path intelligence

Whitepaper

Time is Money

Shoppers buy more when they stay longer

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Quantifying the relationship between how long shoppers stay and how much they spend

FOREWORD

Shopping centres – so often the hub of a local town centre – are an under researched area. In the past, academic research into how shoppers behave in large mall environments has been hampered by a lack of data. Information on how consumers navigate through a centre, how long they stay and how they group stores together on a visit has been either been unavailable or scant and sporadic.

Consequently, shopping mall owners and managers have been at a competitive disadvantage as compared to large retailers in the online retail environment. Online retailers record information on how many visitors come to their site, what pages they look at, how they browse through the site and what other products shoppers look at. This information – together with academic research on economic search behavior – has enabled them to tailor their sites and to improve the overall customer experience. It is no coincidence that more and more of us are choosing to shop online.

This study seeks to reverse that trend. For the first time, techniques that have long been accepted in the online world have been applied to the offline mall. The result is a new metric that will help shopping centre owners and managers to understand the quality of each shopper visit, as opposed to just the quantity of shoppers.

Beyond providing the first empirical research into the impact of shopper dwell time on overall spending, this paper marks a first in identifying a commercial application for 'reality mining' in the UK. Acknowledged as a rich source of social behavioural information but underutilized in practice, mobile data offers a huge commercial potential to automatically and anonymously survey large sample sizes, bringing market research techniques into the 21st century.

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CONTENTS

EXECUTIVE SUMMARY

Shopping centres today face very difficult times. Competition from online stores, retail parks and large supermarkets is increasing. Coupled with this is the increasing cost of fuel, generally lowered consumer confidence and wider expectation of a recession. Consequently foot traffic (footfall) to traditional shopping centres is falling – by 2.6% a year in July 2008[1].

As shopping centre competition increases and the market changes, malls are discovering that understanding shopper behavior is critical. Traditionally managers and owners have looked to understand shopper behavior through understanding footfall to their centre. Yet with footfall falling, consideration is now turning to the quality of the shopper visit. Shoppers vote with their feet, hence the length of time they spend in a centre (dwell time) is a key indicator of the quality of a consumer's overall shopping experience.

This paper describes the outcomes of a unique UK research study undertaken by Path Intelligence Ltd in collaboration with Massachusetts Institute of Technology (MIT) in 2007.

AIMS AND OBJECTIVES

The aim of this study was to understand and quantify the link between the length of time that shoppers spend in a mall ("dwell time") and the impact on overall shopping centre sales. As a secondary goal, the research sought to look at what shopping centre managers could do to improve the quality of a shopper visit and to increase shopper dwell times.

TARGET SAMPLE

The study was conducted at a mixed-use shopping centre between March and November 2007. Dwell time data was captured using FootPath technology from Path Intelligence, which was able to continuously collect statistical data relating to anonymous shopper behaviour during this period.

[1] FootFall National UK Index

SIGNIFICANCE OF THIS STUDY

For some time now there has been a rumbling debate within the shopping centre industry as to whether or not shoppers spend more when they stay longer. The question is critical. Retailers want to know that Shopping Centre A (for example) can bring 10 million shoppers past the doors of its retail unit (and measure the performance of centres on that basis). Yet, if it is the quality of shopper visit (not only the quantity) that matters, shopping centres are being evaluated and retailers are choosing store locations on information that provides only half the story. Moreover, shopping centre managers choose strategies for their malls based on whether or not they want shoppers to stick around. Managers that believe shoppers should stay longer provide more events, seating and encourage catering. Whilst others change car park prices and in-fill event areas with kiosks to encourage shoppers to get in, spend and leave.

Until recently, it has not been possible to quantify the impact of longer dwell times on sales. Dwell time information was only available (at best) twice-yearly from exit surveys of a few hundred shoppers, and hence, there was insufficient information with which to conclusively investigate the linkage.

In contrast, this study used FootPath, the reality mining technology from Path Intelligence to continuously collect dwell time information for each shopper surveyed over a nine month period. This is the largest dataset yet gathered on the dwell times of shoppers and by empirically testing this against sales information from that centre it was possible to investigate and understand the nature of the relationship between the length of time that shoppers stay in the centre and the total sales at that centre.

KEY FINDINGS

PRIMARY CONCLUSION

The key conclusion of the research is that shoppers spend more when they stay longer.

The study demonstrated that there was a significant and positive relationship between dwell time and sales. In particular the research found that increases in the average daily dwell time of 1% were associated with increases in daily sales at the mall of 1.3%. In other words, footfall may be falling but sales can remain high if shoppers spend longer within a mall. It is the quality as well as quantity of visits that count.

SECONDARY RESULTS

The study also took a preliminary empirical approach to identifying additional key factors which directly influence shopper dwell time as follows:

- **Carefully managed centre visitor numbers**
  Specifically the research identified an inverse relationship between foot traffic (footfall) and dwell time – when the centre becomes busy shoppers cut short the time they spend in the centre. Path Intelligence is looking at doing more research in this area for it has been hypothesized that shoppers who visit busy centres feel 'crowded' and leave the mall before they have purchased the items they came for.

- **Vibrant public spaces with in-centre entertainment**
  Shoppers were found to react positively to events and free entertainment – dwell time consistently increased on days when special events took place (although further research is required to identify where shoppers went during this additional time).

- **Fully let shopping centres**
  Shoppers do not appear to enjoy visiting centres in decline. The research findings showed that the presence of empty retail units impacts negatively upon overall shopper dwell times.

HOW CAN CENTRE OWNERS AND MANAGERS USE DWELL TIME INFORMATION?

Path Intelligence have proved conclusively that longer dwell times are associated with higher sales and that centre managers can have a direct impact on the length of time shoppers stay. Now, with the ability to monitor dwell times on a daily basis there has never been a better time to use dwell time as a KPI in one centre or across a portfolio of centres.

In addition the data provided by FootPath can help centre managers and owners to identify:

- What percentage of shoppers are transiting' through the centre on their way to local high streets or transport hubs?

- How effective are in-centre events at not only increasing dwell time, but directing shoppers towards retail units?

