THE LONDON CONGESTION CHARGE AND PROPERTY PRICES: AN EVALUATION OF THE IMPACT ON PROPERTY PRICES INSIDE AND OUTSIDE THE ZONE

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ABSTRACT:

Congestion charging in London was introduced in February 2003 to reduce traffic levels in the centre of London. Postcode sector level property prices for sectors both inside and outside the zone are investigated under the premise that the benefits of transport innovation can be captured by property prices. If housing markets are efficient, residential property prices should capture all the benefits and costs to commuters that a location offers. The aim of this investigation is to firstly compare property prices inside and outside the congestion charging zone, and secondly to measure the sensitivity of house prices to distance from the zone boundary both inside and outside the zone. The main analysis is based on the quasi-experimental differences-in-differences approach. It is found that the gap between property price inside and outside the zone has actually reduced as a result of congestion charging. Also, after the implementation of the congestion charge, the sensitivity of house prices with respect to distance from the boundary has fallen for sectors inside the zone relative to sectors outside the zone.

[1] The authors wish to thank Steve Gibbons for his guidance and suggestions, and for supplying the postcode sector level map of London, without which this analysis would not have been possible. Any errors are of course our own.
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I - INTRODUCTION

> "Congestion Charging in Central London is the most radical transport policy to have been proposed in the last 20 years and it represents a watershed in policy action"
>
> (Bannister 2003, P. 259).

Developed countries face the pressure of alleviating congestion and pollution, the inefficiencies and distortions of existing transport taxes and charges are acknowledged as a major problem. Fixed charges on trucks distort competition and fuel taxes are less predictable. Instead, governments have sought to introduce taxes directly targeted on pollution or congestion. Besides increasing efficiency in reducing pollution and congestion, these reforms also raise government revenues for infrastructure investment.

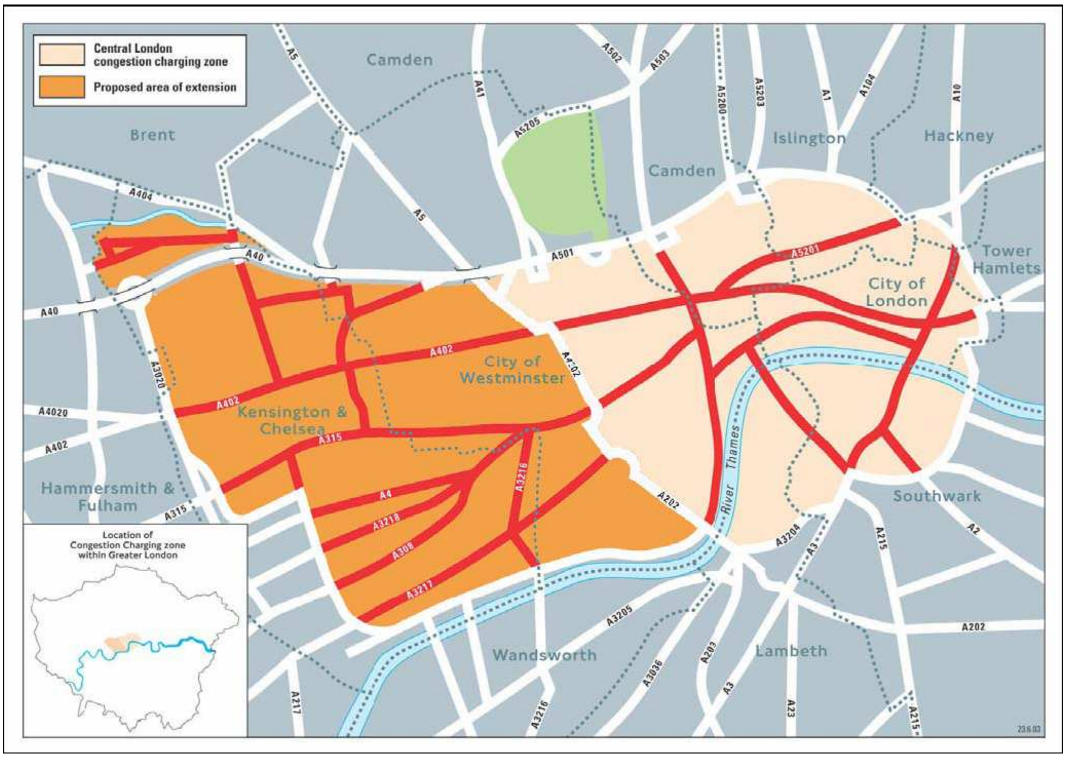
Introduced by Mayor Ken Livingstone on 17 February 2003, London's Congestion Charge (from hereon: CC) was an example of such reform. The aim of congestion charging is to reduce congestion and improve the efficiency of transportation by discouraging travellers from using motor cars and vans, thus reducing congestion and allowing for faster, less polluting journeys and more predictable journey times. A charge of £5[3] per day will be paid by drivers entering the congestion charging zone (CC-Zone) which covers an area of 22km² (see Figure 1 below). There are plans to extend the CC-Zone to cover areas to the west of the current CC-Zone as well. Charging is enforced during working hours (between 7 am and 6:30 pm Monday to

[3] The fee was raised from £5 to £8 in July 2005

Friday). The operation is made efficient by employing an electronic pricing system, which automatically tracks and identifies vehicle registration numbers instead of using physical tolls. Payment could be made through a number of ways, and those vehicles without a registered payment will be recorded and fines issued. By directly targeting the vehicles contributing to congestion within the CC-Zone, the charge can avoid distortion on competition which is usually caused by traditional fixed charges on ownership of vehicles.

FIGURE 1

THE CURRENT CHARGING ZONE AND THE PROPOSED EXTENSION



Source: Transport for London, see http://www.tfl.gov.uk/tfl/cc-ex/map.shtml.

Compared to the more volatile fuel charges, congestion charges are fixed, making much easier the planning of transportation by residents and businesses. The first year of operation has seen positive results: congestion within the CC-Zone has reduced by

30% together[4] with reduced pollution and improved service of public transport which facilitated the needs of residents well. However, congestion charging could have different impacts on areas inside and outside it. According to Prud'homme and Bocarejo (2005), there is little evidence on the impact outside the CC-Zone (page 2). This investigation aims to shed some light onto the situation.

