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Using analytics to understand on-street parking: the impact of special permit use and the benefit of demand based rates over zones

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Abstract

The data gathered as part of the LA ExpressPark demand management project gives an unprecedented view of on-street parking. This paper uses this data to study two aspects in detail: (i) the fraction and distribution of non-paid parking use (which is dominated by special permit use), and (ii) the impact of per-block demand based rates on the availability of cheaper alternatives in walking distance. We see that unpaid parking represents a significant part of total parked time, in particular in areas where parking congestion is a problem. In these areas unpaid parking reaches up to 90% of the total parked time. In the second part of the paper we see that the fine level demand patterns in downtown LA result in relatively heterogeneous rates such that for most locations there is a cheaper side and back street available. For most destinations motorists get a financial incentive to help ease congestion by walking a small distance. This is in contrast to traditional zone-based pricing where such incentives only exist for destinations close to the boundary of zones.

Keywords: Analytics, Intelligent Parking Management, Demand Management.

Introduction

On-street parking is an important part of urban life and urban mobility. Because of the difficulty of accurately measuring the process, many aspects remain only partly understood. With the introduction of smart parking solutions: the combination of occupancy sensors, communicating parking meters and analytics algorithms, this is starting to change. A process that used to be understood largely by instinct or manual and visual patrols is now open for systematic and complete study.

This paper studies two important aspects of on-street parking in downtown Los Angeles: the impact of non-paying customers (a majority of which is due to special permit users) and the contrast between the traditional way parking rates are set, namely set by hand and constant for entire zones, and demand based per-block rates that are determined by algorithms. This paper can be seen as an accompanying paper to the papers (Ghent et al. 2012) and (Ghent et al. 2014). Ghent et al. 2012 gives a more detailed description of the project and Ghent et al. 2014 gives a more preliminary analysis of the impact of rate changes on parking behavior.

In parallel to Los Angeles, San Francisco ran a similar demand based pricing project called SFPark. The difference between the two approaches is described in Zoeter et al. 2014. The SFPark project has been studied by Pierce and Shoup 2013a, Pierce and Shoup 2013b, Millard-Ball et al. 2014a and Chatman and Manville 2014. The paper by Pierce and Shoup in 2013 sparked further discussion and study in Millard-Ball et al. 2013a and Pierce and Shoup 2013c. An important difference between the SFPark and LA ExpressPark data studied here is that SFPark data contained only per-block occupancy data and no payment or per event data. So the payment and duration analysis performed here was not possible before.

Demand based pricing can help to ease congestion and pollution by setting rates such that motorists are incentivized to avoid peak hours and peak locations. When rates are set correctly motorists will find it in their interest to use the flexibility to walk a small distance, to change mode or to adjusting travel times and get a discount in return. For this to have a significant impact, a large part of the parking population needs to pay for parking, for introducing discounts will have no direct effect on motorists that are exempt from paying in the first place. As we will see in the Section “A Study of Unpaid Parking”, in downtown Los Angeles a significant part of the parked time is due to non-paying parkers. This has important implications for demand management initiatives, but also for parking policies in general.

A second important aspect of the parking process is that of the walking distance required to obtain a reasonable discount. If the distance to a cheaper alternative is long, the fraction of motorists that are interested in the cheaper congestion reducing option will be small. With the traditional zone based parking tariffs only spaces at the edges of expensive zones will have cheaper alternatives in walking distance. If rates are determined per block, this makes it potentially possible to increase the number of blocks with cheaper alternatives in walking distance. Detailed demand data and algorithms make it possible to set rates at such fine-grained a level. Web sites, local signs and smart phone applications make it possible to communicate them.

A question that remains is: how is parking demand distributed at a fine scale? Do we see that there are a few distinct centers of attraction where all motorists want to get as close to as possible? We have named this possible effect the *theater effect* in Ghent et al. 2014. If such a theater effect holds, all motorists want to get close to a single location (the stage), demand based rates will lead to zones (all seats in a particular row of seats) that are roughly equally close to the center of attention (stage) and are roughly equally sought after. Pricing can encourage motorists to select a suitable zone (row), but they will still need to circle within the zone (row) because rates will be constant there.

