Does building highways reduce traffic congestion?

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Fundamental law of highway congestions

In a seminal study, Duranton and Turner (2011) [1] finds evidence that points to the existence of the fundamental law of highway congestion in the US.: estimate of the elasticity of vehicle miles traveled (VMT) to the stock of interstate highways in US metropolitan areas is 1.03. The result means that any increase in the stock of highways is accompanied by a commensurate increase in VMT, leaving travel times unaffected.

Unobserved heterogeneity and the elasticity of VMT to highway capacity

In this study we explore the impact of unobserved heterogeneity on the elasticity of VMT to highway capacity using,
1) A partial equilibrium traffic model, 2) a spatially detailed general equilibrium model calibrated to the greater Los Angeles region,
3) Instrumental Variable Quantile Regression (IVQR) and Generalized Quantile Regression (GQR) model estimates.

A simple partial equilibrium traffic model

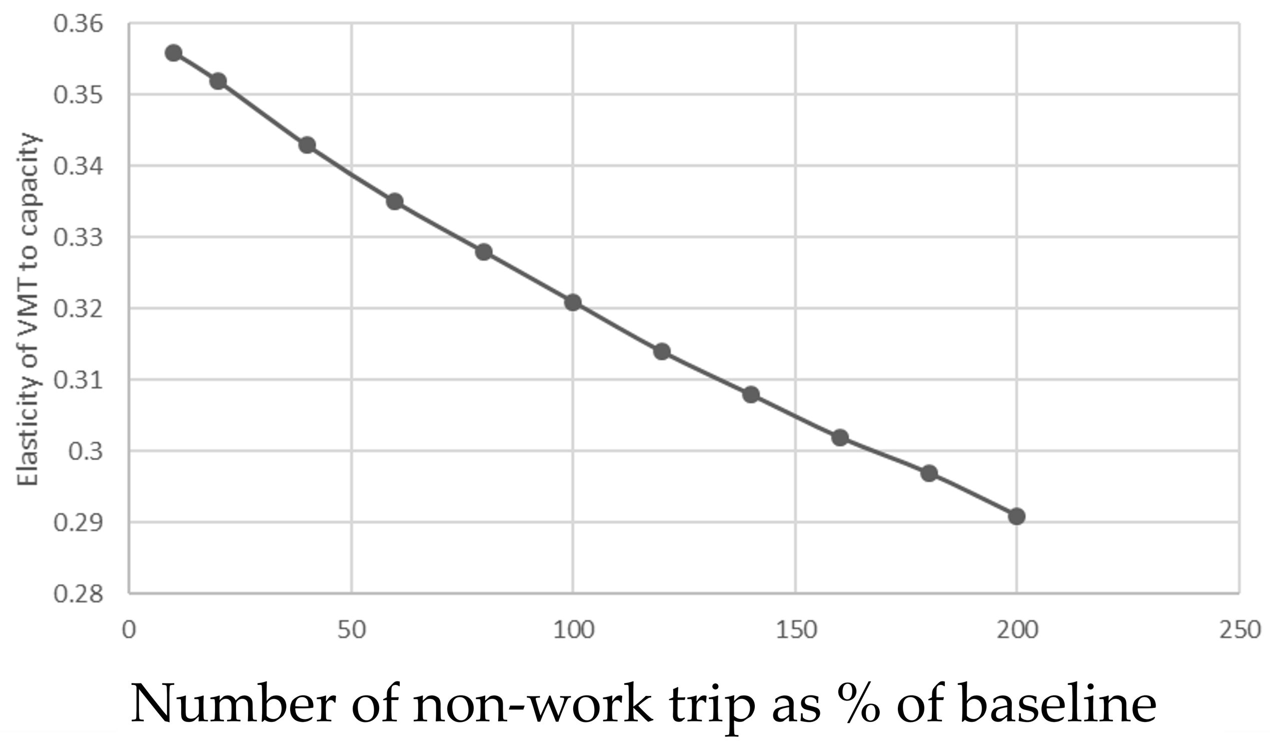
Travel demand is $P(N+x, A)$, where N is inelastic travel demand and x is discretionary travel demand. A is accessibility. $P_{N+x} < 0$, $P_A > 0$, $A_k > 0$, $A_N > 0$ (positive agglomeration externality).Travel cost is increasing and convex in N+x and goes down with capacity (k).
We show that when congestion exacerbates rapidly as road use increases, agglomeration and road capacity is important to accessibility, then

$$\frac{d\varepsilon_{VMT,k}}{dN} = \left[x_{kN} - \frac{x_k x_N}{N+x(N,k)}\right]\frac{k}{N+x(N,k)} < 0 \quad (1)$$

where, $\varepsilon_{VMT,k}$ is the elasticity of VMT to capacity. x is the equilibrium level of discretionary travel. **The elasticity declines with city size.**

