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Recommended Citation

Lan, Yihong; Jiang, Zhenhui; and Hahn, Jungpil, "WILL THEY STILL PAY? A STUDY OF CONSUMER BEHAVIOR IN AN UNMANNED RETAIL ENVIRONMENT" (2022). *ICIS 2022 Proceedings*. 12.

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Will They Still Pay? A Study of Consumer Behavior in an Unmanned Retail Environment

Short Paper

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Abstract

An unmanned retail shelf is a new retail format made possible by the advance in mobile internet and digital payment technologies. With drastically reduced personnel costs and upfront equipment investment, unmanned retail shelves promise the potential of deeper penetration into more convenient locations for consumers. However, a lack of onsite staff can also mean that unmanned retail shelves are more vulnerable to incidences of theft as compared to traditional stores. We investigate the impact of formal and informal surveillance technology in the context of an unmanned retail environment. By investigating the impact of surveillance technology on consumer behavior outcomes such as theft rate, approach rate, and conversion rate, we hope to better understand if surveillance technologies live up to the promises of improving net economic outcomes by delivering better security.

Keywords: Surveillance, privacy, unmanned retail, deterrence, theft

Introduction

Unmanned retail is a new retail format that has gained rapid interest amongst investors and technology companies. Its recent adoption by consumers had been made possible primarily by the proliferation of smartphones, mobile payments, and related technologies. The concept of unmanned retail has existed since the 19th century in the form of vending machines (Chandler et al. 2009). In the early 1990s, technologies such as barcode scanners and credit card payments updated the format with the introduction of self-service checkouts in supermarkets, thereby reducing the number of staff required to man checkout counters.

Recent unmanned retail concepts often have no onsite staff, but this also means that potential customers can enter and exit the vicinity of the retail shelf with no restraint. This leads to increased incidents of theft. To counter this, tech companies have implemented a variety of surveillance technologies from CCTVs to motion sensors, all meant to track users and deter potential thieving behavior. However, the impact of surveillance technologies on consumer behavior is not well studied. Hence, this study plans to measure the impact of technological interventions on our three dependent variables, theft rate, approach rate, and conversion rate to answer our research question as follows:

RQ: how would surveillance technology impact consumer mobile payment behavior in an unmanned retail environment?

To directly deter potential deviant behavior, we identify CCTV as a possible option. CCTV is considered a form of **formal surveillance** under the Crime Prevention through Environmental Design (CPTED) framework, which aims to produce a direct deterrent threat to potential offenders (Lindblom and Kajalo 2011). To counter the absence of customer service staff and indirectly discourage deviant behavior, we identify sensor greeting bells as a form of **informal surveillance** that could also improve the shopping experience (Lindblom and Kajalo 2011). A sensor greeting bell aurally simulates the simplest form of customer service – greeting the customer.

Thus, the two technological interventions, CCTV surveillance, and sensor greeting bells were chosen as our independent variables. For our dependent variables, we measure approach rate, conversion rate and theft rate. We measure approach rate, which reflects the probability of a subject walking by interacting with the shelf. We measure conversion rate, which reflects the probability of a subject paying for the merchandise. We measure theft rate, as this reflects the probability of shoplifting, which is what we seek to reduce in an unmanned retail setting through surveillance technologies. Ideally, our two technological interventions should reduce theft rate, but not approach rate and conversion rate in order to maximize economic outcome for retailers. However, this may not be the case due to potential privacy concerns resulting from the implementation of the two technological interventions. Specifically, potential privacy concerns stemming from surveillance technology could discourage potential customers from approaching and/or purchasing merchandise from the unmanned retail shelf.

By measuring the main effects and interaction effects of CCTV and sensor greeting bells on not just theft rate, but also approach and conversion rate, we developed a framework to evaluate the overall economic impact of implementing formal (CCTV) and informal (sensor greeting bells) surveillance. This framework can be applied during the design of future retail systems to specify the combination of technological interventions to improve economic outcomes for the retail system.

