The Cost of Traffic: Evidence from the London Congestion Charge *by Cheng Keat Tang*

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July 19, 2021

'They say the universe is expanding. That should help with the traffic.'

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'In a move intended to lighten traffic and raise revenue for the city's subways, the New York State government agreed in March to levy congestion fees on cars navigating Manhattan' Adam Bonislawski, WSJ, May 1, 2019

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$$\frac{\partial W_i}{\partial N_i} = u_i + N_i \frac{\partial u_i}{\partial N_i}$$

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- We can't tax traffic because there isn't a "traffic market".
- Empirical question: How much are people disposed to pay to avoid traffic?

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Background

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- February 2003, London introduced the Congestion Charge Zone (CCZ) in Central London.
- A flat fee of £5.00 was levied on commuters driving into the zone between 7:00am to 6:30pm from Monday to Friday, excluding public holidays.

- The demarcated charge zone encompassed the financial centre (Bank), parliament and government offices (Palace of Westminster), major shopping belts (Oxford Circus) and tourist attractions (Trafalgar Square, Westminster Abbey, Big Ben, St Paul Cathedral) (i. e. CBD).

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- The demarcated charge zone encompassed the financial centre (Bank), parliament and government offices (Palace of Westminster), major shopping belts (Oxford Circus) and tourist attractions (Trafalgar Square, Westminster Abbey, Big Ben, St Paul Cathedral) (i. e. CBD).
- The rationale for the charge is not only to mitigate traffic bottlenecks and improve traffic flow and commuting time, but also to generate revenues to improve the public transport system.

Figure: Map of the Original Congestion Charge Zone (CCZ) & the Western Extension Zone (WEZ) (Source: TfL)

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- Air quality also improved (Beevers et al. 2005) and accident and casualty counts declined (Green et al, 2016).

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- Relying on traffic data at a road level, he finds that vehicular flow fell by 6% to 9% after the CC is first introduced in 2003, and 4% to 6% when the WEZ is implemented in 2007.
- Air quality also improved (Beevers et al. 2005) and accident and casualty counts declined (Green et al, 2016).
- The success of the original congestion charge led to the subsequent extension of the congestion charge zone to central west London (WEZ) in 2007 that covers Kensington and Chelsea borough - one of the most expensive and sought after estates in London.

How much do residents value the benefits?

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- He restricts the analysis to properties very close to the congestion charge boundary (within 1 km) to exploit the sharp discontinuity in traffic flow.

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- He restricts the analysis to properties very close to the congestion charge boundary (within 1 km) to exploit the sharp discontinuity in traffic flow.
- This ensures that properties in and out of the charged zone are almost similar other than being affected by the charge (or receiving the benefits from improved traffic conditions).

