Zoning: A Barrier or Solution to Truck Parking Infrastructure Shortages?

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Abstract

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1 Results and Interpretations

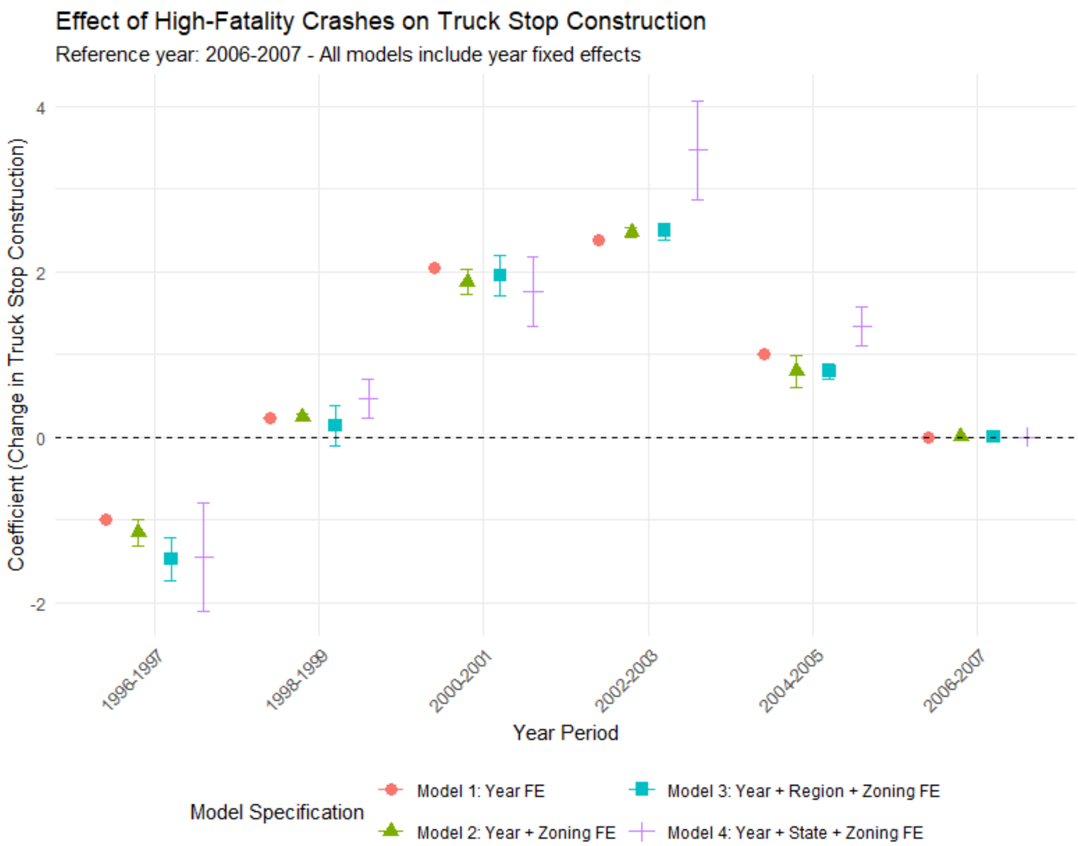

Figure 1: Time Coefficients of Event Study Model

1.1 Time Coefficients of Event Study Model

Figure 2 presents the estimated coefficients from an event study model analyzing the relationship between high-fatality truck crashes and subsequent truck stop construction across four specifications. All models include year fixed effects, with progressive controls for zoning, region, and state fixed effects. The reference period is 2006–2007.

