	3.9
Colma station (San Francisco, CA)	0.85	1.51	730	777	5.3	5.0
South Oak Cliff (Dallas, TX)	1.10	1.24	1864	2280	6.3	6.4
LRT Extensions (Baltimore, MD)	1.19	1.40	736	645	6.0	3.9
Hillsboro Extension (Portland, OR)	1.21	1.38	617	676	7.2	7.3
N/S LRT (Salt Lake City, UT)	1.09	1.33	730	925	4.4	5.9
Tasman West LRT (San Jose, CA)	0.98	1.34	1513	1673	7.8	6.7
Skyway Express (Jacksonville, FL)	1.27	1.25	591	780	8.3	3.8
Red Line (Los Angeles, CA)	0.92	1.47	8794	9635	5.1	5.3
North Line Extension (Atlanta, GA)	0.99	1.30	651	882	5.3	5.1
(b)						
Airport Busway (Pittsburgh, PA)	1.12	1.29	1341	1265	7.7	5.6
Southwest Light Rail (Denver, CO)	1.19	1.37	513	561	4.3	5.6
University Ext (Salt Lake City, UT)	NA	2.18	NA	960	NA	4.0
St Clair Extension (St Louis, MO)	0.99	1.24	376	351	4.8	5.5
North Central Ext (Dallas, TX)	1.08	2.62	1999	2382	6.6	4.2
BART to SFO (San Francisco, CA)	1.10	2.80	740	799	9.4	5.3
Med Center Ext (Salt Lake City, UT)	NA	2.18	NA	960	NA	4.0
South LRT (Sacramento, CA)	1.11	2.80	1141	1374	8.0	5.3
Piers Transitway (Boston, MA)	1.15	2.71	1347	1512	6.9	4.6
Largo Extension (Washington, DC)	1.36	2.72	572	574	8.7	5.5
Interstate MAX (Portland, OR)	1.35	2.86	640	697	5.7	5.1
Hiawatha (Minneapolis, MN)	1.17	2.71	1110	1134	2.9	4.6

Table 11 (continued)

Project name	State average price per gallon of gasoline at time of…		County population (thousands) at time of…		State unemployment rate (June, seasonally adjusted) at time of…	
	Ridership forecast	Observed ridership	Ridership forecast	Observed ridership	Ridership forecast	Observed ridership
Med Center Ext (Memphis, TN)	0.99	2.62	886	920	4.3	4.4
Tren Urbano (San Juan, PR)	NA	NA	437	410	17.2	11.3
Reconstruction II (Pittsburgh, PA)	1.11	2.73	1332	1220	6.3	4.4
Mission Valley East (San Diego, CA)	1.08	2.80	2737	2976	5.9	5.3
Douglas Reconstr. (Chicago, IL)	1.12	2.70	5365	5236	4.5	4.9
Elizabeth Link (Newark, NJ)	1.07	3.07	790	767	7.6	5.1
Hudson Bergen I (Jersey City, NJ)	1.09	3.07	564	592	8.7	5.1
Hudson Bergen II (Jersey City, NJ)	1.09	3.07	564	592	8.7	5.1
North Central (Chicago, IL)	1.12	2.43	5346	5237	4.3	4.5
Southwest (Chicago, IL)	1.12	2.43	5346	5237	4.3	4.5
UP West Ext (Chicago, IL)	1.12	2.43	5346	5237	4.3	4.5
Southeast Corridor (Denver, CO)	1.07	2.76	541	579	3.7	3.6
Central Double Track (Baltimore)	1.19	3.14	657	638	3.6	4.1
Ft Lauderdale Dbl-Track (Miami)	1.02	2.59	2221	2454	3.9	4.0
South Corridor (Charlotte, NC)	0.98	2.28	660	914	3.2	10.7
Sprinter light rail (Oceanside, CA)	1.11	2.98	2624	3104	8.0	12.1
Euclid Corridor (Cleveland, OH)	1.18	2.72	1411	1278	4.5	10.1
East Valley (Phoenix, AZ)	1.07	3.33	2909	3869	4.2	9.7
Frontrunner N (Salt Lake City, UT) (c)	1.55	2.32	936	1035	5.7	7.6
Gold Line Ext. (Los Angeles, CA)	1.51	3.67	9543	9885	5.0	11.7
Central, Airport Links (Seattle)	1.55	3.67	1739	1971	5.1	9.3
Westside Express (Portland, OR)	1.50	3.74	670	726	6.2	11.8
Green Line (Portland, OR)	1.90	3.56	672	748	7.3	9.5
Northstar (Minneapolis, MN)	2.12	3.53	1122	1169	3.9	6.6
NW–SE Line (Dallas, TX)	1.29	3.39	2268	2454	4.8	6.7
The Tide (Norfolk, VA)	1.26	3.36	240	246	4.2	5.6
Mountainlink (Flagstaff, AZ)	2.25	3.37	130	137	10.3	7.5