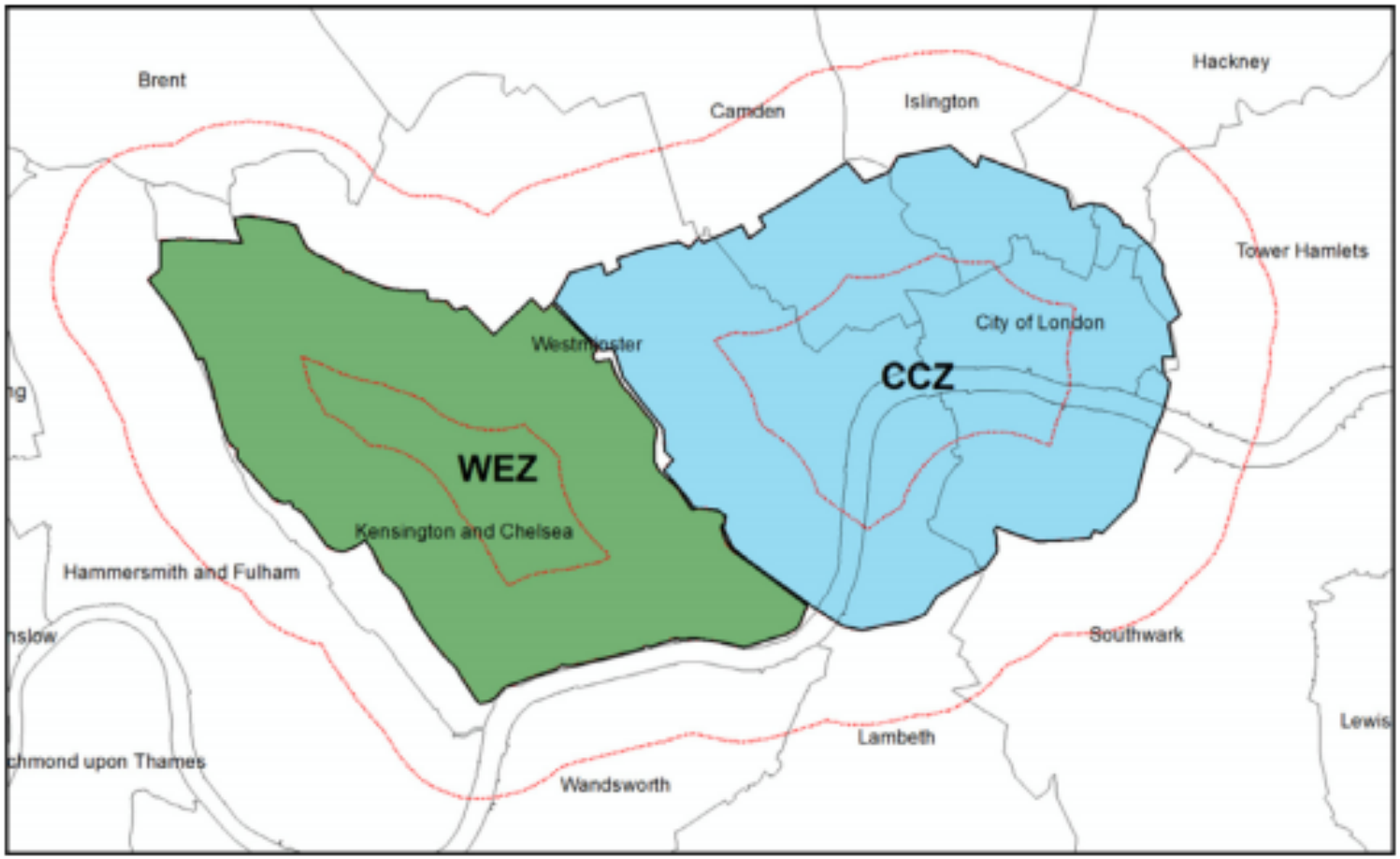

Figure: The London Congestion Charge Zone (CCZ & WEZ) and 1 km buffers (in dash line) from the LCC boundary.

How much do residents value the benefits?

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- When the WEZ was implemented, house prices rose by 4 per cent (about £30,000) relative to comparable transactions outside the zone.

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- Comparing house price changes before and after the CCZ is implemented (dif-in-dif strategy), his findings show that homeowners do pay for these benefits.
- When the WEZ was implemented, house prices rose by 4 per cent (about £30,000) relative to comparable transactions outside the zone.
- However, similar price increases did not occur in the original CCZ when it was introduced in 2003.

Description of Variables used in the analysis.

Variable	Source	Description
Dependent Variable		
Housing Price (Y_{ijkt})	Land Registry	Natural logarithm of property price of transaction i at postcode k, neighbourhood j at quarter q of year t
Traffic Flow (T_{ijkt})	Department Of Transport	Natural logarithm of traffic flow from vehicles with 4 or more wheels for transaction i at postcode k at year t
Collision Outcomes (A_{rt})	STATS19	Counts of collisions outcome (Accidents, Slight injuries, Serious injuries and Deaths) at road section r at year-quarter t
Air Pollutant (P_{mt})	London Air Quality Network	Natural logarithm of air pollutant (NO_2, NOX & $PM10$) at monitoring station m at year-month t
Housing Characteristics (X'_{it})		
New Sales	Land Registry	Dummy denoting whether transaction i is new build
Terrace	Land Registry	Dummy denoting whether the property type for transaction i is terrace

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Leasehold	Land Registry	Dummy denoting whether the tenure for transaction i is leasehold
Location/Neighbourhood Characteristics (V'_{jt})		
Distance to the CCZ/WEZ boundary	-	Elucidian distance of postcode j from the boundary of the CCZ/WEZ
Distance to nearest Grade 1 Park	Magic	Elucidian distance of nearest Grade 1 Park from postcode j in km
Counts of Heritage Buildings	Magic	Number of Heritage buildings within 200m from postcode j
River Thames View	Digimap	Binary variable = 1 if postcode j within 200m from River Thames, 0 otherwise
Minority race residents	Census 2001 & 2011	% of Asian/African/Middle Eastern and other minority race residents in OA
Unemployment rate	Census 2001 & 2011	% of unemployed working adults in OA
Uneducated residents	Census 2001 & 2011	% of residents in OA with no education qualifications
Lone parent households	Census 2001 & 2011	% of single-parent households in OA

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$$Y_{ijkt} = \pi_k + \underline{\zeta LCC_{it}} + X_i'\delta + V_{jt}'\eta + \epsilon_{ijkt} \quad (2)$$

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$$Y_{ijkt} = \alpha_k^{IV} + \underline{\beta^{IV}\widehat{T_{ijkt}}} + X_i'\phi^{IV} + V_{jt}'\omega^{IV} + \tau_t^{IV} + \varepsilon_{ijkt} \tag{3}$$

Where i stands for property, j for neighborhood, k for postcode (block) and t for time (quarterly).