- How their centre compare to others in terms of both the quantity and quality of visitor?

HOW DOES FOOTPATH TECHNOLOGY WORK?

FootPath from Path Intelligence is the UK's first commercially available example of a reality mining tool. That is, it uses machine sensed data to understand human behavioural patterns.

FootPath works by detecting anonymous transmissions from mobile phones carried by centre shoppers. This technology is a powerful asset management tool which replaces the need to conduct lengthy shopper surveys. Instead centre managers and centre owners can gain an automatic insight into how their centres are used.

For retail areas in particular, the advantages of understanding the path that shoppers take is significant. Such information can assist the mall owner/manager to:

- Evaluate and improve their retail tenancy mix by identifying which stores shoppers group together on a typical shopping trip;
- Understand the foot traffic to each retail tenant;
- Ensure stores are being charged the optimal rent given their location within the mall;
- Identify underutilized areas within the shopping centre;
- Understand the impact of anchors stores on the centre;
- Measure the implications of particular promotions or centre events;
- Assist with planning day-to-day centre management operations, such as cleaning and security.

More information about how FootPath works can be found on page 22.

1. RESEARCH STUDY: INTRODUCTION

Shopping centres today seek to maximize at least three Key Performance Indicators (KPI's). These include:

- The total number of shoppers coming to the centre (otherwise known as 'footfall');
- The number of times that shoppers come to the centre over the course of a year (referred to here as 'repeat visits');
- The length of time that shoppers stay at the centre (otherwise known as 'dwell time').

Many shopping centres have technical systems in place to capture information on the total number of shoppers in the centre. These are usually camera-counting solutions that count the total number of shoppers entering and exiting the building. Centres also may have the ability to estimate repeat visitors. Many centres have installed license plate recognition software in their car parks and hence have the capability to interrogate this dataset and identify the number of times the same car has returned to the centre.

However, until recently it has not been possible to quantify dwell time - except through sporadic, one-off surveys – and so 'dwell time' has only played a limited role in evaluating a centre's performance.

In this paper, we use quantitative information on dwell time for shoppers within a busy shopping centre in the UK. The data was collected by detecting shoppers' mobile phone transmissions and was made available for this analysis for the period March – November 2007. With this dataset, for the first time, analysis of the nature and extent of the interaction between dwell time and sales has become possible.

The research study is divided into sections as follows:

In section 2 we present the methodology used to empirically investigate the linkage between dwell time and sales. In this section we also investigate additional factors which may further influence dwell times and discuss the statistical validity of these results - what are the drivers of dwell time and what can centre managers can do to increase shopper dwell times within their centres?

In section 3 we summarise the key research findings and provide a top level summary of the significance of this research.

In section 4 we initiate a discussion on how this knowledge can be used strategically by shopping centre owners and managers and offer suggestions for relevant future research.

2. ESTABLISHING THE LINK BETWEEN DWELL TIME AND SALES

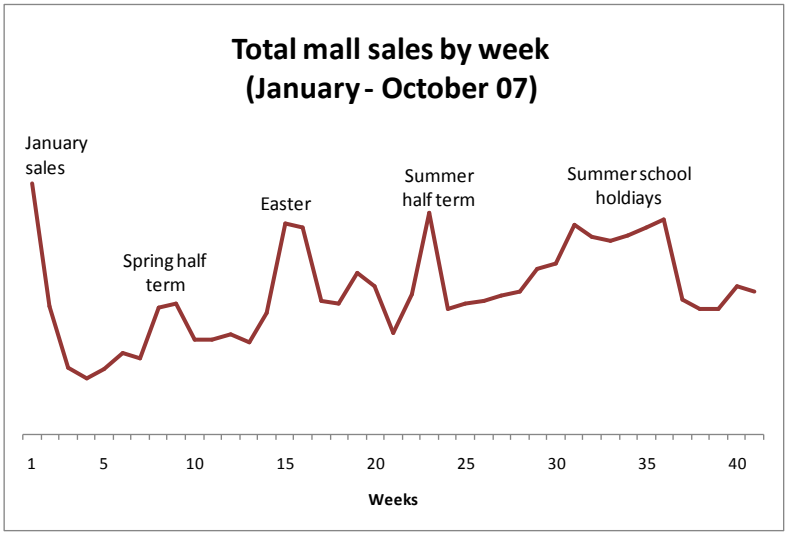
BACKGROUND TO DATA SOURCE

The data for this paper was gathered from an implementation of FootPath, undertaken at a "mixed use" shopping centre consisting of 14 cinema screens, a bowling alley, approximately 90 retail outlets and 20 restaurants/bars. The site also incorporates residential and office space. Approximately one half of the centre is outdoors and due to the site's coastal location, the centre complex is unusually exposed to changes in the weather.

The study was based on total sales for the centre as a whole, for March to November 2007. Each retailer (including bar and restaurant owners) provides centre management with the total amount of goods or services sold over the previous week. For the purposes of this analysis, the total sales made in each individual retail unit have been aggregated to provide a total sales figure for the mall as a whole. (Sales figures for the cinema and bowling alley are not collected).

As shown in Figure 1 below, total weekly sales during the analysis period vary greatly depending on the time of year and the presence (or not) of retail sales events. Not surprisingly sales peak during holiday periods and trough during the winter months before and after the Christmas and January periods.

Figure 1: Total Centre Sales by week (January - October 2007)



CALCULATING SHOPPER DWELL TIMES

Information on the length of time that shoppers spend at the centre was provided to the centre management by Path Intelligence. Path Intelligence's product 'FootPath' anonymously detects transmissions from shoppers' mobile phones, and uses this information to provide (amongst other information) data on the length of time that each shopper spends within the centre. Further information on FootPath from Path Intelligence can be found on page 22 and by visiting www.pathintelligence.com

For the purposes of this analysis dwell times of less than 30 minutes are removed from the dataset. This is because the centre used for the purpose of this research study is located directly adjacent to a mainline train station and it is assumed that dwell times of less than 30 minutes reflect local area residents who are walking through the site en-route to the train station. In a similar manner dwell times in excess of six hours are also removed from the dataset. Any individual staying longer than six hours is assumed to be an office worker on site, or a retail staff member.

