TEMPORAL VARIANCE OF REVEALED PREFERENCE ON-STREET PARKING PRICE ELASTICITY

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Abstract

With any pricing measure the degree of price sensitivity of the consumers is paramount to understanding how they will react to the given price level. This study utilises revealed preference parking trend data from parking meters ex ante and ex post of a general 50% price increase in the hourly cost of on-street parking to estimate the price elasticity of demand in this market for Dublin, Ireland. The case study area is a central on-street parking area with a 3-hour parking limit, which attracts an even mix of business and non-business use. Using a custom-built program for generating hourly and daily occupancy levels, this work presents estimates for the aggregate price elasticity of demand level and individual estimates for specific time periods and days of the week. In terms of simply reduced parking frequency, the average price elasticity of demand was -0.11, whilst factoring in a notable drop in average parking duration, produces a more responsive figure of -0.2. Daily average estimates remain consistent, with one notable exception being Thursday, a ‘late night shopping’ day where a lower price sensitivity was noted. Morning periods were also noted to be more responsive than other time periods in the test area, indicating some potential for influencing the morning inbound peak traffic levels. Additionally, possible confounding factors are concluded, on aggregate, to have likely increased parking activity during the time frame of this study, thus perhaps resulting in an underestimation of the full impact that the parking policy may have had.

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Introduction

Numerous studies have attempted to model and/or investigate the potential influence of parking policy on travel behaviour. Examples of such research include work by Clinch and Kelly (2003 a,b), Shiftan (2002), Calthrop (2002), Hensher (2001), Tsamboulas (2001), Shoup (1999) and Kuppam et al. (1995). However, although all related to parking, there are significant distinctions to be acknowledged between various pieces of parking research, as these affect their applicability to alternate scenarios. The first such distinction is the type of parking facility and the needs it serves. Influencing short stay parking behaviour in a shopping center multi-storey car park (MSCP) relative to all day commuter parking in a private non-residential (PNR) office car park are likely to require different approaches and considerations. A second distinction is the approach of a given parking policy. Parking policy can relate to a change in the price of parking or the supply, again two policy approaches with distinct considerations. Finally the scope of a policy change is also of significant relevance to the observed or calculated results of a given scenario. How much of the parking market is your policy affecting, is it a localised or broader initiative?

This paper examines parking policy in relation to the price elasticity of demand of the on-street parking market in Dublin city center when faced with a citywide increase in the hourly cost of on-street parking of 50%. As parking pricing offers the potential to vary charge by location, day and hour, this paper seeks to explore the variance in effect of a fixed charge parking price increase across the days and hours of a six-day week (Sunday excluded). The study seeks to highlight the importance of daily and temporal price sensitivity variations and their relevance to a policy maker.

Methodology

The generation of the necessary data for this study required revealed preference parking demand data ex ante and ex post of a price change, with as much control or consideration of extraneous factors (that may have influenced demand other than the price change) as possible. Given these data and using the arc elasticity of demand formula, the generation of price elasticity of demand estimates is possible. The first section of this methodology deals with the collection of the required data whilst the second section presents a short review of the various extraneous factors related to demand which were considered or addressed as potentially interfering with parking demand in the test area.

The revealed-preference parking data in this study are drawn from the parking meters in a central on-street parking area of Dublin. Data collections were performed on a weekly basis with data being uploaded to a parking meter database management system (Logiparc©) at the end of each week. These data contained information on every aspect of each individual
parking transaction that took place over the course of 6 weeks, and through manipulation by a custom-built program, were capable of delivering the number of cars that should be legally parked at any given hour on any given day in the test area. Results were collated in the form of average parking occupancy levels for the test area for each day and for four time periods (9am, 12pm, 3pm and 6pm). A simplified version of the format of these raw data as taken from the parking meters and the calculation process conducted by the custom built program (Space Utilisation Program) is outlined in Box 1.

