



THE EFFECT OF GASOLINE PRICES ON PUBLIC BUS RIDERSHIP IN INDIANA

Analysis and Research by
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January 2013


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EXECUTIVE SUMMARY

This study estimates the long-run and short-run effect of gasoline price changes on bus ridership in selected fixed route and demand response systems in Indiana from 2006 through 2011. We find that in the short run, a 10 percent increase in gasoline prices will increase fixed-route ridership by roughly 1.15 percent. This is an elasticity measure. Over the long run, a 10 percent increase in gasoline prices will lead to a roughly 3.4 percent increase in ridership. These findings are consistent with economic research that identifies long-run response to price changes is much higher than short-run response. We also find that demand-response riders are not sensitive to price

changes in gasoline, a finding that was expected. We then simulated the effect of gas price changes on bus transportation demand over the coming decades, under three different scenarios. Under the high gasoline price scenario (at \$5.00/gallon by 2035) we expect ridership on Indiana's bus system to triple to more than 90 million trips per year. Using long-run responsiveness and the Energy Information Administration's gasoline price forecast, we expect ridership to more than double to over 60 million riders by 2035. Using the EIA forecast and low price responsiveness we would expect ridership to rise by 50 percent to 44 million riders by 2035.



INTRODUCTION

The cost of owning and operating an automobile influences the consumer's decision to substitute automobile use for that of public transportation. Fuel prices play a large role in the cost of vehicle operation and so have, indirectly, an effect on public transit ridership. Understanding this dynamic is important to evaluate long-term trends in public transit usage. Information about the effect of gasoline prices on ridership is also an important element in effective management of public transportation systems.

This study examines the role fuel prices play in ridership in Indiana's fixed-route and demand response bus systems and provides ridership forecasts through 2035. To do so we construct a model to estimate the responsiveness of public transit ridership with respect to gasoline prices. This is referred to as a cross-price elasticity of demand. We then compare our findings with those of other researchers. We use these elasticity estimates to construct ridership forecasts under three scenarios. In the final section, we summarize our findings.

GAS PRICES AND PUBLIC TRANSIT RIDERSHIP

Gasoline prices have varied dramatically over the past half-decade, ranging from less than \$2 to more than \$4 per gallon in the Midwest. See Figure 1.

To measure the short-run effect of gasoline prices in ridership, we use the standard elasticity estimate where:

$$\xi_{R,G} = \frac{d \log(R_t)}{d \log(G_t)}$$

We construct an equation to be estimated using data on gasoline prices from the Energy Information Administration and monthly ridership in fixed-route and demand-response systems in Indiana provided by various transit systems in the state from 2006 through 2011.¹ We also include a variable accounting for a linear trend in ridership numbers, a variable which accounts for a recession and a correction for a statistical problem associated with analyzing time series data over time. This yields the equation:

$$\log(R_{it}) = \alpha + \alpha_i + \beta_1 \log(G_t) + \beta_2 REC_t + \varphi T + \phi \theta_t + \varepsilon_i$$

where $\beta_1 = \xi_{R,G} = \frac{d \log(R_t)}{d \log(G_t)}$ in a panel model, of five Indiana cities with demand response and six with fixed-route bus systems. We are also interested in estimating the long-run effect of gasoline prices, and so construct an equation where the ridership in a current month is affected by gasoline prices contemporaneously, and in the same month over each of the previous two years. In such a model, the ridership in the current month is initially estimated as:

$$\log(\hat{R}_{it}) = \gamma + \rho_1 G_{t-12} + \rho_2 G_{t-24} + \varepsilon_i$$

which replaces the dependent variable in equation 2, yielding the long run elasticity of ridership with respect to gasoline prices. Results appear in Table 1.