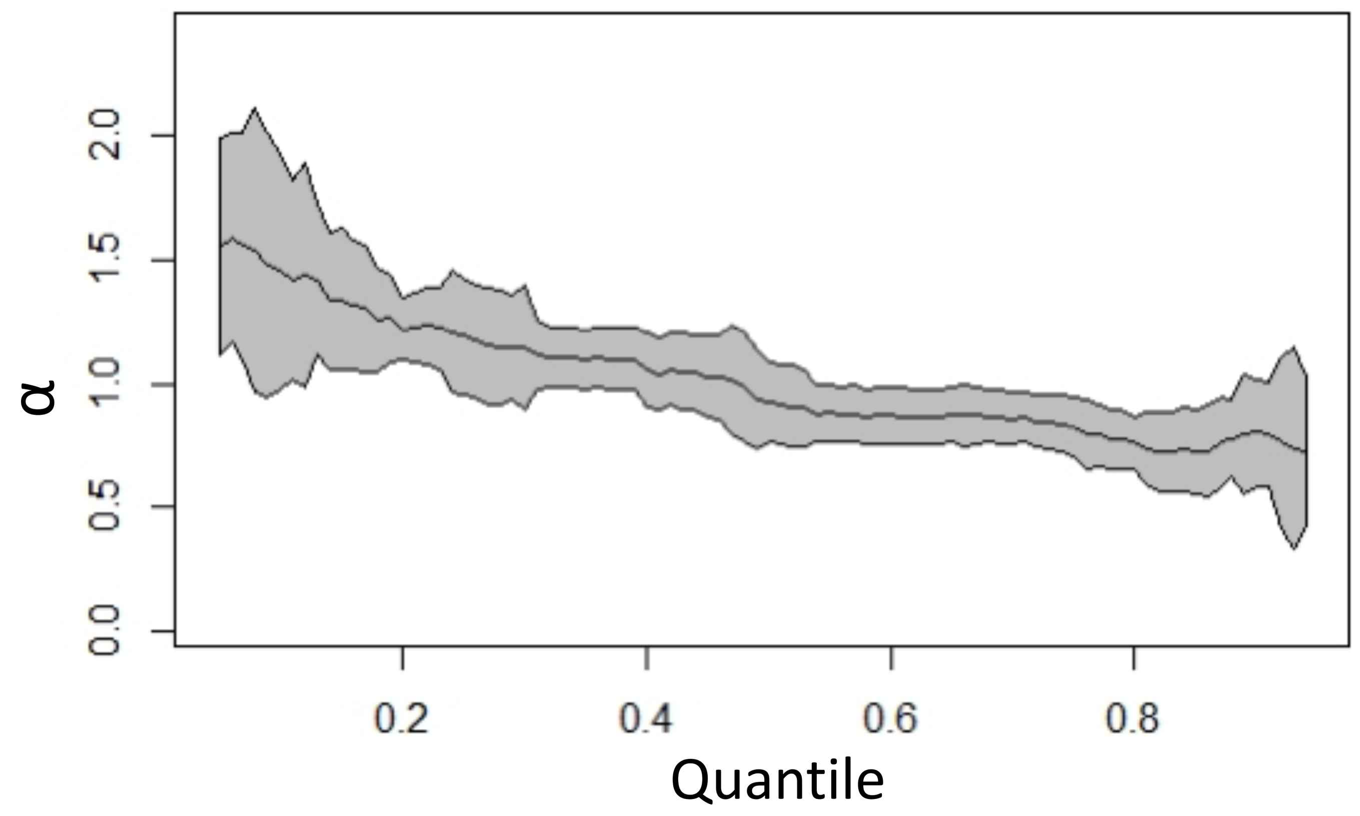
A general equilibrium model

Elasticity of VMT to capacity under different initial VMTs.



LA-TRAN is a spatial computable general equilibrium model [4] calibrated to the greater Los Angeles Region and includes both commute and non-discretionary work trips. The figure above shows that elasticity of VMT to capacity generated using LA TRAN falls with higher initial VMT as a result of higher initial non-work trips. The different initial VMTs simulate different cities with respect to initial VMT.