METHODOLOGY – TWO-STAGE LEAST SQUARES

For this analysis we employed the two-stage least squares regression (2SLS) approach which was necessary because of the selection bias in our data. As explained above our data consists of observations of actual shopper behavior, as opposed to data resulting from a controlled experiment where the isolated effect of dwell time could have been assessed[i]. Because we are looking at actual shopper behavior the interactions between dwell time and sales have not been controlled for, and because of the presence of this dual causality (or feedback effects) an OLS regression would have produced biased estimates of the coefficients[ii]. To avoid this simultaneity bias we needed a model that was capable of distinguishing between the variables that are simultaneously determined (the endogenous variables, in this case dwell time) from those that are exogenous.

The difficulty with running a 2sls, however, is identifying appropriate instrumental variables. Ideally we would like an instrumental variable that is:

- A good proxy for the endogenous variable 'dwell time'; and
- Uncorrelated with the error term and the dependent variable (which in this case is total sales at the centre).

For our analysis we use 'unexpected changes in the temperature' as the instrumental variable[iii]. This variable is calculated by subtracting the forecast daily high temperature from the actual high temperature for each day. (In other words, if the forecast high for a day was 14° but the actual temperature was 10°, than the unexpected weather variable would be -4°)[iv]. The idea behind this approach is to try and capture the spending behavior of the shopper during those additional few minutes when they chose to stay in the centre, rather than to venture out into the 'colder than expected' weather.

'Unexpected changes in the weather' is shown to be an appropriate instrumental variable, for the following reasons:

The instrumental variable (IV) is a good proxy for our endogenous variable 'dwell time' – as shown in the results for the first-stage of the two-stage least squares (see Appendix 2 for further details). In particular, we see that the instrumental variable (changetemp) is:

1. Significant at just over the 5% level (0.052); and

2. Is uncorrelated with the error term and the dependent variable (sales) - In Appendix 1 we show the results from looking at the pair wise correlations of the instrumental variable (changetemp) on the dependent variable (sales) and the residuals (e). We also run regressions of the IV against these two variables. In both cases the IV is shown to be insignificant and to have no correlation to either sales or the residuals.

IS THERE A TIME TREND IN THE DWELL TIME DATA?

Before turning to the output of the regression analysis there is one other aspect of model design that is worth discussing. That is, the presence of a time trend in the dwell time data.

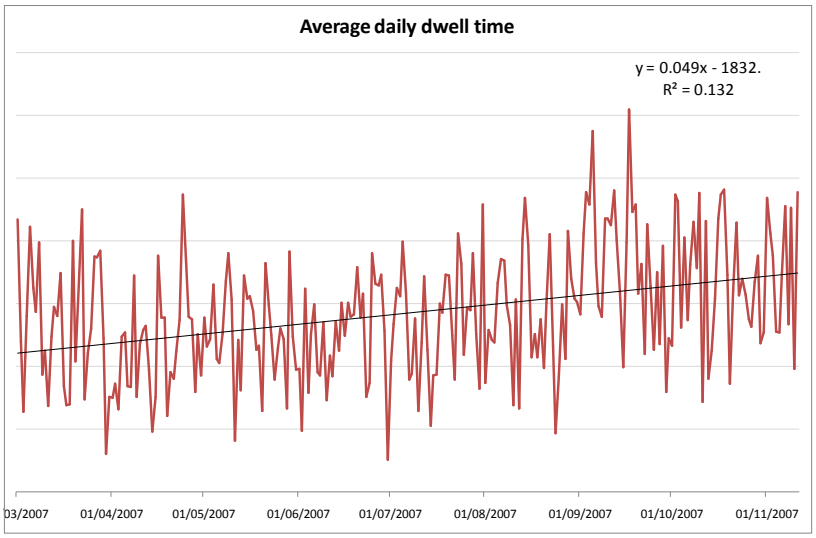
In addition to the expected seasonality that is evident in the retail sales data (Figure 1) we have also found there is an upward trend in the dwell time data (Figure 2).

There are two reasons why such a trend might appear:

(a) Time trend – it is possible that the drift upwards in the average dwell time is the result of a time trend or seasonality effect; or

(b) Learning effect – it is possible that having access to quantitative information on dwell time is changing management behavior. Path Intelligence began providing regular dwell time data to the centre management involved in December 2006. Given this is the first time that such information has been available to centre management on a daily basis, it is possible that the provision of this information has led to changes in management behavior, which in turn has affected the length of time that shoppers stayed in the centre. The 'learning effect' hypothesis has not been tested as part of this research study and hence we have made the assumption that the upward drift in the data is the result of a time trend.

Figure 2: Average daily dwell time at centre



RESULTS: DOES DWELL TIME AFFECT SALES?

The simultaneous equation model for the 2SLS was constructed as follows:

Daily Sales[v] = β0 + β1 IV (Average daily dwell time = Δ temperature) + β2Holiday dummy[vi] + β2Weekend dummy + β3Seasonal Lag + ε

Average daily dwell time = β0 + β1 Δ temperature + β2Holiday dummy+ β3Seasonal Lag + ε

Variable names:

- Sales – value of total daily sales at shopping centre
- Dwell time – the average daily dwell time at shopping centre
- School holidays – a dummy variable taking the value of 1 during the school holidays
- Weekday – a dummy variable taking the value of 1 if the day is Monday to Friday and 0 for Saturday and Sunday
- S.sales – is a seasonal lag

The regression output from this model is provided in Appendix 2. Overall the regression results are pleasing in that the:

- first stage regression has good explanatory power with an F value of 9.31;
- the 'change in temperature' variable - the instrumental variable - is significant at the 10% level (with a P value of just over 0.05); and the
- signs of the coefficients are in line with expectations.

We find that the average dwell time decreases during school holiday periods and on the weekends, as we would expect (see discussion in the following section). Likewise we find a negative relationship between the change in the temperature and the average dwell time. This is what we would expect given that other analysis indicates that the presence of rain (which can be expected to lower the temperature) increases the average dwell time.