Congestion charging can be seen as a natural experiment offering scope for socio-economic analyses. Conventional analyses of the impact of CC have focussed on estimating the economic costs and benefits of the regime since its launch in February 2003. Reports suggest that whilst the CC has fulfilled its aim of reducing traffic volumes inside the CC-Zone and increasing the take up of public transport, and that the economic costs of operating the scheme have outweighed the benefits, (see Prud'homme and Bocarejo (2005)). Gibbons and Machin (2004) argue that evaluating changes in property values is an appropriate method to appraise the economic benefits of transport innovation. And it is with this argument that this paper investigates the changes in property prices in the area surrounding the boundary of the CC-Zone.

Due to the nature of CC, one would expect to observe an asymmetric impact on property values inside and outside the CC-Zone. The most noticeable differences should occur at the boundary, this is the area that this paper will focus on. On one hand, one would expect that inside the boundary, residents will benefit from less congestion,

[4] Perkins (2004)

better air quality and the discounted CC charge amongst other factors. On the other hand, residents outside the CC-Zone face increases in transport costs through the charge directly (minus any time savings) when travelling inside the CC-Zone. They also suffer from the extra congestion outside the CC-Zone caused by drivers avoiding the CC-Zone whenever possible to avoid the fee. These issues will be elaborated on in Section III.

In what follows the issues surrounding congestion charging are briefly discussed followed by a discussion of whether the CC has been an economic success or not. The focus on property prices is then motivated, and a recent study of transport innovation on property prices is reviewed. The aim of this investigation is to firstly investigate property price trends inside and outside the CC-Zone, and secondly to measure how distance from the CC-Zone boundary is related to property prices; more formally the sensitivity of house prices to distance from the boundary. In Section III, the methodology for the empirical analyses is presented and the likely results discussed. Three specifications are presented: weighted cross sectional OLS, a random effects model and a weighted difference-in-differences estimate.

It is found that the gap between property price inside and outside the CC-Zone has actually reduced as a result of congestion charging. This result provides prima facie evidence that the undesirability of being in the CC-Zone for commercial properties, with a clientele who drive into the CC-Zone, outweighs the benefits of less traffic and the positive environment impacts. Also, after the implementation of the CC, the sensitivity of house prices with respect to distance from the boundary has fallen for sectors inside the CC-Zone relative to sectors outside the CC-Zone. This result suggests that location matters less for sectors inside the CC-Zone because all these sectors benefit from less traffic (all sectors are inside the 'firewall') and the discounted fee. Also being outside the CC-Zone is especially undesirable for those living closer to the boundary because driver use these areas as diversions to avoid entering the CC-Zone.

II - THE IMPACT OF THE CONGESTIN CHARGE AND TRANSPORT INNOVATION ON PROPERTY VALUES

As O'Sullivan (2003) mentioned, a certain level of congestion is actually efficient, the optimal level of congestion is a function of road usage demand and the costs of congestion. The optimum level of congestion should occur where the marginal social benefits of road usage (which causes congestion) equals the marginal social costs of congestion. Hence, per unit taxes or a charge should be levied which is equal to the difference of marginal social costs and marginal private costs at the optimum level of congestion to correct for any externalities.

There are different costs and benefits of CC with respect to different types of individuals. On one hand, for those who continue to drive, they pay the charge but benefit from lower traffic volumes. On the other hand, for those who cease to drive into the CC-Zone after the implementation of the CC, they avoid the charge but the time saving is partly missing; unless they switch to using buses[5] or taxis. Overall, O'Sullivan (2003) shows that at least in theory, the benefits outweigh the costs of congestion charging, though for some individuals, the savings in time are not large enough to offset the congestion charge. Incidentally, the average *value of time* for a car driver is estimated to be between just over £10 (ROCOL (2000)) and £14 per hour (DETR 1999). This means that commuters would be willing to pay £5 to cut 20-30 minutes off their journeys. O'Sullivan (2003) argues that a key consideration in the evaluation of congestion charging depends on where the revenue it generates goes. The revenue is not thrown away so it could be used to fund welfare increasing projects. O'Sullivan (2003) argues that the government should substitute congestion charging over the gasoline tax, which is currently used more widely in most of the countries.

Investigations on the impact of CC are rare and have primarily focussed on measuring the economic benefits and costs of CC. In this section the economic impact of the CC is discussed focussing on an investigation by Prud'homme and Bocarejo (2005), and then the literature on transport innovation and in particular its benefits on property prices are discussed.

Prud'homme and Bocarejo (2005) view congestion charging in London as "a mini or

[5] Bus speeds are reported to have increased by 7% (Prud'homme & Bocarejo (2005) page 11).

micro Concord" since their results show that the CC is an economic failure. They focus on the costs and benefits of operating such a system. Congestion charging has been widely accepted as a huge success technically and politically, the "zone traffic reduction objectives have been reached". The number of vehicle kilometers traveled in the CC-Zone declined by about 15%, and their speeds increased by about 17%.

Additionally, bus patronage in the CC-Zone increased. Most people in London consider the congestion charge to bring benefits to society. Moreover, the Mayor of London Ken Livingstone, was re-elected in 2004. The introduction of London congestion charge has been attributed to be the most important element of his success.

However, Prud'homme and Bocarejo (2005) argue that in terms of economics, the results of congestion charging in London do not look as good technically or politically. They point out that the pronouncements regarding the congestion charge from Transport for London (the government organization which runs the scheme) should be seen as tentative; especially in election years. They also argue that the impact of CC is still a short-term behavioural reaction that may not hold in the middle/long run. Their analysis concluded that the net costs of the charge were €73m per annum, (see Table 1). The costs of implementing the system heavily outweigh the benefits, even after taking any agglomeration effects and positive externalities which are not considered by Prud'homme & Bocarejo (2005). A positive point to take from this would be that as the system becomes more mature, the marginal costs are likely to fall.