The Section “Zone Based Pricing versus Demand Based Pricing” studies the patterns in the pre-project rates and the demand based rates at the time of writing and see that at fine scale, in down-town LA, there is evidence of a relatively heterogeneous demand: even though there are clear districts with overall higher demand, and district with overall lower demand, within a district the demand (and hence the rates reflecting this demand) varies at a smaller scale making that the front of a block, the side street and the back street all have different rates. In some cases we even see that opposite sides of the street have different rates: motorists that have the opportunity to take a different approach route can find a discount at a very small walking overhead.

In the discussion we reflect on the results and discuss possible policy implications.

A study of unpaid parking

In California motorists with a reduced mobility can request a special parking permit. Such a permit exempts motorists from paying for on-street parking and it also allows them to ignore time limits. With hourly rates between \$0.50 and \$8 there is a significant financial incentive to make use of such a permit and park on-street. It is an often reported phenomenon that in downtown LA there is a large fraction of parkers that make use of such a permit (See e.g. Shoup 2011).

The current parking infrastructure in downtown LA: occupancy sensors and smart, bi-directionally communicating meters, allow us to study this in detail for the first time. When studied in detail there is a surprising varied pattern of how motorists pay for parking: paying several minutes after arriving, topping up the meter several times, parking short, parking long and making use of money left in the meter. From the point view of policy makers and for demand management, there are two distinct groups of parkers: those that pay for parking and those that do not. We define *non-paying parkers* as those parkers that during their entire stay do not make a single payment. This abstracts away the issues described above of long and short staying, multiple payments, etc. It does not distinguish between violators and special permit users. The current infrastructure does not allow us to do so without manual surveys because permit users do not need to notify their arrival to the system. Based on the sensor and meter data, violators and permit users are indistinguishable. From the point of view of a demand management program they are indistinguishable as well: neither group will respond to rate changes directly. Although they could be affected indirectly, for instance if increased rates mean that paying parkers stay away, more spaces become available for special permit users. From on-street surveys (e.g. Glasnapp et al. 2014) it is known that permit use largely dominates the non-paying group.

We will get back to this point in the discussion section.

Figure 1 shows per block the fraction of parked time that is due to non-paying parkers. The map shows data from January 1 2014 to June 20 2014 and from the hours of 11 am to 4 pm on weekdays. This time window is the middle-of-the-day window in LA's time of day pricing. This window is chosen by the demand management algorithms and is relatively homogeneous.

The right hand side map in Figure 1 shows the fraction of time each block is congested (more than 90% occupied) for the same period and time windows. When comparing the two plots it is clear that a high fraction of unpaid parking often coincides with blocks that demonstrate congestion problems.

To investigate this further, Figure 2 shows the average number of times a space becomes vacant (on the left) and average vacancy durations. Again for the same period and time windows. The number of vacancies map demonstrates that often, for blocks with a high fraction of unpaid parking use, the parking spaces serve only a small number of customers. Combining all plots, we see that in those areas where on-street parking is particularly scarce (high congestion index, Figure 1, right) often the fraction of unpaid parking is high (Figure 1, left), and the parking places serve only a small number of parkers (Figure 2, left), while there is evidence that there are motorists that would like to make use of these spaces (short vacancy duration, Figure 2, right).

Figure 3 shows a histogram of how the unpaid fraction is distributed over blocks. It shows the information of the left map in Figure 1 as a histogram together with its equivalent from the pre-project situation (data from June 1 to December 31 2012). We see that the situation has largely remained the same from 2012 to 2014. The pre-project data from 2012 is from the period between the installation of the sensors and the first rate change. Importantly this is after the installation of credit card accepting meters. The installation of credit card accepting meters has resulted in an increase in the amount of money paid at meters (Ghent 2015). The hypothesis is that people that would have wanted to pay but couldn't with coin only meters, started paying when credit card payment was an option. We do not have detailed data to study this further.