These results are interesting beyond the elasticity measures they were designed to provide. Our estimates point towards more growth in fixed-route transit, relative to demand response, over the short

Figure 1: Nominal Gas Prices [2005-2011]



Table 1: Elasticity Estimate Results, Fixed-Route and Demand-Response Bus Systems

Variable	Fixed Route		Demand Response	
	Short Run	Long Run	Short Run	Long Run
Intercept	11.754*** (273.40)	11.82*** (94.90)	8.133*** (180.02)	9.91*** (72.29)
Gasoline Price	0.115** (2.09)	0.34*** (4.40)	0.072 (0.98)	0.07 (0.93)
Recession	0.009 (0.49)	0.017 (0.28)	-0.010 (-0.43)	0.02 (0.64)
Trend	0.0016* (1.89)	-0.001 (-0.52)	-0.003*** (-3.91)	-0.003* (-1.68)
AR(1)	0.684*** (18.56)	0.59*** (11.12)	0.670*** (13.61)	0.53*** (6.82)
Fixed Effects	Yes	Yes	Yes	Yes
Adjusted R-squared	0.99	0.99	0.99	0.99
Durbin-Watson stat	2.22	1.96	2.57	2.10

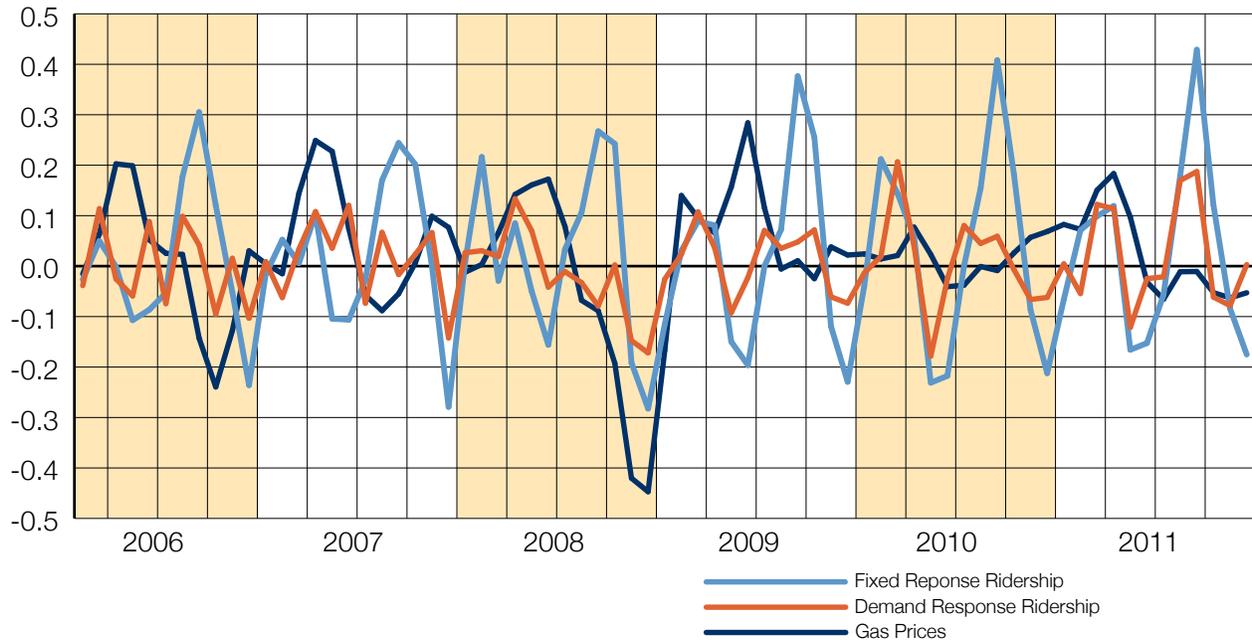
*** denotes statistically meaningful at the .01 level, ** at the .05 and * at the .10 level in standard t- or F statistics.

run, as evidenced by the coefficient on the time trend. Also, we find the recession has not played a statistically meaningful role in changes to demand for either fixed-route or demand-response systems.

We find, without surprise, that demand-response systems are insensitive to gasoline prices in the short run and long run. This we attribute to the demographic profile of users available through survey data. Demand-response passengers are not able to easily substitute between modes of transportation.