TABLE 1
BENEFITS AND COSTS OF THE LONDON CONGESTION CHARGE

	Per day (1,000 e)	Per year ((million e)
Benefits :		
Reduction in congestion costs	272	68
Increased speed for bus users	124	31
Environmental benefits	20	5
Total, recorded benefits	414	104
Costs :		
Implementation costs	689	172
Subsidy to buses	18	5
Total, recorded costs	707	177

Source: Prud'homme & Bocarejo (2005)

In perhaps the most worthy of note research on the effect of transport innovation on property prices, Gibbons and Machin (2003a & 2004) studied the effects of the proximity to rail stations (and the frequency of services) on property prices by developing a hedonic model of house prices. In such a model, property values are considered to be a function of a bundle of identifiable and observable characteristics relating to the property; see Gatzlaff and Haurin (1997) for a critique. For example, its area, the number of rooms, whether there is a garage and its geographical characteristics, plus the socio-economic aspects regarding the area. What made their research so ground-breaking was that they also focussed on the impact of the introduction of the Jubilee Line and Docklands Light Railway extensions, what they refer to as 'transport innovation'. Their cross sectional time-series 'quasi-experimental' approach alleviates the concerns caused by previous cross sectional data studies (which do not take into account how unobserved characteristics could be correlated with the dependent and/or independent variable, for example similar studies by Ihlandfeldt (2001), Landis and Zhang (2001)). These studies also do not take into account the changing nature of the independent variable, i.e. the changing nature of rail access. The approach in the study which follows will be the cross sectional approach as well as the quasi-experimental *difference in differences* approach; considering property prices before and after the introduction of the CC inside and outside the CC-Zone.

The reason *why property prices were investigated* is outlined by Gibbons and Machin (2003a) pp. 2-3. They argue that the benefits of transport innovation can be captured by property prices because if housing markets are efficient, residential property prices should capture all the benefits and costs to commuters that a location offers. Better transport access allows households easier commutes to better paid jobs, if the CC resulted in an asymmetric impact on transport access inside and outside the CC-Zone, the impact will be picked up in the relative changes in property prices.

There is also the argument that transport innovations can bring benefits to the firm too. With data on rents and commercial property values this hypothesis can be explicitly tested. But without rents data, Gibbons and Machin (2003a) argue that residential property prices can reveal that side of the story too. They argue that 'residential prices reflect the underlying land values, which will capture the benefits of location to *all* potential users of a site. *If land is substitutable in use in the residential and business sectors, then land values reflected in residential property prices will capture the benefits to firms too*' (page 2). These are the arguments towards why property prices are investigated for our study.

Gibbons and Machin (2003a) found that a 1km reduction in London Underground and DLR stations adds 1.5% onto property prices, and a service frequency improvement by one train per-hour increases property prices by 0.2%. For their quasi-experimental difference-in-differences (DID) analysis, they find that house prices in the treatment group (houses which experienced a fall in the distance to the nearest London Underground or DLR station at the end of 1999) rose by 52%, compared with the control-group's 39%, yielding a (statistically significant) DID-estimate of 13% over a period from 1997-2001.

The estimate of 13% could undervalue the benefits of the Jubilee-Line/DLR extensions because prices should have increased prior to 1997 because investors may have anticipated these future gains. This was a finding of McDonald and Osuji (1995), who studied the impact of a new transit line linking downtown Chicago to Midway Airport. McDonald and Osuji (1995) claimed that land values might respond in anticipation of transit impact. They found that three years before the line was due to open, properties which were likely to benefit from the line experienced gains in value of 17% more than they otherwise would have been, though it is difficult to ascertain whether the increases were the actually the result of unrelated issues or price trends. If this is true, then Gibbon's and Machin's estimate should be closer to 30% since the announcement of the extension. This problem is less prominent for the purposes for our analysis because the CC plans were confirmed in February 2002, allowing only a year for investors to react.

III - METHODOLOGY AND PREDICTIONS

This is an investigation into whether the CC has affected property prices outside and inside the CC-Zone. The methodology employed will be similar to that of Gibbons and Machin (2003a), whose variable of interest was proximity to rail stations and their train frequencies. This investigation is interested in the proximity to the boundary of the CC-Zone. This investigation proceeds by discussing the likely impacts for residents inside and outside the CC-Zone before explain what the methodology undertaken do and why.

The effects on the desirability of locations relative to the boundary are unclear, and the purpose of this investigation are to try to partially clarify which are the dominant effects. A relatively unambiguous claim would be that because of the nature of the CC and the reduced traffic *inside the zone*, the effects should be different inside and outside the CC-Zone. On one hand, residents inside the CC-Zone have benefited from reduced traffic flows and discounted charges. However the commercial desirability inside the CC-Zone may fall if a significant proportion of their clientele previously drove in from outside the CC-Zone. Also, as argued earlier, if land is substitutable in residential and business use, then land values are reflected in residential property prices.

On the other hand, there is no evidence on traffic flows just *outside the CC-Zone*, traffic flows might have also decreased, but what is not so ambiguous would be the increase in traffic flows at the CC-Zone boundary, in other words, drivers avoiding entering the CC-Zone, and using the boundary as “rat runs”. Additionally it is well known that before 6.30pm commuters park their cars in areas outside the CC-Zone and wait for local radio announcements to inform them that ‘London is Free’, this must have a negative impact on the residents outside the boundary. This needs to be weighed up against the relative increase commercial desirability of this area compared with being just inside the CC-Zone, drivers do not need to pay the charge to shop here.

Further from the boundary, the effects are likely to be even more ambiguous. The CC should not have any direct bearing on commercial and residential property prices, unless its spillover effects were concentrated in specific areas. Residents in these areas who travel to work in Central London by car will experience an increase in transport costs, but there should not be too many people who fall in this category in terms of driving to work, maybe for leisure. Then there is also the issue of parking inside the CC, these costs are also very high, a £5 (and subsequently £8) charge might not be enough to discourage these commuters. Because the effects are likely to be much weaker for areas far away from the CC-Zone, most of the ‘action’ is likely to occur in the surrounding area, this *study only considers sectors which are less than ~10km away* *from the boundary.*

For the residents who continue to travel into London by car, they are likely to benefit from less congestion. However, as was found in Section II, the gains from the time savings are unlikely to compensate for the costs of the charge. Journey times need to be slashed by at least 20 minutes, yet speeds increased by 17%. For the remaining residents who travel into London by public transport (i.e. Bus), they are likely to benefit from time savings (and increased frequency of services), so an effective fall in their travel costs, these benefits would also benefit cyclists.