The second stage results provide the overall parameter estimates from the 2SLS regression. From these results our key conclusions are that:

- There is a significant and positive relationship between dwell time and sales; and that
- Increases in the average daily dwell time of 1% corresponds with an overall increase of sales of 1.3%.

MANAGEMENT LEVERS FOR INCREASING DWELL TIME

The study has shown that there was a significant and positive relationship between average daily dwell time and total sales at the shopping centre. Given that result, in this section we look more deeply at the determinants of dwell time and use these results to better understand what tools centre managers/owners have at their disposal to increase the length of time that shoppers stay. While empirical techniques are used to understand the determinants of dwell time, this is combined with a preliminary discussion that includes suggestions for future research.

WHAT MAKES SHOPPERS STAY LONGER AT THE CENTRE?

Having established that there is a positive link between dwell time and sales, we delved deeper into the dwell time data to better understand what it is that makes shoppers stay longer. The results in Appendix 3 show the output of the OLS regression. These results demonstrate that dwell time is affected by the weather, holidays and centre specific characteristics such as in-centre events and the overall appearance of the shopping centre.

We discuss each of these variables in more detail in the following sections.

THE EFFECT OF THE WEATHER ON HOW LONG SHOPPERS STAY

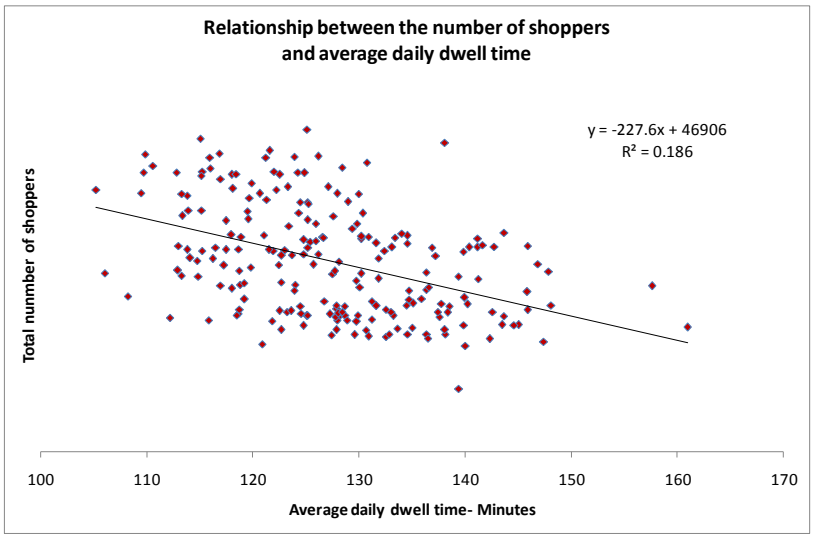
Given that the shopping centre used during this study is both an indoor and outdoor centre, and given its coastal location, we believed that weather would have a significant impact on the length of time that shoppers stay. To investigate this theory we looked at several pieces of weather data including windspeed, temperature and rainfall by day.

The results show that average daily dwell time is not significantly affected by the temperature or the windspeed but that it is affected by rainfall. Shoppers do tend to stay longer in the centre on days when it rained.

THE EFFECT OF HOLIDAYS AND WEEKENDS ON DWELL TIME

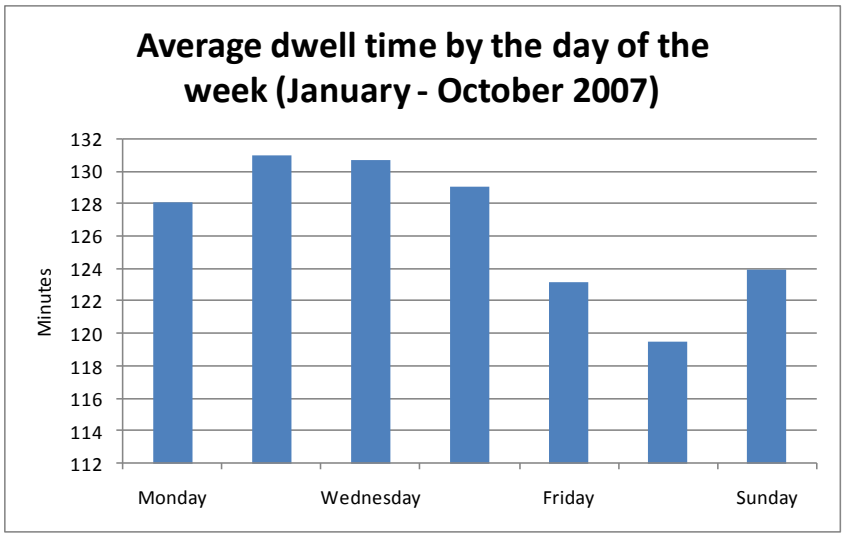
The regression results above show that average daily dwell time declines during the school holidays (note the negative sign on the 'schoolholidays' coefficient) and is lower on weekend days versus weekday days, particularly on Saturday (note the positive coefficient on the weekday dummies and the negative coefficient on the Saturday dummy). This result agrees with other findings that we have examined during this analysis. For example, Figure 3 below shows that there is a negative correlation between the total number of shoppers in the centre and the average daily dwell time. (The total number of shoppers is highest in the centre during holiday periods and weekends).

Figure 3: relationship between the average daily dwell time and total footfall



In addition, we see a strong 'day of the week' effect if we simply plot the average daily dwell time by day. As is shown in Figure 4 below, shoppers tend to stay longer at the beginning of the week, and have shorter dwell times on the weekends (particularly on Saturday).

Figure 4: Average dwell time by day of the week (January to October 2007)



This in itself is a very interesting result. Why would dwell time fall during holiday periods when the centre is congested? The industry's explanation for this phenomenon is that there are two different types of shopper:

1. The 'leisure' shopper; and
2. The 'targeted' (or mission) shopper

'Leisure' shoppers are thought to predominate during the early part of the week and on non-holiday days. Leisure shopping is characterized by behavior that sees the centre as a destination with shoppers enjoying the experience of both shopping and browsing.