Shortly after the first data collection in 2000 there was a citywide increase in the price per hour of on-street parking, with all city levels being increased by 50%. The following summer, in August of 2001, a mirror set of parking data was collected from the same location in order to provide the requisite statistics of ex ante and ex post parking trends. Combination of these data sets allowed generation of revealed-preference price elasticity of demand estimates for the on-street parking market. Results were calculated for the general price elasticity of demand using aggregate figures, as well as for individual days and hours in an attempt to notice temporal variations in price sensitivity.

Insert Box 1 about here

Potential Confounding Factors

As mentioned, in taking the approach of ex ante and ex post demand analysis for the generation of price elasticities, particularly with a 1-year gap, attention was needed for extraneous confounding factors, which may have also influenced levels of demand during this time period. Two clear factors to consider when interpreting results of this kind are changes to the supply of, or demand for, this service. In relation to the former, consultation with the relevant authorities indicates that there was no change in either on-street or off-street parking space provision during the timeframe of this study. In terms of the latter factor, general demand, it was noted that the aggregate number of private vehicles and trips into Dublin increased in the interim year somewhat, though accurate and specific figures for use in the study were unobtainable. However, given the increase in cars and trips generally, one could assume that parking demand as a derivative also rose somewhat. As the overall parking activity results show that demand fell, there is the potential that the full impact of the price change was masked somewhat by an increasing demand level. Thus, on these grounds, our results may underestimate somewhat the true, ceteris paribus, impact of the price change.

Two other considerations were changes in the price of alternatives and fiscal changes. In relation to the former, the pricing of alternative MSCPs did increase marginally during this period, however, such increases are common and are generally implemented to maintain prices in real terms. Related to this are changes in real income and inflation, for this study
results are presented in real and nominal terms. However, no adjustments were made in relation to the growth in real income for the period which was approximately 6%.

Other considerations were changes in street laws and traffic routing. In relation to the test area there was one change in a tributary road that leads off the area. However, assessment of this in conjunction with the director of traffic, suggests no likely impact on parking in the test area. In addition, weather patterns for both years were examined and found to be similar in both summers, and finally enforcement and illegal parking were considered as part of the larger study but ultimately were not used in modifying results in any way. It was confirmed however by parking authorities that there is very little illegal parking in this area generally, and enforcement records suggest a consistent trend over both years. In terms of over-and under-stay of paid parking, it is assumed there would be a good degree of consistency between both years given the six week duration of each sample.

A more fundamental factor for concern was related to the accuracy of the data collected from the machines. As a counter to this, the data collections in both years included trial periods for testing the data for errors and consistency. This was achieved using various methods such as walk-up car counting surveys to verify the results from the parking meters for a specific period.

Overall, with regard to these potential confounding factors, the general trend suggests that demand for on-street parking (with the exception of the price change being measured) should have increased during the study’s timeframe. Thus, whilst there is no reliable method of assessing the degree of substitution that may have occurred, the possibility must be considered. A related household survey and two on-street surveys suggest that a greater net impact in terms of reduced parking levels should have been registered. However, as parking demand is, to some extent, a derivative of private motoring demand, it is possible that the increased number of trips into the city between the years and added numbers of vehicles on the road masks the full effect by contributing to parking activity. It is also possible that new users were attracted by the increased reliability and availability of parking spaces. Nonetheless, from a policy perspective, the net result in terms of parking levels is still of significant value, as it represents the end effect with all other factors playing whatever role they may have played.

Interpretive notes for results

Prior to interpretation of the results, there are a number of factors, which warrant further mention. Firstly, this study represents an ex post analysis of parking levels just less than one year after the price change. As such, it is accepted that these elasticities represent a specific
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time frame for possible change and indeed the figures may vary significantly from the short to the long run.

Secondly, these elasticities relate to an on-street parking market, where there is a mix of business and leisure users with presumably few ‘all-day commuters’. This is expected due to the 3-hour parking limitation on any given parking transaction. Whilst there is potential for ‘meter feeding’ and all day parking by this method, it is thought to be uncommon. Therefore, the study is dealing with a distinct type of market, which may be very different to analysis of all day business commuters parking in an office parking facility for example.