The interaction terms for high-fatality crashes exhibit statistically significant positive coefficients across most time periods, robustly rejecting the null hypothesis of no policy response to accidents. The most pronounced effects occur in the 2002–2003 × High Fatality inter-

	Year FE	Year + Zoning FE	Year + Region + Zoning FE	Year + State + Zoning FE
1996-1997 × High Fatality	-1.000***	-1.161***	-1.477***	-1.451**
	(0.000)	(0.082)	(0.132)	(0.336)
1998-1999 × High Fatality	0.233***	0.244***	0.133	0.457**
	(0.000)	(0.016)	(0.123)	(0.120)
2000-2001 × High Fatality	2.038***	1.871***	1.949***	1.759***
	(0.000)	(0.078)	(0.122)	(0.211)
2002-2003 × High Fatality	2.384***	2.472***	2.487***	3.466***
	(0.000)	(0.031)	(0.053)	(0.306)
2004-2005 × High Fatality	1.000***	0.794***	0.791***	1.335***
	(0.000)	(0.096)	(0.049)	(0.121)
Num.Obs.	411	411	411	411
RMSE	1.72	1.70	1.67	1.41
Year FE	Yes	Yes	Yes	Yes
Zoning Category FE	No	Yes	Yes	Yes
Region FE	No	No	Yes	No
State FE	No	No	No	Yes

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

Reference period: 2006 - 2007

Effect of High-Fatality Crashes on Truck Stop Construction

Figure 2: Summary Table of Time Coefficients

action, with coefficients ranging from 2.384*** (Model 1, baseline) to 3.466*** (Model 4, state and zoning FE). These magnitudes imply that localities exposed to high-fatality crashes in 2002–2003 constructed approximately 2.4 to 3.5 additional truck stops over the subsequent decade, relative to the reference period. The lagged response aligns with infrastructure development timelines, as the 2002–2003 effects likely reflect construction initiated in response to crashes occurring 5 years prior, consistent with planning, permitting, and construction phases.

Coefficients for 2000–2005 interactions are uniformly positive and statistically significant ($p < 0.001$ in most specifications). For instance, Model 3 (year, region, and zoning FE) yields a coefficient of 2.487*** for 2002–2003, suggesting localities increased truck stop supply by roughly 2.5 units over ten years following a high-fatality crash. The results are robust across specifications, with declining RMSE (1.72 to 1.41) and stable significance levels as fixed effects are added.

1.2 Zoning Category and Fixed Effects

Figure 4 and Figure 3 present coefficient estimates for zoning categories across three model specifications, revealing findings that challenge initial hypotheses. Contrary to expectations, zoning category fixed effects exhibit negligible explanatory power, with coefficients for Exclusion, Reform, and Wild Texas zones remaining statistically insignificant in nearly all models. This undermines assumptions that restrictive zoning (e.g., Exclusion zones) systematically constrains construction or that liberalized zoning (Reform zones) consistently facilitates it. For Exclusion Zones, coefficients are insignificant in Model 1 (0.145, $p=0.271$) and Model 3 (0.048, $p=0.616$), with only a marginally positive effect in Model 2 (0.740+, $p<0.1$), suggesting limited evidence of regulatory suppression. Similarly, Reform

Figure 3: Zoning Category Coefficients Plot

	Year FE Only	Year + Region FE	Year + State FE
Exclusion	0.145	0.740+	0.048
	(0.271)	(0.335)	(0.616)
Reform	-0.540+	-0.433	-0.217
	(0.226)	(0.228)	(0.192)
Wild Texas	0.020	-0.079	0.018
	(0.364)	(0.387)	(0.502)
Num.Obs.	411	411	411
Year FE	Yes	Yes	Yes
Region FE	No	Yes	No
State FE	No	No	Yes

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Reference category: Traditional. All models include year fixed effects.

Effect of Zoning Categories on Truck Stop Construction (2006-2016)

Figure 4: Zoning Category Coefficients Table

Zones show a marginally negative coefficient in Model 1 (-0.540+, p<0.1), but this effect disappears when region or state-level fixed effects are introduced, implying that spatial heterogeneity rather than zoning itself may drive observed patterns. Wild Texas Zones further reinforce null results, with coefficients consistently near zero (e.g., -0.079 in Model 2, p=0.387). Collectively, these results question the presumed causal role of zoning categories in shaping construction outcomes, highlighting the need to consider alternative mechanisms.