Table 12 Sources of external control variables for projects in study sample (a) (1/3), (b) (2/3) and (c) (3/3)

Project name	State average gasoline price at time of…		County population at time of…		June central city unemployment at time of…	
	Rider-ship forecast	Observed ridership	Rider-ship forecast	Observed ridership	Rider-ship forecast	Observed ridership
(a)						
Heavy Rail (Baltimore, MD)	(41)	(41)	(42)	(42)	(44)	(44)
Heavy Rail (Washington, DC)	NA	(41)	(42)	(42)	(44)	(44)
Heavy Rail (Miami, FL)	(41)	(41)	(43)	(43)	(44)	(44)
Light Rail (Buffalo, NY)	(41)	(41)	(43)	(43)	(44)	(44)
People Mover (Miami, FL)	(41)	(41)	(43)	(43)	(44)	(44)
Benfield Transitway (Portland, OR)	(41)	(41)	(43)	(43)	(44)	(44)
Light Rail (Pittsburgh, PA)	(41)	(41)	(43)	(43)	(44)	(44)
People Mover (Detroit, MI)	(41)	(41)	(43)	(43)	(44)	(44)
Light Rail (Sacramento, CA)	(41)	(41)	(43)	(43)	(44)	(44)
El Cajon Extension (San Diego, CA)	(41)	(41)	(43)	(42)	(44)	(44)
Guadalupe (San Jose, CA)	(41)	(41)	(43)	(42)	(44)	(44)
Orange Line (Chicago, IL)	(41)	(41)	(43)	(42)	(44)	(44)
SW Transitway (Houston, TX)	(41)	(41)	(43)	(42)	(44)	(44)
Metrolink (St Louis, MO)	(41)	(41)	(42)	(42)	(44)	(44)
Metromover Extensions (Miami, FL)	(41)	(41)	(43)	(42)	(44)	(44)
Metro Extension (Baltimore, MD)	(41)	(41)	(42)	(42)	(44)	(44)
Colma station (San Francisco, CA)	(41)	(41)	(42)	(42)	(44)	(44)
South Oak Cliff (Dallas, TX)	(41)	(41)	(42)	(42)	(44)	(44)
LRT Extensions (Baltimore, MD)	(41)	(41)	(42)	(42)	(44)	(44)
Hillsboro Extension (Portland, OR)	(41)	(41)	(42)	(42)	(44)	(44)
N/S LRT (Salt Lake City, UT)	(41)	(41)	(42)	(42)	(44)	(44)
Tasman West LRT (San Jose, CA)	(41)	(41)	(42)	(42)	(44)	(44)
Skyway Express (Jacksonville, FL)	(41)	(41)	(43)	(42)	(44)	(44)
Red Line (Los Angeles, CA)	(41)	(41)	(43)	(42)	(44)	(44)
North Line Extension (Atlanta, GA)	(41)	(41)	(42)	(42)	(44)	(44)
(b)						
Airport Busway (Pittsburgh, PA)	(41)	(41)	(42)	(42)	(44)	(44)
Southwest Light Rail (Denver, CO)	(41)	(41)	(42)	(42)	(44)	(44)
University Ext (Salt Lake City, UT)	NA	(41)	NA	(42)	NA	(44)
St Clair Extension (St Louis, MO)	(41)	(41)	(42)	(42)	(44)	(44)
North Central Ext (Dallas, TX)	(41)	(41)	(42)	(42)	(44)	(44)
BART to SFO (San Francisco, CA)	(41)	(41)	(42)	(42)	(44)	(44)
Med Center Ext (Salt Lake City, UT)	NA	(41)	NA	(42)	NA	(44)
South LRT (Sacramento, CA)	(41)	(41)	(42)	(42)	(44)	(44)
Piers Transitway (Boston, MA)	(41)	(41)	(42)	(42)	(44)	(44)
Largo Extension (Washington, DC)	(41)	(41)	(42)	(42)	(44)	(44)
Interstate MAX (Portland, OR)	(41)	(41)	(42)	(42)	(44)	(44)
Hiawatha (Minneapolis, MN)	NA	(41)	NA	(42)	NA	(44)
Med Center Ext (Memphis, TN)	(41)	(41)	(42)	(42)	(44)	(44)