Finally, the pricing change occurred in the on-street market only. The price change was a general increase of 50% for on-street parking in the city centre area. MSCP facilities and private parking facilities were entirely independent of this change. The MSCP price also increased in this period as mentioned above, however, the increase was smaller and the price change still left on-street parking marginally lower in cost than MSCP facilities.

Results

Table 1 presents the first set of price-elasticity results for the area and examines the price elasticities of demand based on average parking levels at specific time periods for a six-day period from Monday to Saturday. As with all results in this section, figures are presented for the 50% nominal price increase that occurred and also the price change in real terms, 45.1%.

- Insert Table 1 about here -

If we examine these same time brackets only for the weekday (Monday through Friday), the results remain consistently inelastic with a few minor yet notable distinctions. As shown in Table 2 the 9am period during the week is slightly more responsive again than the full week elasticity value from Table 1. No other exceptional distinctions are noted between weekday and full week data, with 12pm and 3pm still highly inelastic and the weekday 6pm value exhibiting slightly less response than the full week 6pm value also.

- Insert Table 2 about here -
The next sets of results presented are those of the elasticities generated using demand-level changes specific to individual days of the week. Once again a highly inelastic trend is noted across the results as shown in Table 3. However, relative differences between the days and their responsiveness highlight some noteworthy distinctions. The most inelastic day is Thursday with a price elasticity (real and nominal rounded up to the same figure) of −0.02.

- Insert Table 3 about here -

The rest of the figures with the exception of Saturday, which is the most responsive day relatively speaking (but still quite inelastic), show further evidence that this on-street parking market is not particularly responsive to this particular price change. In Tables 4 and 5 we detail as an aggregate figure what the change in parking levels for the area was in response to the real and nominal price change. These results are again segregated into weekday parking level elasticity and full (6 day) week figures.

- Insert Table 4 about here -

The difference between the results is marginal and the clear result is an average price elasticity of demand for on-street parking in the test area of approximately −0.1. This highly inelastic value is also supported by survey results that indicated the majority of users were unaffected by the change.

- Insert Table 5 about here -

Other revealed preference results

Other than the elasticity figures, a summary of the quantified changes between 2000 and 2001 in the on-street test area is presented in Table 6. These are results based around output from the Logiparc© and SUP programs. Here we see that the inelastic market has meant the price change resulted in a healthy revenue increase and only a slight reduction in total parking events. The other significant change is the 16.5% drop in average duration, which would indicate a higher degree of turnover for the spaces, thus improving general availability. As we also measured an aggregate 4.18% drop in total parking activity, we can assume this increased turnover came without the expense of greater total parking-related traffic for the area.

- Insert Table 6 about here -
Discussion

The first clear observation is the inelastic nature, on aggregate, of this on-street parking market for the 50% price increase. The 12pm grouping especially is very inelastic, with the other afternoon time of 3pm notably returning a low figure also. A consideration for policy is that the most price elastic sub-market appears to be at 9am, suggesting that pricing changes could have a positive effect on the inbound peak traffic period in the morning, as this period clearly experienced the greatest reduction in parking activity for the time periods sampled. Thus there is potential that some form of ‘spiked’ morning charge may have a noticeable affect on morning parking and morning inbound journeys as a result.

As was demonstrated in Table 2, the 9am period during the week is slightly more responsive than the full-week elasticity value shown in Table 1. While the difference is small, this indicates that pricing policy may potentially have a greater effect on the morning parking period, specifically on the midweek period, when peak hour congestion is presumably at its highest.

In Table 3, the elasticity of demand figure for Thursday reinforces the evidence that “Late Night Shopping” Thursday is a unique day amongst the full week and is particularly unresponsive to pricing measures according to aggregate demand levels. The ‘Late Night Shopping’ theory suggests that, due to Thursday being the sole weekday with many shops opening late into the evening, it has a less price-sensitive parking market.