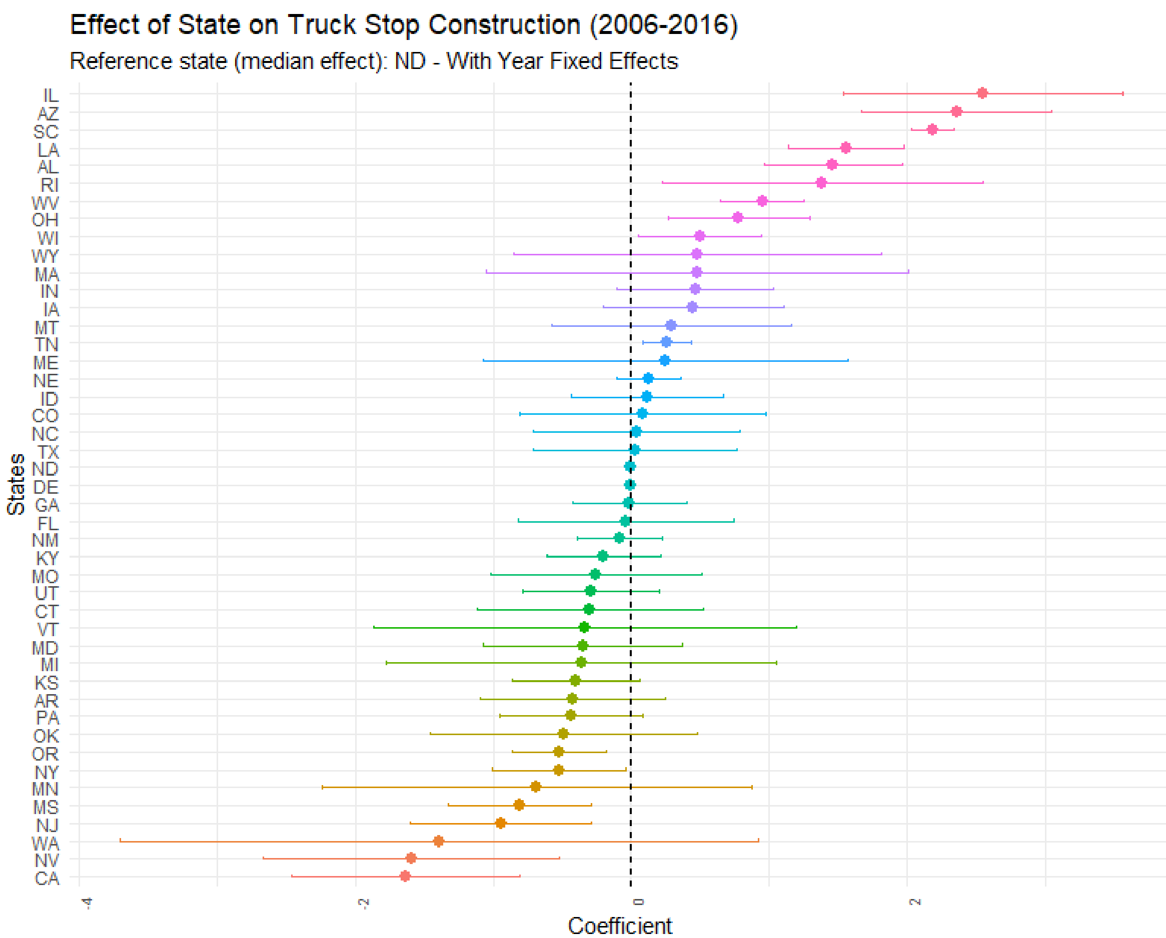

Figure 5: Coefficient of State Fix Effect

Figure 5 presents the estimated state fixed effects on truck stop construction between 2006 and 2016, with North Dakota serving as the reference category. The coefficients represent deviations from the median effect, accounting for year fixed effects.