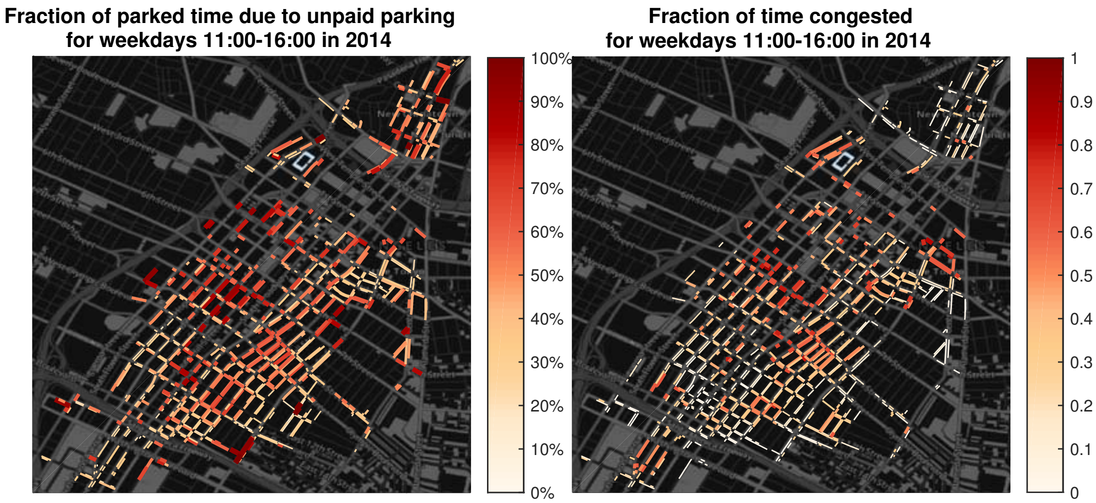

Figure 1 - Fraction of parked time that is due to unpaying parkers (left) and the fraction of time that a block is congested (occupancy > 90%), right. Data is from January 1 to June 20 2014 and for weekdays 11 am to 4 pm.

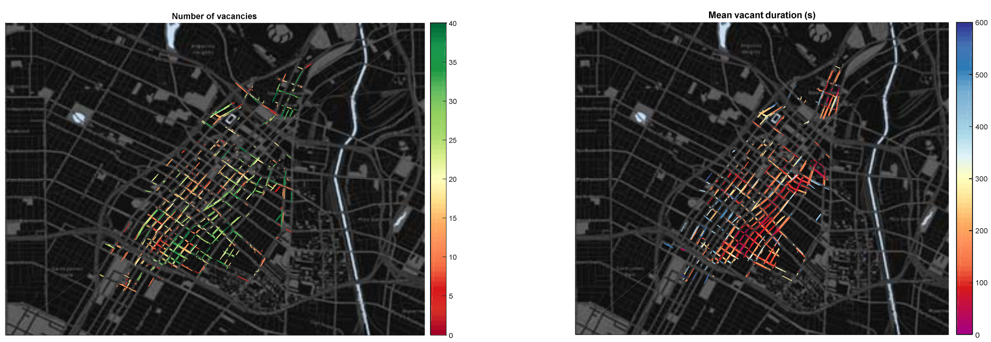

Figure 2 - The average number of vacancies on weekdays 11 am - 4 pm (left) and mean durations of vacancies (right). Both plots are based on data from January 1 to June 20 2014.