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- Furthermore, , if better quality houses are sold after the charge is enforced and these attributes are not reliably accounted for, WTP estimates could be overestimated.

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- Home owners living in the charge zone are entitled to a 90% waiver of the charge. Are house price effects capturing the present value of these savings?
- Furthermore, , if better quality houses are sold after the charge is enforced and these attributes are not reliably accounted for, WTP estimates could be overestimated.
- He conducts a battery of balancing tests on observable characteristics to allay these concerns.

Results: Prelim

Panel C: Unconditional Difference in means

		Before	After	Differences
Log Traffic Flow	Outside LCC	9.98	9.72	-0.26
		(0.01)	(0.01)	(0.01)
	Inside LCC	9.88	9.58	-0.29
		(0.01)	(0.01)	(0.01)
	Differences	-0.10	-0.14	-0.03
		(0.01)	(0.01)	(0.01)
Log Sale Prices	Outside LCC	12.93	13.11	0.19
		(0.01)	(0.00)	(0.01)
	Inside LCC	13.09	13.34	0.25
		(0.01)	(0.00)	(0.01)
	Differences	0.16	0.23	0.06
		(0.01)	(0.01)	(0.01)

Figure: Effect on traffic.

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First Stage, Reduced form, IV and OLS estimates from sample 1000m to 500m from the LCC B

	(1) 1000m	(2) 900m	(3) 800m
Panel A: First Stage (Log Traffic)			
LCC	0.0918***	0.0965***	0.0985***
	(0.0168)	(0.0175)	(0.0187)
R2	0.98	0.98	0.98
Mean Traffic	17,797	17,769	17,761
Δ Traffic	1562	1635	1667
Panel B: Reduced Form (Log House Price)			
LCC	0.0280***	0.0315***	0.0375***
	(0.0100)	(0.0105)	(0.0112)
R2	0.76	0.75	0.75
Mean HP	653,898	653,376	652,714
Δ HP	18,555	20,931	24,958
Panel C: IV Regressions			
ln(Traffic)	0.3047***	0.3267***	0.3808***
	(0.1176)	(0.1188)	(0.1281)
R2	0.08	0.07	0.07
No.of Postcodes	5077	4646	4253
1st Stage F-Statistics	29.84	30.54	27.73
Panel D: Naive OLS Regressions			
ln(Traffic)	0.0197	0.0170	0.0250
	(0.0216)	(0.0224)	(0.0236)*
Obs	53,490	49,654	45,168
R2	0.76	0.75	0.75

Figure: Regression results.

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- After the introduction of the LCC, traffic flow in the zone is 8.77% lower when compared to neighborhoods outside but within 1km from the LCC boundary.
- The estimates become larger when the analysis is limited to observations closer to the charge boundary, suggesting that traffic is displaced from inside to outside the charge zone.
- This makes the policy an ideal instrument for identifying the WTP to avoid traffic because it generates large variation in local traffic conditions even between properties in the same neighbourhood just inside and outside the charge zone

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- Results reveal that a 1% increase in traffic volume corresponds to a 0.30% decrease in housing values for sales 1000m from the LCC boundary.
- This elasticity ranges from -0.33 to -0.38.

Concerns over the IV

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  This could increase the values for homes outside the zone that are better connected to public transportation nodes as driving into the zone becomes more expensive after the charge is enforced.
- Removal of Sales closest to the LCC boundary: Although restricting to properties close to the charge boundary can minimize unobserved neighbourhood differences, the spillover effects could be greater as well.

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- Estimates 2 only with these observations. Results are statistically insignificant.
- Given that these properties in the discount zones are very close to the LCC boundary, traffic conditions could be adversely affected by the charge due to traffic displacement.

Conclusion

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- IV estimates indicate that the elasticity of housing values with respect to traffic flow is 0.30. These results are robust across a battery of robustness and placebo tests.
- Based on the Census estimates on the number of dwellings, there are a total of 205,383 houses in the CCZ and WEZ. This implies that the charge has generated an aggregate windfall of around £3.8 billion for homeowners in the zone relative to those outside the zone.
- The total cost of enforcing the LCC is around £8.3 billion

Backup

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- Furthermore, based on census data, residents in the WEZ are more likely to own a car and drive more to work, stay further away from their workplace and earn much higher wages.
- All these factors could explain a larger willingness to pay to avoid traffic congestion.