Finally, if consideration is given to a price elasticity of demand estimate which takes account of the 16.5% drop in duration, we would see a more responsive on-street market. However, as we simply had one aggregate figure for the drop in average parking duration for this period, it was not possible to calculate elasticity estimates in this manner for all days and times. So a single figure for the price elasticity of demand based on all data and considering the drop in average parking duration was generated. The method was simply to use a point elasticity formula and to substitute the percentage change in price with a calculated percentage change in ‘real’ average price paid for a parking ticket, thus reflecting the percentage change in average ticket price. The result of this delivered a single elasticity of demand estimate for the area of –0.2. However from a TDM perspective the key value remains the observed net reduction in actual parking events rather than adjustments for slight moderation of average parking times.

Conclusion

This paper has shown that temporal variances in price elasticity of demand for parking exist and that perhaps more targeted and specific tariffs and charges should be implemented. This
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highlights an important consideration for policy makers with regard to assessment of their market and the likely specific hourly or daily impacts a TDM pricing measure may have. Whilst the paper has shown a relatively low aggregate impact, the variance in specific time periods or days is noticeable and may become even more pronounced at higher pricing levels. This ‘progressive impact’ phenomenon was noted in a separate paper (Clinch and Kelly 2003 c) wherein the responsiveness of non-business users to business users (in a stated preference survey) was noted to become more pronounced as tariff price scenarios scaled upwards.

The methodology and techniques employed within this paper to assess parking activity and demand can make future and indeed ongoing analyses of parking events and the impact of policy changes more widespread should they be implemented and imitated elsewhere. Such information could allow an ongoing tailoring of market demand through the pricing instrument and potentially be developed and applied to MSCP markets and with some modification to a PNR levy or charging system.
Acknowledgments

Financial support from the Irish Council for the Humanities and Social Sciences and Dublin City Council is greatly appreciated. We are most grateful to Owen Keegan, Director of Traffic Dublin City Council, for his advice and support. However, the views expressed are those of the authors.
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References


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Table 1 St. Stephen’s Green: Price elasticity by hour Mon-Sat (2000/2001)

<table>
<thead>
<tr>
<th>Time</th>
<th>50% nominal</th>
<th>45.1% real</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average 9am</td>
<td>-0.35</td>
<td>-0.38</td>
</tr>
<tr>
<td>Average 12pm</td>
<td>-0.01</td>
<td>-0.02</td>
</tr>
<tr>
<td>Average 3pm</td>
<td>-0.08</td>
<td>-0.08</td>
</tr>
<tr>
<td>Average 6pm</td>
<td>-0.15</td>
<td>-0.16</td>
</tr>
</tbody>
</table>

Table 2 St. Stephen’s Green: Price elasticity by hour Weekday (2000/2001)

<table>
<thead>
<tr>
<th>Time</th>
<th>50% nominal</th>
<th>45.1% real</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average 9am</td>
<td>-0.40</td>
<td>-0.43</td>
</tr>
<tr>
<td>Average 12pm</td>
<td>-0.02</td>
<td>-0.03</td>
</tr>
<tr>
<td>Average 3pm</td>
<td>-0.06</td>
<td>-0.06</td>
</tr>
<tr>
<td>Average 6pm</td>
<td>-0.12</td>
<td>-0.13</td>
</tr>
</tbody>
</table>

Table 3 St. Stephen’s Green: Price elasticity by day 2000-2001

<table>
<thead>
<tr>
<th>Day</th>
<th>50% nominal</th>
<th>45.1% real</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Monday</td>
<td>-0.08</td>
<td>-0.08</td>
</tr>
<tr>
<td>Average Tuesday</td>
<td>-0.15</td>
<td>-0.16</td>
</tr>
<tr>
<td>Average Wednesday</td>
<td>-0.10</td>
<td>-0.11</td>
</tr>
<tr>
<td>Average Thursday</td>
<td>-0.02</td>
<td>-0.02</td>
</tr>
<tr>
<td>Average Friday</td>
<td>-0.10</td>
<td>-0.11</td>
</tr>
<tr>
<td>Average Weekday</td>
<td>-0.10</td>
<td>-0.11</td>
</tr>
<tr>
<td>Average Saturday</td>
<td>-0.18</td>
<td>-0.19</td>
</tr>
<tr>
<td>Total Daily Average</td>
<td>-0.10</td>
<td>-0.11</td>
</tr>
</tbody>
</table>