In an ideal world, a hedonic house price model, using full postcode unit level data should be built to conduct our analyses, such as that in Gibbons and Machin (2003a). A hedonic model would allow us to conclude that any differences the results suggest are a result of the fundamental problem that is being considered (i.e. caused by the CC). And not by factors such as the types (sizes and features) of houses in certain areas inside and outside the CC-Zone overriding the CC effect; barring unobservables being correlated to the independent variable. Their model also considered desirability issues for the areas, such as the performance of schools (see Gibbons and Machin (2003b) as to why this is important). However, because of limited time resources, this study cannot conduct such thorough and watertight study. The data which is the most broken down and freely available would be the Land Registry postcode sector level data, and this is the data that this paper shall use. Distances from each sector to the CC-Zone boundary can be easily, but labouriously measured.

Gibbons and Machin (2003a) also conducted their analyses using cross-sectional time series data, they argue that this would alleviate the problems associated with purely cross-sectional studies such as those by Ihlandfeldt (2001), Landis and Zhang (2001); namely unobserved variables being correlated with the independent or dependent variable and especially the changing nature of rail access. The argument is not as strong for our analysis of the CC because the CC boundary has not changed. If and when the *western extension* of the CC materializes, the resulting investigation would be a lot more interesting.

Using cross sectional data would also leave results vulnerable to "seasonal" fluctuations, for example if at the point in time when the snapshot was taken, houses near the CC-Zone boundary were desirable because they had specific factors. Taking multiple snapshots over time allows these effects to even themselves out. The postcode sector level data also contains information regarding the number of houses used to generate the average for the sector at every point in time, allowing the use of a weighted regression, sectors (and periods) in which there were more sales are given more weight, unfortunately in STATA, weighted analysis does not go well with panel data analysis, so both methods have to be carried out separately. The CC was introduced in February 2003 and quarterly data was downloaded for the period from 2000 Q1 to 2006 Q1.

A model similar to that of Gibbons and Machin (2003a) will be used:

$$Ln(price)_{it} = a + b*distance_i + c*(postcode\ district\ dummies) + d*(time\ trend) + e*(quarter\ dummies), \quad (1)$$

where t denotes the quarter, and i denotes the time period. The variable that this study is concerned with is *distance*, this is the *Euclidian distance* (km) from approximately the centre of the district to the closest point on the CC boundary. These distances were *manually measured* using a map of the *London Postcode Sectors (1999), published by Geoplan in association with Royal Mail*. The natural logarithm of property prices is chosen as the dependent variable because this is the variable chosen for many studies (for example Gibbons and Machin (2003a)), the coefficient estimates can then be interpreted as the unit change in the dependent variable causing a percentage change on prices. Before going into more detail about the specification and developing the hypotheses, it is important to mention some of the problems incurred regarding the data. First of all, measurements of *distance* involved crossing the Thames in some sectors (E14 3, E14 9). Secondly, the CC-Zone boundary lies inside some sectors (such as E1 6, SE1 2, SE11 4 and EC2A 3, to name but four). Thirdly, there are some sectors which are effectively split into two parts (by another sector), this poses a problem when deciding on its distance from the CC boundary (such as NW1 2 and W1H 1 to name but two). *All of these sectors were removed from the dataset*. The problems regarding the lack of residential properties *inside* the CC-Zone are compounded by the strange nature of sales. In some sectors, there are many sales one quarter, and then the sector will not appear again for many periods. Also, some sectors with sales recorded by the land registry could not be found on the map, mainly in W1 (e.g. W1B 1, W1K 5 to name but two), and likewise some sectors on the map did no have any recorded sales, either the two problems are related, or these sectors are the commercial areas. Any sectors on the map which had observations from the land registry (no matter how few) are included in the final dataset. In terms of the picture regarding how complete the panels are, outside the CC-Zone, the panels are almost perfectly balanced, with some sectors having one or two missing (zero sale) values. Inside the CC-Zone, there are only a few sectors with complete data.

The postcode district dummy variables help to control partially for the differences across the sectors, if using a fixed-effect panel estimate, these will be differenced out. Also because the distance from the CC boundary is constant, a fixed effects estimate would not be suitable. The results of a random-effect model will also be included in the analysis. A time trend is added to control for inflation and quarter dummies are added to control for seasonal effects in the property market.

Most properties inside the CC-Zone and in the surrounding areas are flats/maisonettes, so only the price of flats is considered in the analysis. This also alleviates the problem of controlling for different housing characteristics, genuine differences in house prices are more likely to occur because of the quality of housing, in terms of size etc as opposed to the type of housing.

The model in (1) will be run for the period before and after the introduction of the CC. And because we expect the effects to be felt differently inside and outside of the CC-Zone, it will also have to be run separately for the sectors inside and outside the CC-Zone. The (exponent of the) constant will indicate the price of an average property in a reference district at *t=0* and the reference quarter (Q1). The *reference district* is SW1 because this district is only one which contains sectors both inside and outside the CC-Zone[6], without a reference district, comparisons would be even more difficult.

For the *sectors outside the CC-Zone*, prior to the implementation of the CC, the sign on the coefficient on distance would be ambiguous if the model is stated correctly. Distance should have no effect if everything else was controlled for. However, in reality this will not be the case because properties closer to the centre will command higher prices ceteris paribus, and the centre is where the CC-Zone is. After the implementation of the CC, and once again assuming that the model took everything into consideration, the coefficient on distance might become positive because the areas nearest to the boundary will suffer the most. In other words, ceteris paribus, the further away from the boundary, the more desirable properties are. However, once again, one would expect the closeness to the centre effect to still dominate.

[6] This also applies to SE1, but SE1 only has one sector outside the CC-Zone (SE1 5).

Even with this overriding effect, the effect that this investigation is interested in can be still be measured by considering the difference between the estimates before and after the implementation of the CC. If there was a negative estimate for the period before the implementation of the CC, a less negative estimate after the implementation would support the hypothesis that the CC has had a negative impact on the desirability of the properties near the CC-Zone boundary (ignoring any effects captured by the constant term).