'Targetted' shopping, in contrast, occurs when the centre is busy. During such times shoppers come into the centre, purchase what they need and leave. They are 'targeted' on the purchases that they need to make and see the centre merely as a means for making those purchases, not as a destination in and of itself.

While some industry research has been conducted to verify this hypothesis[vii] more work is required. Even if we accept the above hypothesis, it is still not clear why there are more targeted shoppers during holiday periods. Is it, for example, that families shop differently when they visit the centre together? Or, is it because individuals who work during the week tend to be 'targetted' shoppers and those who are not working outside of the home are 'leisure' shoppers? Or is our hypothesis wrong altogether, and dwell times fall during busy periods because shoppers dislike crowds? If this latter hypothesis is right, centres may be missing sales opportunities from shoppers, if those individuals 'cut short' their shopping trip because of overcrowding. Finally, is

this phenomenon is culture-specific. Do Europeans and Americans behave the same way when the centre is congested? Or is this simply a UK- only phenomenon?

In the absence of further research on this topic it is difficult to know which approach centre management should take to increase total sales at the centre on weekend and holiday days. There are two competing options. These are:

1. Increase churn – If weekend and holiday shoppers are 'targetted' shoppers then centre management should actively seek to decrease average dwell time on the weekend to increase the throughput of such shoppers (for example, car parking charges could be punitive after 60 minutes or so); or

2. Decrease congestion – On the other hand, if shoppers shorten their shopping trips to the centre during congested periods because they feel crowded and uncomfortable, centre management should seek to alleviate congestion in the centre (by removing stalls in the walkways and increasing toilet facilities, for example).

Further research could provide a definitive answer to centre management as to the best approach to take.

THE EFFECT OF ADDDITIONAL CENTRE-SPECIFIC CHARACTERISTICS ON AVERAGE DWELL TIME

It is clear that it is not only external factors – such as the day of the week or the weather – that affect how long shoppers stay at a centre but also centre-specific characteristics that determine the 'atmosphere' of a centre. In this analysis we looked at two such characteristics. These were

- in-centre events (such as, Italian or French markets or Santa's grotto) and
- the number of empty retail units.

Below we discuss each in turn.

IN-CENTRE EVENTS

In our analysis we included a dummy variable that took the value of 1, if there was an event being held within the centre on that day. As can be seen in the results above, the sign on that coefficient is positive (indicating that dwell time does tend to increase on 'event' days) but the overall relationship is not significant.

It is interesting to note that most events are held either on the weekend or during holiday periods. As we have seen in the preceding discussion dwell time is lower during these periods, and it may be that these two effects are canceling each other out. Indeed it may well be that the event is increasing overall total shopper numbers to the centre but that this increases congestion,

leading shoppers to feel crowded which in turn contributes to lower dwell times.

It would be interesting – although not straightforward – to study the most effective use of events in future research. In particular, it would be useful for centre management to know whether it is worthwhile to hold more events during weekdays and during non-holiday periods. Does the provision of an event during this period drive sufficient footfall to the centre and increase dwell times by enough to justify the cost of holding that event?

EMPTY RETAIL UNITS

In addition to the provision of events within the centre, we also looked at the effect of the appearance of the centre on the length of time that shoppers stay at the centre. We modeled the appearance of the centre through a variable that counted the number of empty retail units on each day. Centres that have a lot of empty shops have a 'run down' look that is not appealing to shoppers, and we hypothesized that this would decrease dwell time – both because the atmosphere of the centre is not attractive, but also because there are fewer shops for visitors to stop at.

Unlike many shopping centres, the site used during this research is fully-let (in fact there is a waiting list of retailers seeking space). The overall feel of the centre is upbeat and appealing. Nevertheless, like any centre, the retailers within the centre do change and during that period of change the particular retail unit is boarded-up while the shop is being refitted. Over the course of our study there were several such changes, with up to four units being re-fitted at any one point in time[viii] .

Our results show that - as we would expect – average dwell time decreases as the number of empty retail units increase. At this site this relationship is not significant, which is not surprising given the small number of empty retail spaces at any one point in time.

RETAIL TENANCY MIX

One clear omission from this initial study is the fact that we did not look at the impact of the retail tenancy mix on the length of time that shoppers stay within the centre. Indeed there are several factors that would produce a worthwhile follow up investigation. These include:

- The mix of retailers including:
    - The mix of different categories of retailers such as ladieswear, menswear, home furnishings etc
    - The impact of 'branded' or 'destination' retailers (that is, retailers with strong brand names such as Gap and Marks & Spencer for which shoppers are willing to travel some distance for); and
- The location of retailers within the centre.

Ideally we would like to know whether the centre was offering an attractive mix of retailers to the shopper and whether or not there were any retailers missing from the centre[ix]. We would expect that by presenting a more attractive selection of retailers, the centre would encourage shoppers to stay longer.

Unfortunately it was not possible to investigate the effect of retail tenancy mix on dwell time within this study as the research period was too short to compare material changes in the retail tenancy mix[x]. Future research should look to conduct cross-sectional studies across multiple centres to understand the relationship between dwell time and tenancy mix in more detail.

3 SUMMARY OF RESULTS

The primary purpose of this paper was to establish whether or not there was a relationship between the length of time that shoppers stay in a centre and the total overall sales at that centre. To answer that question we use a two-stage least squares approach with total sales at the centre as our dependent variable and 'unexpected changes in the weather' as our instrumental variable.

In conclusion we find that there is a positive and significant relationship between the length of time that shoppers stay at the centre and the total sales at that centre. The coefficient on the instrumental variable indicates that increases in the average daily dwell time of 1% are associated with increases in sales of 1.3%.

Having established this result, the second part of this paper examines how centre management can maximize sales at their centres by increasing the length of time that shoppers spend at their centre. To begin we analyse empirically the drivers of dwell time, using quantitative data on the length of time that shoppers stay at the centre. We find that the average daily dwell time is significantly affected by:

- Changes in the weather - in particular dwell times increase on rainy days;
- School holidays – dwell time is shown to fall during the school holidays; and
- The day of the week – dwell time is highest early in the week (Monday through Wednesday) and lowest on the weekend (particularly Saturday);

Dwell time may also affected by centre-specific characteristics such as the provision of events, the number of empty retail units and the overall retail tenancy mix.