¹ Fixed-route transit systems included in the analysis are Bloomington, Gary, Indianapolis, Fort Wayne, Lafayette, and Terre Haute. Demand-response systems included in the analysis are Bloomington, Gary, Indianapolis, Fort Wayne, and Terre Haute.

Figure 2: Volatility in Gas Price and Ridership
 [Month-to-month percentage change in ridership and gasoline prices, 2006-2012]



We find that gasoline prices change fixed-route ridership behavior in the short run and long run. With an elasticity measurement of 0.115, we would find that a 10 percent increase in gasoline prices is associated with a 1.15 percent increase in passengers in the month the price change came into effect. Over the long run, rider responsiveness to gasoline prices grows to 0.34— a 10 percent increase in gasoline prices that is associated with a 3.4 percent increase in fixed-route ridership. This finding is consistent with earlier studies of long-term response to gasoline prices. However, the short-run trend disappears in this model, which is likely a function of the bulk of the observation period occurring during the recession and slow recovery. By shortening the time window of a long-run response to one year and eliminating the recession correction, we observe a slightly positive time trend in the estimates (results not shown).

OTHER STUDIES AND IMPLICATIONS

Bland (1984) estimated an inelastic short run response of transit ridership to gasoline prices. Doi and Allen (1986) report elasticities in the 0.112 to 0.113 range, which is similar to the results of

this work, which estimate an elasticity of 0.115. Wang and Skinner, (1984) find a much higher range, with short-term elasticities in the 0.08 range, and longer-term elasticities in the 0.80 range. Goodwin (1992) reviews these studies, reporting a mid-range of elasticities of 0.34, with short-run responses much lower. This finding is nearly identical to the results offered here. There are several studies that report elasticity measures for gasoline use and transportation. Hicks (2006) reports the responsiveness of alternative fuel vehicles to gasoline prices, estimating an inelastic response.

It is clear that with volatility of gasoline prices comes short-run changes to ridership. Figure 2 demonstrates the monthly percent change of ridership (fixed-route and demand-response) and nominal gasoline prices. This month-to-month movement may place significant burdens on local systems, especially if most new riders are peak-hour users of the system. Figure 2 clearly shows that spikes in gas prices are followed by spikes in fixed-route ridership.

An equally urgent problem is the trend noted in Table 1. Our estimates show that when controlling for other factors, a roughly 0.16 percent increase in ridership in fixed-route systems occurs each month. Thus, without regard to the long-run path of gasoline

prices, we can expect annual increases of fixed-route systems of just under 2.0 percent. This result suggests that an analysis of long-term demand for fixed-route bus riders in Indiana is in order.

A FORECAST OF FIXED ROUTE RIDERSHIP

Predicting the growth of transit ridership requires not only an estimate of long-term changes in gasoline prices, but also an estimate of population growth and demographic and population shifts in areas where transit systems are offered. The preceding estimates permit this type of forecast. To do so, we adapt the monthly model above to statewide, annualized levels of changes in population and gasoline prices, and offer a series of projections.

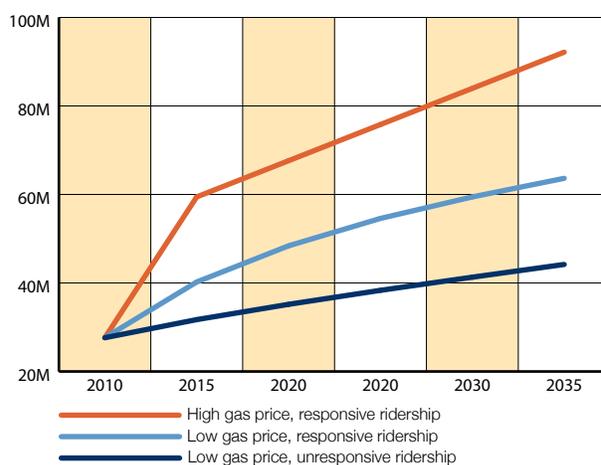
For gasoline prices, we use the Energy Information Administration’s long-run energy forecasts through 2035. This forecast predicts gasoline prices rising from \$2.68 per gallon in 2010 to \$3.71 in 2035, a result that is optimistic given the recent price of retail gasoline. We also use a slightly more pessimistic forecast, with gasoline prices rising to \$5.00 per gallon in 2035. In each model we maintain the small, short-term trend from our short-run estimates. This accounts for population growth in Indiana’s urban regions, which are certain to boost demand for public transit without regard to gasoline prices. This trend accounts for as much as 85 percent of all transit growth in the low gasoline price, low price responsiveness estimate for 2035 to less than 10 percent of transit growth in the long run responsiveness, high gasoline price scenario. Table 2 provides these forecasts, while Figure 3 illustrates the three scenarios.