The effects for *sectors inside the CC-Zone* are a little more ambiguous, residents inside the CC-Zone are not hit so hard by the charge, but commercial properties, especially those near the boundary whose customers are car drivers from outside the CC-Zone, are. Another point to bear in mind would be that the reduced congestion and environmental impact should improve the quality of life for residents inside the CC-Zone, but the impact of these improvements should prima facie be unrelated to the distance from the boundary.

The specification in (1) allows for four separate snapshots to be taken. To formally test for disparities, the *difference-in-differences* approach is also taken. The treatment (control) group are the sectors outside (inside) the CC-Zone. Here a specification of the following form is run:

$$
\begin{aligned}
Ln(P) = {} & \alpha_1 + \alpha_2 * AFTER + \alpha_3 * OUT + \alpha_4 * AFTER * OUT + \\
& \beta_1 * DIST + \beta_2 * DIST * AFTER + \beta_3 * DIST * OUT + \beta_4 * DIST * OUT * AFTER + \\
& \gamma_1 * TimeTrend + \gamma_2 * QuaterlyDummies + \gamma_3 * DistrictDummies \quad ,
\end{aligned}
\tag{2}
$$

where *AFTER* represents a dummy variable which is equal to unity if the measurement was taken after the implementation of the CC, *OUT* is a dummy variable signifying a sector outside the CC-Zone, *DIST* is the distance variable in (1) and the other variables are as described in (1).

The variables allocated α coefficients help to disentangle the change in the constant, for example, in the absence of the Quarterly and District dummy variables, α_1 is the mean price of properties at $t=0$ inside the CC-Zone, (and the average price in the reference sector if the district dummies in the third row are added). The coefficient of major concern is α_4, this is the DID estimate of the constant, its interpretation is *the extra growth in property prices for properties outside the CC-Zone after the launch of the CC*. The variables allocated β coefficients help to disentangle the effect of the coefficient on distance. The other coefficient of major concern is β_4, this is the DID estimate of the coefficient on distance, its interpretation is the *extra growth in prices per km away from the boundary of the outside area relative to the inside area*. For example a coefficient on β_4 of 0.1 would indicate that after the implementation of the CC-Zone, the impact of the distance from the boundary on property prices of house prices outside has increased by 10% relative to properties inside the CC-Zone. In other words, when outside the CC-Zone it is more desirable (by 10% per km) to locate away from the boundary (relative to inside the CC-Zone).

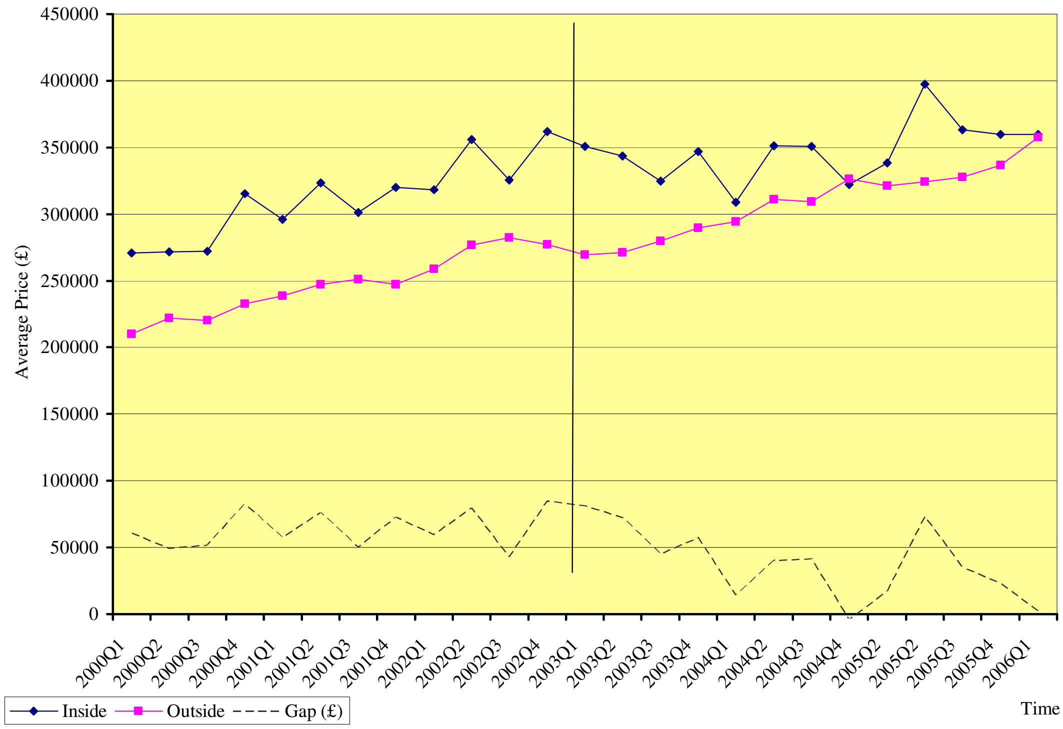
IV - DATA AND RESULTS

In this section, summary statistics of the data are presented along with a graphical analysis and the results from regressions specified by (1) and (2). The data from the Land Registry contains quarterly postcode sector level data for 38 postcode districts inside and close to the CC-Zone. Inside the CC-Zone, the range of the distances from the centre of the sector to the boundary is 0.7km to 2.1km. The (un-weighted) mean distance is 0.79km with a standard deviation of 0.47km. For the sectors outside the CC-Zone the range of the distances from the centre of the sector to the boundary is 0.7km to 8.8km. The (un-weighted) mean distance is 2.54km with a standard deviation of 1.76km.

The property prices are nominal and are based on all completed sales (not just mortgage based sales from some other sources). The (un-weighted) mean price for the sectors inside the CC-Zone is £338,000 (standard deviation: £168,000) and inside the CC-Zone, it is £282,000 (standard deviation: £193,000. Clearly there is more variation outside the CC-Zone, probably because a larger area is covered, hence a larger mix of the types of flats. Figure 2 provides a better picture of the trends in (nominal) property prices over the period the data is concerned with. The means are all *weighted* by the number of sales in the particular sector over the quarter.

FIGURE 2

TRENDS IN PROPERTY PRICES OVER THE PERIOD



Quarterly data from the Land Registry since January 2000. The top two lines represent weighted means of the average nominal prices in the two cohorts. The lower line indicates the gap.