We also found that in-centre events are positively related to dwell times but that this relationship is not significant. Likewise, we found that the greater the number of empty retail units the shorter shopper dwell times tended to be, but again this relationship was not significant within the participating centre.

Our regression did not include a measure of the overall retail tenancy mix in the centre, as the study period was not sufficiently long to capture a large enough movement in the retail tenancy mix to be material. To achieve this we recommend that future research take a cross-sectional approach across a number of centres to identify the effect of the attractiveness of the retailers at the centre and its impact on the length of time that shoppers stay within the centre.

4 HOW CAN CENTRE MANAGEMENT USE THIS RESEARCH?

As noted in the introduction to this paper, this analysis is the first of its kind to look in detail at the impact and drivers of dwell time. Further research is required before concrete management tools can be gained. However, initial indications from this research suggest that centre managers may wish to consider the following:

- Ensuring that the centre is a comfortable 'refuge' from the weather (so as to maximize sales during the period when shoppers are sheltering from the weather);
- Conduct further research on shopper behavior during holiday and weekend periods – Centre management can choose to either increase the churn of shoppers during holidays and weekends or they can look to minimize shoppers sense of being crowded. However, before any action is taken we believe it is necessary to look in more detail at why shoppers shorten their shopping trips on holidays and weekends;
- Promote events – although the relationship between the provision of events and the length of time that shoppers stay within the centre is insignificant we do find that the relationship is positive[xi]
- Minimise empty retail space – although less important at a thriving scheme such as was present at this shopping centre, we do find that shoppers tend to shorten their shopping trips if retail space is empty; and
- Encourage longer shopping trips on weekdays – Increasing dwell times has been shown in the earlier part of this paper to increase overall total sales at the centre. The centre is not congested during the early part of the week, and this seems to be the most appropriate time to focus on increasing dwell times.

Further research is needed to identify the most effective way to encourage shoppers to stay longer during the early part of the week, but ideas include:

(a) changing car parking prices to encourage longer dwells;
(b) encouraging cross-store promotions (for example, stores at opposite ends of the centre could offer discounts on each other's products to encourage shoppers to walk the full length of the centre, and thereby to pass many other retailers on route);
(c) offering free or subsidized refreshments breaks (other research[xii] has shown that shoppers are most likely to purchase at the first store they visit. Further research could be conducted to identify whether or not the probability of purchase is 'reset' following a refreshment break)

RECOMMENDATIONS FOR FUTURE RESEARCH

One of the interesting findings in this research is that the length of time that shoppers stay at the centre decreases during school holidays and weekends. It is unclear what is driving this result and further research is needed to identify whether:

1. Weekend and holiday shoppers are different from weekday shoppers – one hypothesis is that weekend shoppers are 'targetted' shoppers who come to the centre, buy what they need and then leave, as opposed to weekday shoppers who are more relaxed 'leisure' shoppers; or

2. Shoppers dislike congestion and cut short their shopping trips as a result.

The result of this research would assist centre management to know whether they should increase the churn of shoppers during busy periods (so as to allow more 'targetted' shoppers through the centre), or – by contrast - whether they should seek to eliminate congestion in the centre.

In addition, we argue that future research should look at and quantify the effectiveness of management intervention in increasing dwell times (particularly during the early part of the week). In particular, research could focus on conducting experiments with management to quantify the effectiveness of measures to increase dwell times such as:

(a) changing car parking prices to encourage longer dwells;
(b) encouraging cross-store promotions (for example, stores at opposite ends of the centre could offer discounts on each others products to encourage shoppers to walk the full length of the centre, and thereby to pass many other retailers on route);
(c) offering free or subsidized refreshments breaks (other research[xiii] has shown that shoppers are most likely to purchase at the first store they visit. Further research could be conducted to identify whether or not the probability of purchase is 'reset' following a refreshment break)

FOOTPATH FROM PATH INTELLIGENCE

BACKGROUND

FootPath from Path Intelligence is a proprietary, patent-pending, new technology that is able to accurately locate mobile phones whilst indoors. A reality mining tool, FootPath allows shopping centre managers/owners, airport and railway station managers, exhibition centres, art galleries and museums to understand the way that their customers or passengers flow through their centre by detecting the movement of their mobile phones. This tool is the only automated and reliable method for identifying the path that people take through a large indoor area.

FootPath is an attractive technology for a number of reasons including:

- Extremely large sample size as mobile penetration is above 80% in Europe;
- Accurate to within a few metres;
- Large range detectors minimize the number required to cover large areas like shopping centres; and
- Sample remains completely anonymous – the system simply detects the presence of a mobile phone. Path Intelligence have carefully developed the system to ensure absolute privacy of the individual. At no point can an individual be identified by FootPath.

HOW IT WORKS

The FootPath™ system consists of a small number of discreet detector units installed throughout the centre. These units calculate the movement of consumers without requiring the shopper to wear or carry any special equipment. The units measure signals from the consumers' mobile phones using unique technology that can locate a consumer's position to within a few metres. The units feed this data (24 hours a day, 7 days a week) to a processing centre where the data is audited and sophisticated statistical analysis is applied to create continuously updated information on the flow of shoppers through the centre. At anytime the shopping centre management can access the data via PI's secure web-based reporting system – PI Explorer. FootPath™ can be installed in one centre or across a portfolio, providing you with quantifiable information to monitor your centre and assess the impact of your business decisions.