	(1) Announce	(2) Shrank	(3) Expand	(4) Pcd>=5	(5) North	(6) Transport	(7) Rem Near	(8) 50m Houses
Panel A: First Stage (Log Traffic)								
LCC	0.0095	0.0266	0.0306	0.0921***	0.1165***	0.0857***	0.1032***	0.1111***
	(0.0069)	(0.0187)	(0.0260)	(0.0174)	(0.0185)	(0.0167)	(0.0199)	(0.0212)
R2	0.99	0.97	0.97	0.97	0.98	0.98	0.98	0.98
Mean Traffic	17,784	18,859	17,515	17,776	17,771	17,797	17,697	17,684
Δ Traffic	170	496	545	1565	1954	1461	1735	1860
Panel B: Reduced Form (Log House Price)								
LCC	0.0042	0.0086	0.0024	0.0262**	0.0280**	0.0319***	0.0363***	0.0305**
	(0.0178)	(0.0158)	(0.0143)	(0.0102)	(0.0110)	(0.0098)	(0.0118)	(0.0141)
R2	0.73	0.73	0.78	0.73	0.75	0.76	0.75	0.74
Mean HP	653,231	675,357	405,187	652,432	653,854	653,898	655,288	649,900
Δ HP	2767	5783	951	17,321	18,556	21,186	24,255	20,112
Panel C: IV Regressions								
ln(Traffic)	0.4463	0.0536	0.0531	0.2844**	0.2402**	0.3723***	0.3523***	0.2742**
	(1.9081)	(0.6192)	(0.4654)	(0.1187)	(0.0987)	(0.1298)	(0.1252)	(0.1299)
Obs	14,283	47,351	47,451	47,760	48,730	53,490	43,118	28,903
R2	0.04	0.10	0.16	0.07	0.07	0.07	0.08	0.06
No.of Postcodes	1905	3836	4577	3016	4556	5077	4241	2749
1st Stage F-Statistics	1.90	2.02	1.38	27.96	39.76	26.33	26.89	27.51

Figure: Robustness tests.

	(1) New Build	(2) Flat	(3) Leasehold	(4) % No Education	(5) % Minority Race	(6) % Lone Parents	(7) Unemployment Rate
LCC	0.0142	0.0010	0.0014	1.3981***	0.6432	0.1368	0.1799
	(0.0308)	(0.0040)	(0.0038)	(0.4906)	(0.6052)	(0.2420)	(0.1399)
Obs	53,490	53,490	53,490	53,490	53,490	53,490	53,490
R2	0.58	0.66	0.67	0.90	0.93	0.87	0.83
	(8) Floor Area	(9) Bathrooms	(10) Bedrooms	(11) Central Heat	(12) Garage	(13) Age	
LCC	8.1493	0.0117	0.1252	0.1240	0.1236	4.5503	
	(5.9594)	(0.0945)	(0.1511)	(0.2802)	(0.1377)	(8.9128)	
Obs	826	826	826	826	826	826	
R2	0.73	0.63	0.68	0.57	0.67	0.86	

Figure: Balancing tests.

Is the elasticity estimate reasonable?

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- The implementation of the LCC resulted in a 8.77% reduction in traffic flow that led to a 7.24% reduction in PM10. These estimates suggest that a 1% increase in traffic corresponds to a 0.83% (7.24 $\div$ 8.77) increase in PM10.

Is the elasticity estimate reasonable?

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- The implementation of the LCC resulted in a 8.77% reduction in traffic flow that led to a 7.24% reduction in PM10. These estimates suggest that a 1% increase in traffic corresponds to a 0.83% ($7.24 \div 8.77$) increase in PM10.
- Chay et al. (2005) report that the elasticity between house prices and particulate concentrations ranges from 0.20 to 0.35.

Is the elasticity estimate reasonable?

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- Plugging in the lower bound of these estimates, the estimated impact of the increase in PM10 from traffic flow on housing values is around 0.166 ($0.83\% \times 0.20$). This is approximately 55% ($0.166 \div 0.30$) of the elasticity of house price with respect to traffic flow at 0.30.

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- Plugging in the lower bound of these estimates, the estimated impact of the increase in PM10 from traffic flow on housing values is around 0.166 ($0.83\% \times 0.20$). This is approximately 55% ($0.166 \div 0.30$) of the elasticity of house price with respect to traffic flow at 0.30.
- The proportion goes to around 75% if I plug in the mid-range elasticity of 0.275.

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- Plugging in the lower bound of these estimates, the estimated impact of the increase in PM10 from traffic flow on housing values is around 0.166 ($0.83\% \times 0.20$). This is approximately 55% ($0.166 \div 0.30$) of the elasticity of house price with respect to traffic flow at 0.30.
- The proportion goes to around 75% if I plug in the mid-range elasticity of 0.275.
- The rest of the 25–45% of the effects could stem from improved traffic safety, reduced noise pollution and travel time.