Table 4 2000 - 2001 Revealed elasticities based on nominal 50% price change

<table>
<thead>
<tr>
<th></th>
<th>% Change</th>
<th>Parking level</th>
<th>Elasticity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weekday parking level 2000</td>
<td></td>
<td>17766</td>
<td></td>
</tr>
<tr>
<td>Weekday parking level 2001</td>
<td>3.53</td>
<td>17138</td>
<td>-0.09</td>
</tr>
<tr>
<td>6 Day parking level 2000</td>
<td></td>
<td>21439</td>
<td></td>
</tr>
<tr>
<td>6 Day parking level 2001</td>
<td>4.18</td>
<td>20543</td>
<td>-0.11</td>
</tr>
</tbody>
</table>
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### Table 5 2000 - 2001 Revealed elasticities based on real 45.1% price change

<table>
<thead>
<tr>
<th></th>
<th>% Change</th>
<th>Parking level</th>
<th>Elasticity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weekday parking level 2000</td>
<td>3.53</td>
<td>17138</td>
<td>-0.10</td>
</tr>
<tr>
<td>Weekday parking level 2001</td>
<td>4.18</td>
<td>17766</td>
<td>-0.12</td>
</tr>
</tbody>
</table>

### Table 6 St. Stephen’s Green: Summary statistics for 2000 to 2001 changes

<table>
<thead>
<tr>
<th>Variable</th>
<th>2000</th>
<th>2001</th>
<th>Percentage Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Localised Price</td>
<td>IR£1 (€1.27)</td>
<td>IR£1.50 (€1.90)</td>
<td>+ 50 %</td>
</tr>
<tr>
<td>Total Spaces</td>
<td>208</td>
<td>208</td>
<td>No change</td>
</tr>
<tr>
<td>Number of Machines</td>
<td>20</td>
<td>20</td>
<td>No change</td>
</tr>
<tr>
<td>Average Price of Ticket</td>
<td>IR£1.51 (€1.92)</td>
<td>IR£1.91 (€2.43)</td>
<td>+ 26.5 %</td>
</tr>
<tr>
<td>Average Duration of Parking</td>
<td>90 Minutes</td>
<td>76 Minutes</td>
<td>- 16.5 %</td>
</tr>
<tr>
<td>6day 6week Parking Events</td>
<td>21,439</td>
<td>20,543</td>
<td>- 4.18 %</td>
</tr>
<tr>
<td>Estimated Revenue</td>
<td>€41,162.88</td>
<td>€49,919.49</td>
<td>+ 21.3 %</td>
</tr>
</tbody>
</table>
Box 1 Calculating occupancy statistics for parking area

**Raw Parking Data:**

The Logiparc© system provides three vital pieces of information, which allow the generation of parking level statistics. These are shown below with an example.

1. The exact date and time a parking transaction begins  
   28/07/01 14:25pm
2. The value of the transaction  
   €3.17
3. The legal amount of parking time purchased  
   2Hrs 30 Mins

**Calculating Area Occupancy:**

In order to deliver a figure for the number of cars parked in an area at a given hour on a given day, the raw parking data must be manipulated as follows:

Query: Number of cars parked on St. Stephen's Green at 3pm on Saturday 28th July 2001

**Process:**

1. Filter all data to leave only those parking meters located on St. Stephen's Green
2. Filter all remaining data to leave only those transactions taking place on Saturday 28th July 2001
3. For all transactions in this area on that day, add the time purchased to the transaction start time to give an estimate of the legal parking checkout time.
4. Filter all results to leave only the number of cars with an estimated checkout time after 3pm.