Literature Review

In this section, we develop our theoretical perspective on the underlying mechanisms driving the relationships between the independent and dependent variables in the context of unmanned retail. Firstly, with regards to customer theft rate, we review deterrence theory to understand the mechanisms underlying retail theft prevention. We then discuss ‘Crime Prevention through Environmental Design’ (CPTED), which provides us the framework with which to understand the deterrent qualities of our two independent variables, CCTV surveillance and sensor greeting bells. Secondly, with regards to customer approach rate, we draw from information privacy literature to understand the impact of our technological interventions on the willingness of potential customers to approach the unmanned retail shelf from a privacy risk perspective. Thirdly, with regards to customer conversion rate, we apply assurance theory and social presence theory to understand the impact of these technological interventions on trusting intentions, perceived security risk, and correspondingly, purchase intentions and customer conversion rate.

Deterrence Theory

Deterrence theory applies a utilitarian philosophy to crime (Akers 1990) by assuming that individuals evaluate the costs and benefits associated with a situation, and then make rational decisions based on increasing pleasure (e.g., benefits) and decreasing pain (e.g., risks/costs) (Dootson et al. 2017). The 18th-century founder of utilitarianism, Jeremy Bentham, believed that the rate of commission of a particular offense varies inversely with the celerity, certainty, and severity of punishment for that crime (Gibbs 1968). Silberman (1976) noted that ‘studies on the effects of certainty and severity of punishment on crime rates consistently describe weak, although significant, negative association between certainty of punishment and crime rates.’ Indeed, Matsueda et al. (2006) found that for both theft and violence, a higher perceived chance of success at both commission and escaping punishment will increase the likelihood of occurrence.

This study focuses on unmanned retail environments, which, in the process of replacing human cashiers with mobile payment technologies, have removed a major deterrent to theft from the retail shelf. The absence of a human cashier means that there is a much lower certainty of punishment for the potential violator since there is no one on site to observe, identify, and apprehend him or her. It follows that this reduced certainty of punishment leads to an increased perceived opportunity to commit theft and get away with it. This also explains why current unmanned retail shelf models suffer from high levels of theft.

CPTED – Formal and Informal Surveillance

Surveillance refers to the capacity of the built form to provide opportunities for surveillance for residents and others using the building configuration and the design and placement of windows and building entrances (Cozens and Love 2015). Within the CPTED framework, surveillance can be further separated into formal and informal surveillance methods (Moffatt 1983).

Formal surveillance aims to produce a direct deterrent threat to potential offenders through the deployment of personnel whose primary responsibility is ensuring security (e.g. police, security patrols), or through the introduction of some form of surveillance technology, such as CCTV (Cozens and Love 2015; Reynald and Elffers 2009; Welsh and Farrington 2004). The presence of these interventions also presents the potential for action either immediately through active enforcement by security personnel; or by recourse, through collecting evidence from analyzing CCTV recordings. Visibility and unverifiability lie at the heart of how the surveillance gaze can effectively fulfill its purpose and control its subjects. The panoptic condition of video surveillance imposes self-vigilance. This internalization of control then results in an easy and effective exercise of power (Foucault 1980).

Informal surveillance indirectly deters crime by capitalizing upon the ‘natural’ surveillance provided by people going about their everyday business (Welsh and Farrington 2004). Informal surveillance is promoted by physical features and activities in a way that maximizes visibility and fosters positive social control. Some practical implementations include keeping stores well-lit and fostering positive social interaction between sales staff and customers (Lindblom and Kajalo 2011). By increasing subjects’ perception that they can be seen, a technological intervention would increase the subjects’ perceived apprehension risk and certainty of punishment. By fostering positive social control, it would increase the perceived seriousness of committing a crime, which could, in turn, increase the expected severity of punishment. Reynald and Elffers (2009) highlight social control as a crucial part of informal surveillance. By fostering positive social interaction and control, a sensor greeting bell that plays a greeting message as a customer enters the vicinity of the retail shelf could be considered as a form of informal surveillance under the CPTED framework (Lindblom and Kajalo 2011).