These three scenarios offer slightly different futures for fixed-route public transit. Under the first scenario, the short-term ridership trend continues, with riders exhibiting little responsiveness to underlying gasoline price trends. Under the second scenario, the short-run trend continues, with riders exhibiting a more responsive adjustment to long-term changes in gasoline prices. In both of these examples, gasoline

Table 2: Annual Ridership on Fixed Route Systems

Year	Low gas price, unresponsive ridership	Low gas price, responsive ridership (most likely scenario)	High gas price, responsive ridership
2010	27,624,750	27,624,750	27,624,750
2015	31,718,738	40,221,636	59,448,462
2020	35,171,832	48,398,562	67,625,388
2025	38,336,524	54,586,507	75,802,315
2030	41,308,947	59,448,463	83,979,241
2035	44,185,237	63,647,425	92,156,167

Figure 3: Forecasts of Fixed Route Service Demand in Indiana [2010-2035]



prices remain, in inflation adjusted terms, close to their current level through 2035 as forecast by the Energy Information Administration of the U.S. Department of Energy. In our third forecast, we include the long-run trend, our estimated long-term responsiveness of riders to gasoline prices, and a higher gasoline price estimate of a slow growth to \$5.00. While we view the second forecast (the middle scenario) as the most likely outcome, under each scenario we see significant transit growth. Under our low ridership forecast, we see a roughly 60 percent growth in transit ridership through 2035, while at the high forecast we see growth in ridership exceeding 333 percent of current levels. Under our most likely forecast, which would see modest trends in urban population and gasoline prices rising to only \$3.71 in 2035 (in inflation adjusted dollars), we observe a 130 percent higher level of ridership in Indiana than that which we currently experience.

²This forecast is in 2009 constant dollars, and permits significant supply expansion over time.



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SUMMARY

Indiana's current fixed-route and demand-response systems serve very different groups of citizens who exhibit responsiveness to higher gasoline prices that are similar to citizens in other regions of the country. Estimates of growth in population of Indiana through 2035, conducted by a number of sources, suggest that all the positive growth is likely to occur in urban regions where transit is available. Our trend analysis suggests that this will continue to manifest itself into growth in fixed-route bus systems in Indiana. Taken together, the trends in responsiveness to gasoline prices and growth in urban population suggest that even under the most conservative scenarios, demand for fixed-route bus systems will grow robustly over the coming two generations.

Under alternative forecasts, some of which are offered here, this demand for fixed-route systems could be much greater. For example, gasoline price growth at a level roughly \$1 more than its recent high price could lead to a

more than tripling of demand for ridership. More important to policy deliberations is the interrelated nature of public transit and economic growth and the implications for the future of urban areas in Indiana. If public transit is viewed as a desirable good by potential residents (both households and business), who then make their location decisions based upon the availability of transit, we would observe growth in public availability generating additional residential and commercial growth. This is very much akin to the observed effects of congestion relief in highway transportation that have fed population growth in most large urban areas in the United States.

Planning and policy considerations regarding transit must consider these options, and develop a suite of options to deal with increased demand for fixed-route transit under alternative growth paths.

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