INFORMATION FROM FOOTPATH™ HELPS CENTRE OWNERS AND MANAGERS TO:

PERFORMANCE:

- Improve their retail tenancy mix and attract more shoppers to their centre
- Maximise the revenue from tenant stores by optimizing the layout of their centre

LETTINGS/RENTAL:

- Optimize the price of retail units by understanding the impact of a store's position on its rent per square foot
- Target potential tenants for empty lots by understanding which stores consumers consider complementary
- Reduce rental disputes by using our independent data on traffic past each unit or site
- Present current and prospective tenants with actual shopper movement to demonstrate traffic past the site and linkages between the site and other retailers

OPERATIONS:

- Optimize staffing levels according to shopper flow in specific areas of their centre (e.g. Food courts and toilets) to reduce costs and increase customer service
- Reduce pedestrian bottlenecks by understanding people flow at peak times
- Optimize maintenance schedules by understanding the 'most trodden' routes

MARKETING:

- Quantify the impact of particular promotions or centre events
- Optimize the pricing of advertising space within your centre
- Attract new revenue through advertising, sponsorship and on-mall trading with proof of potential customer exposure

REALITY MINING

FootPath™ is a reality mining technology and the only system available on the market today that can gather information on shopper paths continuously and accurately. Reality Mining originated from the MIT MediaLab and is defined as the collection of machine-sensed environmental data pertaining to human social behavior. In other words, using data generated from mobile phone transmissions to understand more about human (in this case, shopper) behaviour. Reality mining brings data mining to a new paradigm because it enables automatic analysis of very large sample sizes or groups of individuals. For more information on reality mining visit http://reality.media.mit.edu/.

PATH INTELLIGENCE – OUR STORY

Path Intelligence is a UK technology start up based in Port Solent Marina, Portsmouth. The company was founded by Toby Oliver and Sharon Biggar in 2004 after the pair began developing the FootPath system.

Inspiration for FootPath came in 2003 whilst Toby Oliver was working for a sports sponsorship company advising Volvo on the Volvo Great Race. After he left the firm, Toby wondered how companies could quantify the effectiveness of their sponsorship investment. Going a step further wouldn't companies love to find an easy way to calculate how many people were attending their events and being exposed to their brands? What does almost everyone carry with them that could be counted and used as a tag? The obvious answer was a mobile phone and so the search began to identify a way to passively and anonymously identify the location of mobile phones accurately.

This search began at MIT in Boston, where Toby came across the concept of reality mining, and the key technologies used by Path Intelligence – namely the open source Gnuradio and the USRP. Then in 2004 Toby went to Barcelona to write the business plan and to Paris to perform an initial scope of the market.

Path Intelligence was recognized for its innovative ideas very early on:

- January 2005 – Semi-finalists in the MIT business plan competition
- Februiary 2005 – Runners up in the Cornell Business School business plan competition
- June 2005 – Finalists in the Technium Challenge competition.

Since then the company has gone from strength to strength. Path Intelligence received a Pocket award and a Small Firms Loan Guarantee in 2005 and in 2006 installed into a trial site, where we were able to conduct this study.

In 2007 Path Intelligence competed against entries from 50 other businesses across the South East of England to win the SEEDA (South East Enterprise Development Agency) Award of £25,000. In the same year Path Intelligence also received investment from San Fransisco based VC's O'Reilly Alphatech Ventures.

Path Intelligence's aim is to become an "offline Google Analytics". That is, it seeks to bring tools that are readily available in the online world to assist businesses that operate in the offline world.

For more about Path Intelligence visit www.pathintelligence.com or email info@pathintelligence.com.

APPENDIX 1 – CHECKING THE APPROPRIATENESS OF THE INSTRUMENTAL VARIABLE

Below we show the results of our investigation of the appropriateness of our chosen instrumental variable (changetemp) on both the dependent variable (sales) and the residuals (e).

In the following analysis we regress the IV (changetemp) on the dependent variable (sales) and look at the pair wise correlation between the two variables. We find that the IV is insignificant and is not correlated with sales.

```
. regress sales changetemp
```

Source	SS	df	MS	Number of obs =	191
				F(1, 189) =	0.26
Model	2.2235e+09	1	2.2235e+09	Prob > F =	0.6130
Residual	1.6371e+12	189	8.6618e+09	R-squared =	0.0014
				Adj R-squared =	-0.0039
Total	1.6393e+12	190	8.6279e+09	Root MSE =	93069

sales	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
changetemp	-2434.101	4804.181	-0.51	0.613	-11910.8	7042.603
_cons	320115.5	7487.202	42.76	0.000	305346.3	334884.8

```
. pwcorr sales changetemp
```

	sales	change~p
sales	1.0000	
changetemp	-0.0368	1.0000

We then repeated that analysis by looking at the correlations between the IV (changetemp) and the residuals (e). Again we find that the IV is insignificant and uncorrelated with the error term.

```
. regress e changetemp
```

Source	SS	df	MS	Number of obs =	191
				F(1, 189) =	1.17
Model	3.0845e+09	1	3.0845e+09	Prob > F =	0.2814
Residual	4.9960e+11	189	2.6434e+09	R-squared =	0.0061
				Adj R-squared =	0.0009
Total	5.0269e+11	190	2.6457e+09	Root MSE =	51414

e	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
changetemp	2866.857	2653.977	1.08	0.281	-2368.365	8102.078
_cons	-1907.845	4136.16	-0.46	0.645	-10066.81	6251.123

```
. pwcorr e changetemp
```

	e	change~p
e	1.0000	
changetemp	0.0783	1.0000

APPENDIX 2 – OUTPUT OF 2SLS REGRESSION OF DWELL TIME ON SALES

```
. ivregress 2sls sales (dwelltime=changetemp) schoolholidays weekday S.sales, f
> irst

First-stage regressions
```

Number of obs	= 175
F(4, 170)	= 9.31
Prob > F	= 0.0000
R-squared	= 0.1797
Adj R-squared	= 0.1604
Root MSE	= 9.0913

dwelltime	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
schoolholi~s	-4.205953	1.656686	-2.54	0.012	-7.47628	-.9356266
weekday	7.604687	1.606029	4.74	0.000	4.434359	10.77501
sales						
S1.	-.0000217	7.27e-06	-2.98	0.003	-.000036	-7.32e-06
changetemp	-.9524655	.4864149	-1.96	0.052	-1.912657	.0077256
_cons	126.2991	1.318799	95.77	0.000	123.6957	128.9024