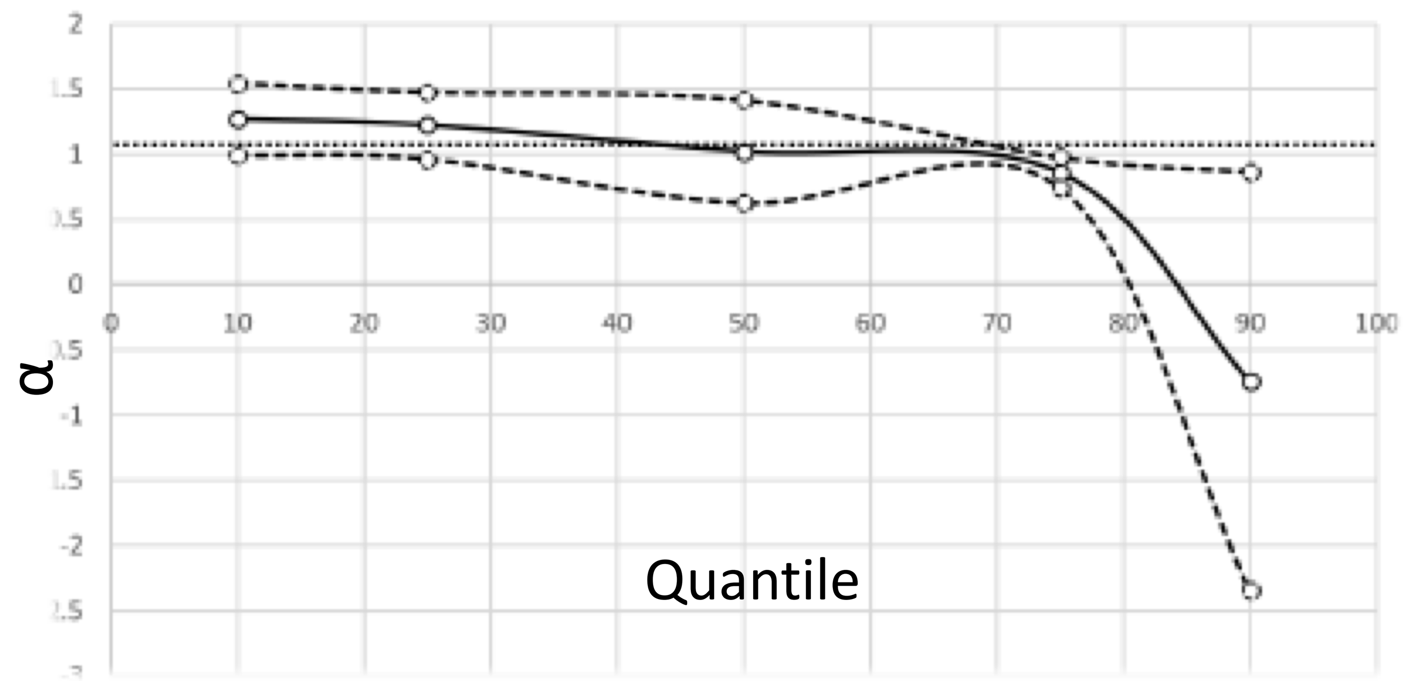
IVQR and GQR estimates



IVQR estimates of elasticity of VMT to stock of interstate highways in the US.

$$ln(Y_{it}^d) = \alpha(U_{it}^d)ln(d_{it}) + \beta(U_{it}^d)\boldsymbol{x}_{it} \quad (2) \quad \text{IVQR}$$

Y_{it}^d: Vehicle kilometers travelled,
d_{it}: Stock of interstate highways (treatment),
$\boldsymbol{x}_{it}$: Vector of observed MSA characteristics (controls),
U_{it}^d: Unobserved MSA characteristics(0,1)
i = MSA, t = Year
Shaded region/dotted lines represent 95% CI.



GQR estimates of elasticity of VMT to stock of interstate highways in the US.

$$ln(Y_{it}^d) = \alpha(\dot{U}_{it}^d)ln(d_{it}) \quad (3a)$$
$$\dot{U}_{it}^d = f(\boldsymbol{x}_{it}, U_{it}^d) \sim U(0,1) \quad (3b) \quad \text{GQR}$$

α is the elasticity of VMT to highway capacity. Both can be viewed as random coefficient models where the heterogeneity is indexed by a random variable drawn from an uniform distribution that determines the rank of the unit. Both IVQR [1] and GQR [3] shows that elasticity declines with quantiles. In both cases the median estimates are close to one but at higher quantiles the elasticity declines below one.

Conclusion

Elasticity of VMT to highway capacity is shown to decline with initial VMT and in the US the estimate fall below one showing the building roads can alleviate congestion in the most congested cities.

References

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