Table 12 (continued)

Project name	State average gasoline price at time of…		County population at time of…		June central city unemployment at time of…	
	Rider-ship forecast	Observed ridership	Rider-ship forecast	Observed ridership	Rider-ship forecast	Observed ridership
Tren Urbano (San Juan, PR)	NA	NA	(43)	(42)	(45)	(45)
Reconstruction II (Pittsburgh, PA)	(41)	(41)	(42)	(42)	(44)	(44)
Mission Valley East (San Diego, CA)	(41)	(41)	(42)	(42)	(44)	(44)
Douglas Reconstr. (Chicago, IL)	(41)	(41)	(42)	(42)	(44)	(44)
Elizabeth Link (Newark, NJ)	(41)	(41)	(42)	(42)	(44)	(44)
Hudson Bergen I (Jersey City, NJ)	(41)	(41)	(42)	(42)	(44)	(44)
Hudson Bergen II (Jersey City, NJ)	(41)	(41)	(42)	(42)	(44)	(44)
North Central (Chicago, IL)	(41)	(41)	(42)	(42)	(44)	(44)
Southwest (Chicago, IL)	(41)	(41)	(42)	(42)	(44)	(44)
UP West Ext (Chicago, IL)	(41)	(41)	(42)	(42)	(44)	(44)
Southeast Corridor (Denver, CO)	(41)	(41)	(42)	(42)	(44)	(44)
Central Double Track (Baltimore)	(41)	(41)	(42)	(42)	(44)	(44)
Ft Lauderdale Dbl-Track (Miami)	(41)	(41)	(42)	(42)	(44)	(44)
South Corridor (Charlotte, NC)	(41)	(41)	(42)	(42)	(44)	(44)
Sprinter light rail (Oceanside, CA)	(41)	(41)	(42)	(42)	(44)	(44)
Euclid Corridor (Cleveland, OH)	(41)	(41)	(42)	(42)	(44)	(44)
East Valley (Phoenix, AZ)	(41)	(41)	(42)	(42)	(44)	(44)
Frontrunner N (Salt Lake City, UT) (c)	(41)	(41)	(42)	(42)	(44)	(44)
Gold Line Ext. (Los Angeles, CA)	(41)	(41)	(42)	(42)	(44)	(44)
Central, Airport Links (Seattle)	(41)	(41)	(42)	(42)	(44)	(44)
Westside Express (Portland, OR)	(41)	(41)	(42)	(42)	(44)	(44)
Green Line (Portland, OR)	(41)	(41)	(42)	(42)	(44)	(44)
Northstar (Minneapolis, MN)	(41)	(41)	(42)	(42)	(44)	(44)
NW–SE Line (Dallas, TX)	(41)	(41)	(42)	(42)	(44)	(44)
The Tide (Norfolk, VA)	(41)	(41)	(42)	(42)	(44)	(44)
Mountainlink (Flagstaff, AZ)	(41)	(41)	(42)	(42)	(44)	(44)

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Table 12 (continued)

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