Figure 2 shows that prior to the introduction of the CC, the gap between the two areas has remained relatively steady. After the first quarter of 2003, a decline of the gap has been witnessed, on two occasions it has completely disappeared. There could be many reasons for this: 1) this was brought about by the congestion charge; see the discussion outlined in Section III. 2) a shift in the weights of the sectors which were used to calculate the averages; the more expensive sectors in the 'outside' sectors witnessed more sales and the less expensive sectors inside the CC-Zone also witnessed more sales (unlikely; the sales numbers are relatively stable). 3) unreliability (larger variance) of the 'inside' data; as mentioned earlier, the data inside the CC-Zone is not as clean as the data outside the CC-Zone. 4) demand or supply factors unrelated to the CC that led to the ‘inside’ sectors being less desirable. 5) seasonal effects (for the disappearance of the gap); it was the first quarter on both occasions where the gap has disappeared.

Figure 2 provides prima facie evidence that as a result of congestion charging, property prices outside the CC-Zone have appreciated relative to inside the CC-Zone. This is counter-intuitive against the argument put forward earlier which suggested that residents inside the CC-Zone would experience larger gains in their property values because they benefit from a better environment and pay a discounted fee. However, this finding does run in accord with the belief that commercial properties inside the CC-Zone are less desirable, and because land use is substitutable between commercial and residential uses, residential prices have also fallen. For the formal regression analysis on the matter, the differences between the districts, seasonal effects and ultimately the distance from the CC-Zone are all controlled for. The results from the regressions outlined by (1) and (2) are presented and discussed for the remainder of this section.

i) OLS Cross Section Estimates

Table 2 displays the results for the OLS estimates, the estimates are weighted by the number of sales for a sector and robust standard errors are used to correct for heteroskedacticity. Considering the estimates one by one, the distance coefficient indicates the percentage change in property values for an increase in every kilometre away from the CC-Zone boundary. Outside the CC-Zone, prior to the introduction of congestion charging, every kilometre away movement from the CC-Zone boundary leads to a 7% fall in the price of flats even when taking into account the district dummies. The sign of the coefficient is consistent with property prices increasing as we approach Central London. After the introduction of the CC, this estimate fell to 6%, whether this difference is statistically significant is explored with the difference-in-difference estimate in Table 4. The constant indicates that the average price of flats (on the boundary) in period 0 (1999 Q4) in the reference sector (SW1), in the reference quarter (Q1) is (EXP(12.8)=) £362,000. The unchanged constant together with the reduction in the magnitude of the coefficient on distance suggests that the desirability of being closer to the CC-Zone boundary has fallen after the introduction of the CC, this issue is tackled formally when considering the difference-in-differences estimate. The time trend coefficient indicates that in the period before the introduction of the CC, prices increased by around 3% per quarter and in the period after, the figure fell to 1.5% (both inside and outside the CC-Zone).

Inside the CC-Zone, the sensitivity of property prices to distance from the CC-Zone boundary also has the correct sign to be consistent with properties closer to the centre being more expensive. The sensitivity halved after the introduction of the CC, previously, it was more valuable to be closer to the centre, but after the introduction of the CC, the relative desirability has been equalised. This ignores the effect of the constant, but since the 95% confidence intervals of the constant before and after the change overlap, this is a fair assumption. All the estimates of these main variables are significant at the 1% level.

TABLE 2
THE CONGESTION CHARGE AND PROPERTY PRICES: OLS CROSS SECTION ESTIMATES

Dependent Variable: Ln(Price)

Independent Variable	Outside Before	Outside After	Inside Before	Inside After
Distance	-0.074	-0.063	0.405	0.241
	(0.010)***	(0.009)***	(0.047)***	(0.043)***
Time Trend	0.030	0.016	0.027	0.014
	(0.002)***	(0.002)***	(0.004)***	(0.004)***
Constant	12.789	12.845	12.354	12.472
	(0.055)***	(0.059)***	(0.045)***	(0.085)***
Quarter Dummies	YES	YES	YES	YES
District Dummies	YES	YES	YES	YES
Weights	SALES	SALES	SALES	SALES
Records	1791	1804	523	523
Total Sales	5371	5237	5751	5174
R^2	0.785	0.744	0.427	0.405

Notes: Robust (White-corrected) standard errors in parentheses, *,**,*** indicate significance at the 10%, 5% and 1% level respectively. STATA's "analytic-weights" function was used to weight the estimates by the number of sales in a postcode sector.

ii) Random Effects Model

Table 3 displays the results using a random-effects model. However, here the estimates are not weighted by the frequency of observations per sector. To repeat what was said earlier, a fixed-effects model is not suitable because all the variables being considered remain constant except for the dependent variable, so nothing is picked up.

TABLE 3
THE CONGESTION CHARGE AND PROPERTY PRICES: RANDOM EFFECTS ESTIMATES

Dependent Variable: Ln(Price)

Independent Variable	Outside Before	Outside After	Inside Before	Inside After
Distance	-0.045	-0.045	0.263	0.217
	(0.033)	(0.030)	(0.125)**	(0.106)**
Time Trend	0.033	0.017	0.021	0.011
	(0.001)***	(0.001)***	(0.003)***	(0.003)***
Constant	12.856	12.913	12.659	12.951
	(0.074)***	(0.071)***	(0.139)***	(0.130)***
Quarter Dummies	YES	YES	YES	YES
District Dummies	YES	YES	YES	YES
Weights	NONE	NONE	NONE	NONE
Records	1791	1804	523	523
R^2 (Within)	0.386	0.169	0.105	0.037

Notes: Standard errors in parentheses, *,**,*** indicate significance at the 10%, 5% and 1% level respectively.

The key point to note from these estimates is that for the sectors outside the CC-Zone, the distance from the boundary is not a significant factor (even at the 10% level) in determining the property prices both before and after the implementation of the CC. This could be because the cross section estimates are biased (hence the need for a panel method), and that the district dummies are enough to capture the distance effects, or because the random-effects model suffers from the lack of weighting. Due to the latter problem, the cross section estimates are the ones which should be valued more highly. Inside the CC-Zone, the drop in the relationship between price and distance is not as obvious as that from the weighted OLS estimates in Table 2, but the post-implementation estimate is of a similar magnitude.

iii) Difference-in-differences Estimates

Table 4 displays the results from regressions of (2). Specifications I and III deal solely with the issue of whether the constant is different across the two cohorts and whether it has changed post-CC implementation. For these two specifications, the estimates of all of the 'alpha' estimates are deemed to be significant at the 1% level; except for the coefficient on 'outside' in specification III.