Instrumental variables (2SLS) regression

Number of obs	= 175
Wald chi2(4)	= 6755.91
Prob > chi2	= 0.0000
R-squared	= 0.6836
Root MSE	= 51815

sales	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
dwelltime	3256.025	56.68977	57.44	0.000	3144.915	3367.135
schoolholi~s	90305.47	9422.818	9.58	0.000	71837.09	108773.9
weekday	-172794.3	9471.524	-18.24	0.000	-191358.2	-154230.5
sales						
S1.	.553137	.041347	13.38	0.000	.4720983	.6341756
_cons	(dropped)					

Instrumented: dwelltime
Instruments: schoolholidays weekday S.sales changetemp

APPENDIX 3 – UNDERSTANDING THE DETERMINANTS OF DWELL TIME – THE OLS REGRESSION OUTPUT

```
. regress dwelltime meantemperature rainfallmm events schoolholidays emptyretai
> lunits monday tuesday wednesday thursday friday saturday autumn spring
```

Source	SS	df	MS		
Model	10061.3667	13	773.951282	Number of obs	= 255
Residual	16141.8342	241	66.9785651	F(13, 241)	= 11.56
				Prob > F	= 0.0000
Total	26203.2009	254	103.162208	R-squared	= 0.3840
				Adj R-squared	= 0.3507
				Root MSE	= 8.184

dwelltime	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
meantemper~e	.1572116	.2136812	0.74	0.463	-.2637096	.5781329
rainfallmm	.2169031	.110017	1.97	0.050	.0001855	.4336207
events	1.716015	1.395444	1.23	0.220	-1.03281	4.464839
schoolholi~s	-3.478664	1.613488	-2.16	0.032	-6.657003	-.3003254
emptyretai~s	-.7533559	.5536697	-1.36	0.175	-1.844006	.3372938
monday	6.760627	2.049418	3.30	0.001	2.723567	10.79769
tuesday	8.626738	2.049923	4.21	0.000	4.588684	12.66479
wednesday	9.791201	2.073928	4.72	0.000	5.705861	13.87654
thursday	5.910264	2.033387	2.91	0.004	1.904785	9.915743
friday	1.89214	1.997182	0.95	0.344	-2.042022	5.826302
saturday	-4.550249	1.918221	-2.37	0.018	-8.328869	-.7716283
autumn	8.693495	1.552461	5.60	0.000	5.63537	11.75162
spring	-.795442	1.657399	-0.48	0.632	-4.06028	2.469396
_cons	122.1823	3.950769	30.93	0.000	114.3999	129.9648

```
. estat vif
```

Variable	VIF	1/VIF
spring	2.40	0.416617
thursday	1.95	0.512127
tuesday	1.94	0.515530
wednesday	1.94	0.515701
monday	1.94	0.515784
meantemper~e	1.92	0.519700
friday	1.88	0.530863
autumn	1.86	0.537838
saturday	1.74	0.575467
events	1.73	0.577042
schoolholi~s	1.61	0.621506
emptyretai~s	1.22	0.820066
rainfallmm	1.07	0.936352
Mean VIF	1.78	

```
. estat dwatson

Number of gaps in sample:  1

Durbin-Watson d-statistic( 14,   255) =  1.954532

. estat hettest

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of dwelltime

         chi2(1)      =     5.16
         Prob > chi2  =   0.0231
```

EXPLANATION OF NOTES

[i] A different approach to investigating the link between dwell time and sales would have been to run controlled experiments. It is relatively easy to think (at least) in theory of such experiments. For example, two possible experiments are as follows:

An experiment could have been devised whereby a group of people were randomly selected, taken to the centre and told to behave as they would normally within a centre. (Perhaps even given $500 and told that they could either spend the money or take it home with them) When they look like they are ready to leave the centre, an experiment supervisor would tell them that they can't leave for another hour. (It would be important for the experiment that this news was unexpected). At the end of that hour they would be asked if they purchased any additional items during that time.

Alternatively, researchers could observe what happens when a commuter train scheduled to depart from the centre is delayed (or deliberately ask a train to be delayed). Researchers could then board the train and ask those on board whether they purchased any additional items from the centre during the time that the train was delayed.

[ii] Simultaneous equation systems violate the classical assumption that the error term and the explanatory variables are independent of each other.

[iii] An alternative would have been to simply use 'rainfall' as the instrumental variable. Rainfall is shown to be a significant driver of dwell time but we were concerned that rainfall would not be independent of sales, for it is likely that there are different types of shopper that visit the centre when it is raining.

[iv] While this does not capture 'unexpected rain' per se, we assume that rain will lower the overall temperature on the day and will therefore be captured through that measure

[v] Daily sales figures have been estimated from the weekly sales figures on the basis of daily footfall numbers.

[vi] The 'Holiday dummy' takes the value of 1 if the day is regarded as a school holiday for state-run schools and 0 otherwise.

[vii] For example, the authors are aware that Experian Group have recently conducted a face-to-face survey of 300 shoppers to better understand their shopping behaviour

[viii] It should be noted that with over 120 available retail and restaurant outlets this is a very small percentage of the total shopping area.

[ix] We would expect that dwell time would be lower at centres that were missing a critical category of retailer. For example, the authors are aware of a centre in London

that failed to provide a bookstore. When a bookstore opened across the street from the centre, many shoppers chose to leave the centre to visit the bookstore. In this situation we would expect dwell time at that centre to be lower than otherwise would have been anticipated.

[x] While some retailers did change during the period of the study it tended to be the smaller stores and/or the restaurants. The larger and more heavily branded stores remained constant. For that reason there was insufficient change to be able to discern an impact on average dwell time.

[xi] Centre management may also like to experiment with holding events on weekdays and non-holiday periods. The FootPath information can be used post-event to evaluate the costs and benefits of this.

[xii] In 2006 Experian conducted a survey of 1000 shoppers. This survey asked shoppers to detail how many stores they entered on their shopping trip and which of those stores they actually purchased from. Experian found that shoppers were most likely to purchase at the first store that they entered, and that the probability of purchase decreased with each subsequent store.

[xiii] Ibid.