Economically, states with significantly positive coefficients, such as Illinois and Arizona, may have more favorable regulatory environments, higher demand for truck stops, or less restrictive zoning laws. Conversely, states with large negative coefficients, such as California and New York, likely impose stricter land-use regulations, face higher land costs, or have geographical constraints limiting truck stop expansion.

The confidence intervals indicate the statistical uncertainty around these estimates. Wider intervals suggest greater variability in truck stop construction within a state, potentially due to heterogeneous local policies or smaller sample sizes.

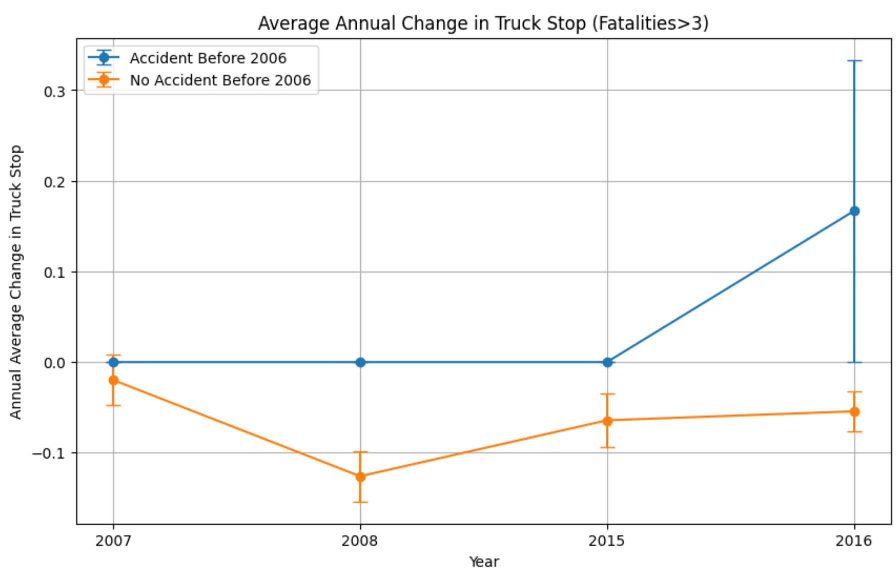

Figure 6: Parallel Trends Counties with accident Against without accident before 2006

1.3 Parallel Trends

The results suggest that pre-treatment trends in truck stop construction are similar across treated and control group. In Figure 6, counties that experienced high-fatality accidents before 2006 consistently exhibit a higher rate of truck stop construction relative to coun-

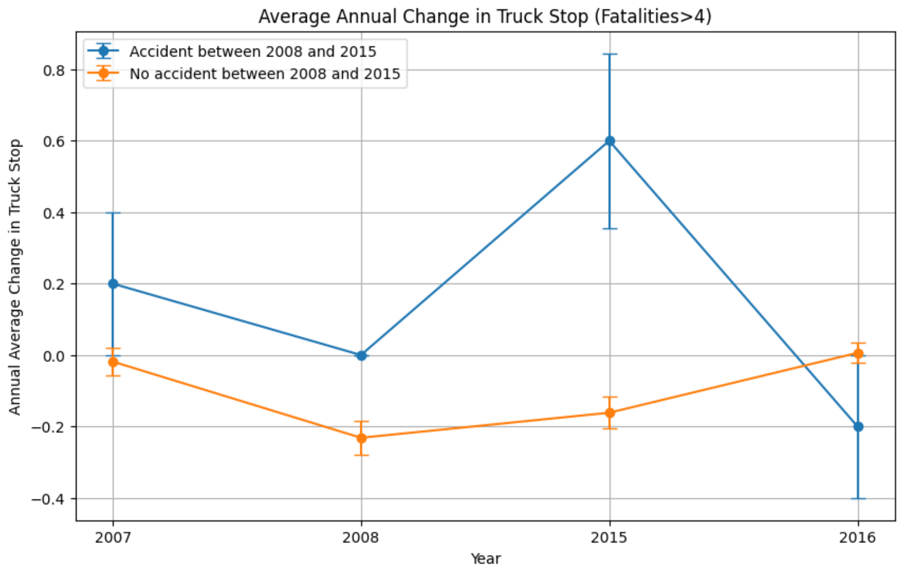

Figure 7: Parallel Trends Counties with accident Against without accident between 2008 and 2015