The results indicate that in a notional sector of SW1 which is on the boundary (and in the reference categories as before), the average price for a sector inside before the implementation of the CC was around £268,000. Being outside (as opposed to inside) the CC-Zone costs the home owner between 5-27% 'before'. Afterwards, being outside the CC-Zone benefited the owner by 10-12% relative to being 'inside', where prices fell by 17% after the implementation of the CC-Zone. These results mirror the picture painted by Figure 2. Being inside or outside the CC-Zone (controlling for the other effects) does matter, and it is more beneficial to be outside the CC-Zone post implementation than before.

Specifications II and IV, which take into account the 'beta' estimates as well paints a different picture with respect to the nature of the constant term. Being inside or outside mattered before implementation (although estimates from the two alternative specifications have different signs), but not after. The 'beta' estimates are all significant at the 5% level and both specifications yield estimates of the same sign.

They signal that for sectors inside the CC-Zone, pre-implementation, every km movement away from the boundary increased prices by 25-50% (the same as the results from Table 2). Outside the CC-Zone, the figure is 7-33% points less compared to inside the CC-Zone.

TABLE 4

THE CONGESTION CHARGE AND PROPERTY PRICES: DIFFERENCE IN DIFFERENCES ESTIMATES

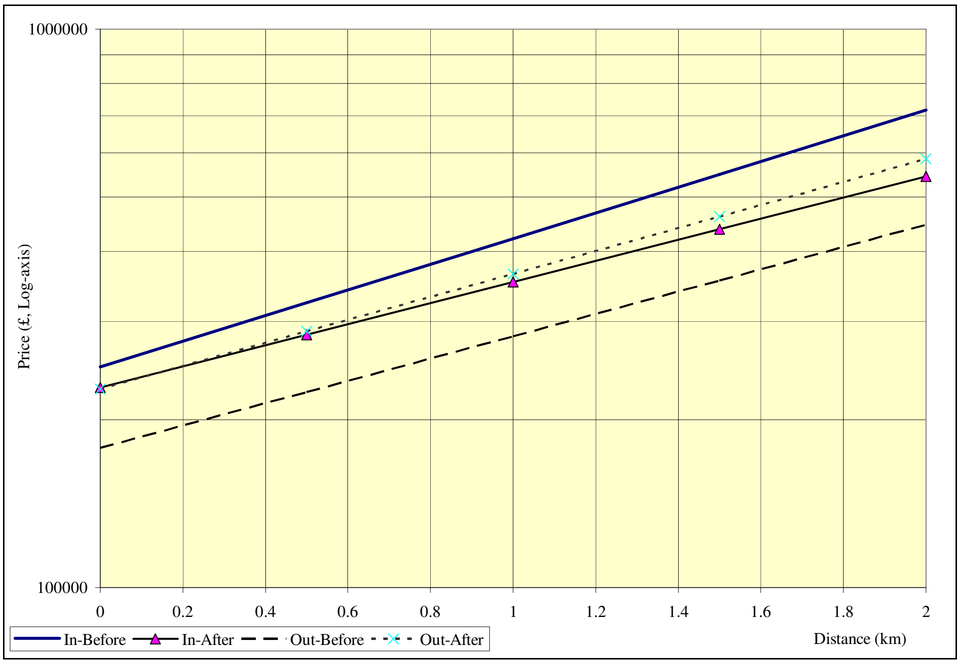
Dependent Variable: Ln(Price)

Independent Variable	I	II	III	IV
Constant	12.429 (0.024)***	12.241 (0.037)***	12.719 (0.041)***	12.423 (0.036)***
After	-0.168 (0.037)***	-0.066 (0.057)	-0.172 (0.030)***	-0.085 (0.042)**
Outside	-0.274 (0.022)***	0.171 (0.039)***	-0.046 (0.053)	-0.333 (0.048)***
After*Outside	0.101 (0.030)***	-0.031 (0.057)	0.119 (0.027)***	-0.006 (0.042)
Distance		0.240 (0.039)***		0.529 (0.043)***
Distance*After		-0.123 (0.056)**		-0.094 (0.047)***
Distance*Outside		-0.334 (0.040)***		-0.069 (0.044)***
Distance*Outside*After		0.135 (0.057)**		0.108 (0.047)**
Time Trend	0.023 (0.002)***	0.023 (0.002)***	0.023 (0.001)***	0.023 (0.001)***
Quarter Dummies	NO	NO	YES	YES
District Dummies	NO	NO	YES	YES
Weights	SALES	SALES	SALES	SALES
Records	4641	4641	4641	4641
Total Sales	11701	11701	11701	11701
R^2	0.110	0.216	0.714	0.733

Notes: Robust (White-corrected) standard errors in parentheses, *,**,*** indicate significance at the 10%, 5% and 1% level respectively. STATA's "analytic-weights" function was used to weight the estimates by the number of sales in a postcode sector.

FIGURE 3

THE CONGESTION CHARGE AND PROPERTY PRICES: THE EFFECT OF DISTANCE FROM BOUNDARY, DIFFERENCE IN DIFFERENCES PLOTS



Note: When inside the CC-Zone, an increase in distance from the CC-Zone boundary indicates a movement closer to the centre of London, whereas for sectors outside the CC-Zone an increase in distance is consistent with moving away from the centre of London.

Post-implementation the value of distance switched to being negative for sectors inside the CC-Zone, every km movement away from the boundary reduced prices by 9-12%, it was more desirable to be further away from the centre and closer to the boundary. Outside the CC-Zone, it also became more desirable to be away from the centre, property prices increased by (13.5-12.3=) 1.2% to (10.8-9.4=) 1.4%. This result provides clear support for the hypothesis that due to the implementation of the CC, properties outside and close to the boundary are less desirable because drivers are using these areas to avoid having to pay the charge during the hours when it is enforced. The linear plots presented in Figure 3 of the relationship between distance and price estimated in specification IV help to clarify the situation.