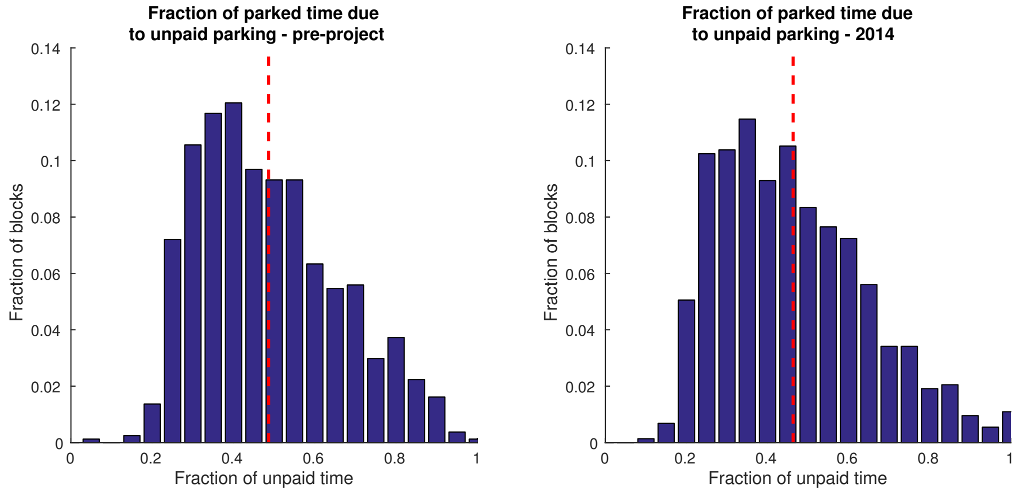

Figure 3 - Histogram of the fraction of unpaid parking time for June 1 to December 31 2012 (left) and January 1 to June 20 2014 (right). In both cases data is from weekdays 11 am to 4 pm. The right plot represents the same statistics as the left map in Figure 1.

Zone based pricing versus demand based pricing

In California Demand based pricing and sensor supported smart parking solutions have many advantages. One is that it should be possible to reduce parking search time to essentially zero via occupancy sensors and reservation systems. A second is that it allows rates to be set per block instead of per zone. This gives better incentives to motorists to use the flexibility they have in choosing their parking location. Whereas in a zone based system it is often not realistic to walk to a cheaper alternative. With per-block rates it is.

Figure 4 demonstrates this. The lines show the fraction of spaces in LA downtown where a cheaper alternative is available in a given radius. All spaces colored in Figure 1 are taken into account. The blue line describes the pre-project situation where rates are zone based. The red line shows the situation under June 2014 rates. This is after several iterations of demand based rate updates.

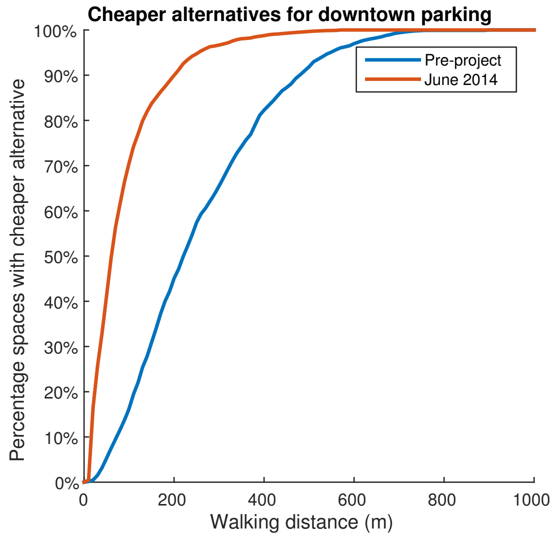

Figure 4 - The fraction of spaces in the project area that have a cheaper alternative in a given radius.

Figure 5 shows this information for a radius of 250 meters using maps. This clearly supports our intuition: only at the boundary of a zone with a cheaper neighboring zone is there an incentive to help reduce congestion. The demand based rates lead to a situation where essentially all locations give incentives to help reduce congestion. The only white blocks (blocks where no cheaper alternatives are available) are those block that are the cheapest in LA's rate ladder ($0.50/hr). Empirically most of these blocks show no congestion problems (cf Figure 1, right) so no incentives are needed.