ties without such accidents. This is expected, given that accidents could signal a need for increased infrastructure, reinforcing our estimates. Meanwhile, Figure 7 demonstrates parallel trends before the accident period (2008-2015). After 2015, a clear divergence emerges, with accident-prone counties experiencing a sharp increase in truck stop construction (+0.6 annual change). This pattern supports a causal interpretation: post-accident infrastructure responses drive the observed increase, rather than pre-existing trends or omitted variables. These results suggest that bias due to non-parallel pre-treatment trends is unlikely to be a significant issue.

1.4 Bias

A potential source of *downward bias* in our estimates arises from unobserved capacity expansions at existing truck stops. Because the data set captures only new construction (i.e., the establishment of additional truck stops) rather than expansions of current facilities, any increase in capacity that does not involve constructing an entirely new site remains unaccounted for. As a result, the observed impact on truck stop supply may be understated relative to the true effect.

Additionally, concerns might arise regarding the time variation of zoning classifications. However, empirical evidence suggests that zoning regimes or classifications tend to remain stable over time (McLaughlin 2012). In regions characterized by a particular zoning regime, there appears to be a tendency to reinforce existing regulatory frameworks. In fact, more restrictive zoning categories often become increasingly exclusive as they mature, effectively "doubling down" on their initial properties. This self-reinforcing characteristic may deter new truck stop development, further exacerbating the downward bias in our estimates due to unobserved capacity expansions. Lastly, potential omitted variables such as lobbying activities by trucking firms could further distort our findings, although the overall direction of this bias remains uncertain.

2 Related Literature

The present study contributes uniquely to the literature on transportation infrastructure by examining truck stop construction as a localized response to high-fatality truck crashes a topic that, to our knowledge, has not been addressed with a comparable data-set. Prior research has primarily focused on infrastructure investments in broader transportation networks or on the impact of land use regulations on housing development McLaughlin (2012) . This leaves us with no comparable estimates.

3 Policy Implications and Conclusion

The results indicate that most localities *self-regulate* truck stop supply in response to safety concerns, suggesting that widespread top-down interventions may be unnecessary. In the wake of severe accidents, counties appear to respond by establishing additional truck stops, thereby mitigating shortages. This market-driven adjustment aligns with a broader pattern in which local stakeholders address capacity constraints when they become salient.

Nevertheless, several outlier states ,as California, Nevada, New York, New Jersey, Mississippi, and Oregon, exhibit persistent shortages (Figure 5). These regions may require more targeted policy interventions to overcome entrenched regulatory barriers, geographic constraints, or other structural issues that impede adequate truck stop provision. While the impact of zoning classifications appears minimal in most settings, localized reforms or incentives in these high-demand corridors could alleviate persistent shortages and enhance freight safety.

In conclusion, the evidence supports the notion that truck stop shortages are largely addressed by local market forces in response to adverse events, reducing the need for uniform federal or state-level policy. However, policymakers should focus on *systemic failures* in select corridors, particularly where infrastructural constraints and stringent zoning regulations persist. By concentrating resources on these high-need areas, governments can more effectively promote road safety and maintain efficient freight operations. Future research should explore the deeper varying institutional contexts driving our observations.

References

McLaughlin, R. B. (2012), 'Land use regulation: Where have we been, where are we going?', *Cities* **29**, S50–S55.