The figure demonstrates more clearly the closing of the gap between ‘outside’ and inside’ sectors. At this stage it is useful to repeat the fact that graph indicates the notional value of a property in SW1 (a sector which is both inside and outside the CC-Zone). It is surprising that with respect to the constant, being inside or outside mattered more pre-implementation than post-implementation; the virtual ‘firewall’ was not there before. Once again, the finding that post-implementation prices inside the CC-Zone fell is consistent with the prediction that residential property prices should also reflect commercial property prices because land use is substitutable. Post-implementation commercial properties inside the boundary are less desirable because it costs more for drivers from outside the CC to access them.

More importantly, the results indicate that whist the distance ‘semi-elasticity’ of price was stronger for the sectors inside the CC-Zone before implementation of the CC, the relative sensitivity has reversed. In other words, distance away from the boundary is more valuable outside the CC-Zone post-implementation relative to being inside. This is consistent with the belief that post-implementation, distance matters less when inside because everybody inside benefits or is hurt in the same way. However, when outside, it hurts to be close to the boundary because in these areas, traffic flows should increase because drivers are using these areas to avoid entering the CC-Zone.

V - CONCLUSIONS

The impact of congestion charging in London on property prices has been investigated under the premise that property values are an appropriate method to appraise the economic benefits of transport innovation. Previous studies into this relatively uncharted area have focussed weighing the costs and benefits of the system. Although congestion charging has reduced traffic flows and has been a political success, the economic costs outweigh the benefits by nearly 2:1. This study is concerned with measuring the relative impact of congestion charging inside and outside the CC-Zone through property prices.

The price of flats in the postcode sectors which are close to the CC-Zone have been investigated because flats are the main types of properties in the area under investigation. This alleviated the wrongs of not developing a full hedonic model to a certain extent. Only sectors close to the CC-Zone were considered because it was argued that the effects are felt less significantly by sectors far away. The main variable of interest was the distance from every sector to the CC-Zone boundary, this was manually measured using a postcode sector map of London.

Two main results have been found. Firstly, for property prices in general, it is found that surprisingly, being outside or inside the CC-Zone mattered before the implementation of the CC and matters much less after the implementation of the CC;

the gap has effectively closed. A reason for observing this phenomenon could be because commercial property demand inside the CC-Zone may be reduced as a result of the implementation of the CC. Drivers have to pay to enter the CC-Zone, making commercial areas outside the CC-Zone more attractive to businesses. And because of substitutability of land use between commercial and residential purposes, the decline in relative property prices inside the CC-Zone could be a reflection of the reduction in commercial desirability.

Secondly, as hypothesized, distance from the boundary when outside the CC-Zone becomes a more important issue relative to inside the CC-Zone after the implementation of the CC. Inside the CC-Zone, it matters less because all residents benefit from the reduced traffic and they pay a discounted charge. Outside the CC-Zone, the residents living closest to the boundary experience potential increases in traffic flows due to drivers avoiding the CC-Zone so as not to incur a charge, so properties closer to the boundary are less desirable. In the empirical analysis incorporating district level dummies, it was found that outside the CC-Zone, every kilometre movement to or away from the boundary can change prices by 7% (before) to 6% (after). Inside the CC-Zone, every kilometre movement to or away from the boundary can change prices by 40% (before) to 24% (after). Further analysis to verify the findings could be conducted on the western extension of the CC-Zone when that happens. This is can confirm the findings here or offer an alternative picture on the impact of congestion charging.

A drawback of the approach taken is that because of limited time and resources, a hedonic model of property prices was not developed. With more information on housing specifics (e.g. the size of the house and its characteristics) and information regarding neighbourhood characteristics more concrete conclusions can be drawn. Additionally post-code unit level information could possibility yield further revelations towards the nature of the sensitivity of house prices to the distance away from the CC-Zone-boundary.

REFERENCES

Bannister, D. (2003). 'Critical Pragmatism and Congestion Charging in London', *International Social Science Journal*. 176. Pp. 249-264

Bowes, D. and K. Ihlandfeldt (2001), 'Identifying the Impacts of Rail Transit Stations on Residential Property Values', *Journal of Urban Economics*, 50, 1-25.

DETR (1997). 'Highways Economics Note No. 2', Department of the Environment, Transport and the Regions.

Gatzlaff, D.H. and D.R. Haurin (1997). 'Sample Selection Bias and Repeat-Sales Index Estimates' *The Journal of Real Estate Finance and Economics*, Springer, 14, 33-50.

Gibbons, S. and S. Machin (2003a). 'Rail Access and House Prices: An Evaluation of the Wider Benefits of Transport Improvements', Department of Transport Report (November).

Gibbons, S. and S. Machin (2003b). 'Valuing English Primary Schools', *Journal of Urban Economics*, Vol. 53 (2), 197-219.

Gibbons, S. and S. Machin (2004). 'Rail Access and House Prices: An Evaluation of the Wider Benefits of Transport Improvements', *CEP Discussion Paper CEPDP0611*, Centre of Economic Performance, LSE.

GOL (2000). '*Road Charging Options for London*', (March) Government Office for London.

Landis, J. and M. Zhang (2001). 'Using GIS to Improve Urban Activity and Forecasting Models: Three Examples', in *Spatial Models and GIS*, A. Stewart Fotheringham and Michael Wegener eds., GISDATA 7, Taylor-Francis, London

McDonald, J.F. and C.I. Osuji (1995). 'The Effect of Anticipated Transportation Improvement on Residential Land Values', *Regional Science and Urban Economics*, 25, 261-278.

O'Sullivan, A. (2003), '*Urban economics'5th Edition,* Boston : McGraw-Hill/Irwin

Prud'homme, R. and J.P. Bocarejo (2005) '*The London Congestion Charge: A Tentative Economics Appraisal*'', the PIARC Seminar on Road Pricing with Emphasis on Financing, Regulation and Equity, Cancun, Mexico

Perkins, S. (2004), '*Charging For the Use of Roads: Policies and Recent Initiatives*', Fifth Annual Global Conference on Environmental Taxation Issues, Experience and Potential, Pavia, Italy, 9-11 September.

Transport for London website, http://www.tfl.gov.uk