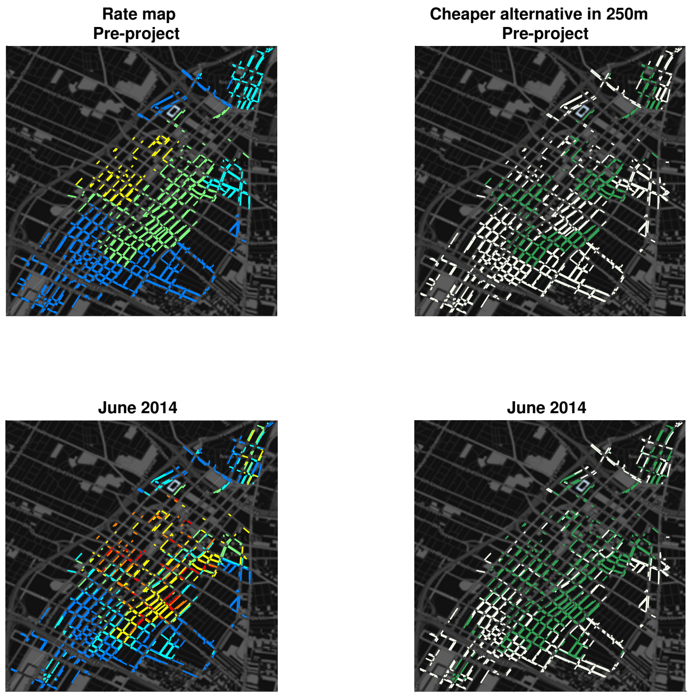

Figure 5 - Different rate maps (left column) lead to different incentives. The right column shows which blocks have a cheaper alternative in walking distance (green).

The plot and maps above graphically emphasize the point that demand based rates make behavior change possible. They graphically show the existence of a cheaper alternative. In practice not only the existence of a cheaper alternative is important, but also the size of the discount. To fully determine the size of the discount we also need the duration of parking events. The walking cost to a further location is incurred only once, whereas the per hour rate change has an impact that scales with the duration. If we introduce a cheaper alternative in the vicinity, we expect locations with short parking events to change less than blocks with (paying) long staying parkers. One way to do this in more detail is by replaying historical parking events. If we fix certain model parameters such as value-for-time, the relative discounts can then be determined accurately. We leave this study for future research.

Discussion

Detailed data obtained as part of the LA ExpressPark project allows us to study certain critical components of the on-street parking process. This paper has highlighted two: the impact of non-paying parkers and the effect of demand based rates on the effective incentives for motorists to use walking to help reduce congestion.

Unpaid parking, defined here as parking by motorists that do not make a single payment during their stay, is the result of parkers that do not take into account rates when deciding on their parking location. We see that in downtown LA there is a high fraction of parked time that can be attributed to non-paying customers, in particular in areas with congestion problems where the fraction of unpaid parking time can reach 90%.

For the demand management project LA ExpressPark this implies that in large areas rate changes will have little effect on parking patterns, because the majority of parking is by motorists that do not pay.

From field studies it is known that special permit users dominate the group of non-paying parkers. The LA data shows that non-paid parking use is particularly high in areas with congestion problems and that non-paying parkers tend to block spaces for a disproportionally long time. This could be seen as support for the argument made in Shoup 2011 that current special permit policies should be reconsidered. Providing free parking for reduced mobility users is not supported by general economic theory: a subsidy could be given, but giving it in the form of free parking results in over use of the scarce resource. William Vickrey for example made a strong case for this arguing that special use of parking, for example by an ambulance, should still be charged according to the demand based rates, but reimbursed from other funds if necessary. This provides proper incentives to avoid peak hours and peak locations to all users in appropriate ways.

Before the change of parking laws, an intermediate step could be to require permit users to notify the central parking system after arrival using e.g. a smartphone application. This has multiple advantages: the non-paid parking use can now be accurately separated between violators and special permit users. This is good for a general understanding and to aid directed enforcement and general enforcement strategies. A second advantage would be that it would disincentivize fraudulent use of permits because permits can be validated by the system and a single detected violation could lead to a fine for historical uses of the permit as well.

A full demand based parking system holds, via an integration with navigation and reservation systems, the promise to reduce “cruising-for-parking” to 0. Our study of the demand based rate map shows that even without guidance there is a distinct advantage of demand based rates: the detailed per-block rates give incentives to walk to a side or back street to help reduce congestion in the majority of cases. This could suggest an intermediate parking system on the way towards a full-fledged system such as provided by LA ExpressPark. A rationalization of parking rates of say every decade would give the benefits of the geographically heterogeneous demand based rates without the costs of continued supports of sensors. The success of such an approach depends on how big mid- to long term changes in parking demand turn out to be and hence how reasonable infrequent updates to the fine grained rates will be. This is something we can study in detail after more data is available from the LA ExpressPark system.

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