Benefits of Surveillance and Privacy Concerns

Surveillance technology invokes privacy concerns perhaps more directly than any other type of technology because surveillance equipment, by its very nature, is designed to enable a surveillant to observe that which the subject does not want to be observed (Kearns 1998). Hence, we would expect that privacy concerns pertaining to surveillance technology would impact how consumers choose to interact with the unmanned retail shelves. For example, consumers could choose to avoid interacting with the unmanned retail shelves altogether due to privacy concerns caused by the presence of surveillance technology. Indeed, critics have

claimed that surveillance technology is sweeping up massive amounts of data without evidence of the technologies being effective in improving security (Cayford and Pieters 2018).

However, surveillance technology proponents have made the case for its implementation in various contexts, such as progress towards efficient administration within large-scale bureaucratic organizations (Lyon 2008), employee safety and security within the workplace (Watkins Allen et al. 2007), increased physical security of people and property within a law enforcement context (Clarke 1988), and for the provision of deterrence and information to understand and prevent terrorist acts within a national security context (Reddick et al. 2015).

In the unmanned retail context, through formal surveillance such as CCTV, which provides an accurate video record of all interactions with the unmanned retail shelf, customer assurance can be achieved. This would mitigate the transaction and merchandise related concerns associated with unmanned retail shelves. Assurance implies a situation in which security is sound and the system provides trust and confidence in the organization’s security and privacy practices (Spears et al. 2013).

Through informal surveillance such as a sensor greeting bell, which as a verbal cue, social presence could be induced within approaching subjects. Social presence refers to the degree to which a medium allows a user to establish a personal connection with other users (Short et al. 1976). It represents the capability of a medium to allow a user to experience others as being psychologically present (Fulk et al. 1987). According to Short et al. (1976), social presence is a subjective quality of the communication medium and relates to the social psychology concepts of intimacy (determined by physical distance, eye contact, smiling, and personal topics of conversation) and immediacy (determined by the medium’s capacity in transmitting information). Therefore, social presence can be a function of both verbal cues such as the sensor greeting bell.

Research Model and Hypothesis

Figure 1 below summarizes our research model and theorizing framework. We theorize the main effects of formal and informal surveillance on approach rate, conversion rate, and theft rate, as well as the moderating effects of informal surveillance on formal surveillance. We theorize the main effects of formal and informal surveillance on approach rate, conversion rate, and theft rate, through the theories reviewed such as privacy, assurance, deterrence, CPTED, and social presence.

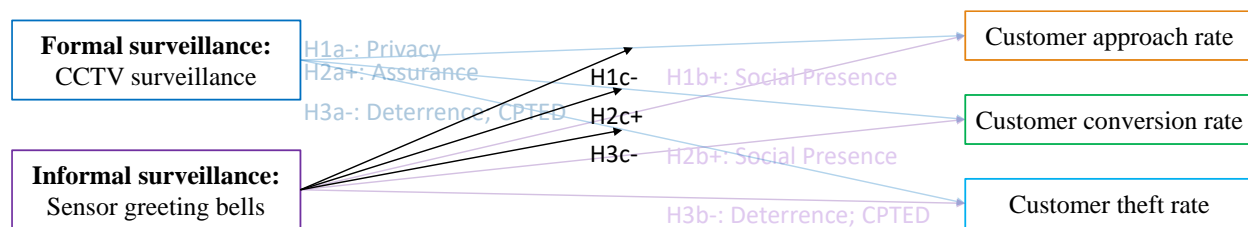


Figure 1: Research model

Customer Approach Rate

We define the customer approach rate as the proportion of subjects that approach and display an active interest in the unmanned retail shelf in relation to the total number of subjects that passed by the retail shelf. We categorize subjects who had stopped in front of the retail shelf for more than five seconds as approaching subjects. The customer approach rate reflects the effectiveness of the retail environment in capturing interest from potential customers to interact with the retail shelf. Customer approach rate is an important measure since approaching the retail shelf is an intermediate state for all paying customers.

In our study, CCTV surveillance technology could be a cause for information privacy concerns due to its capabilities to collect and store video data of the subject. In terms of the three IUIPC dimensions, the presence of CCTV cameras indicates to subjects that video data about them will be **collected** once they

approach the unmanned retail shelf. Once the video data is collected, the subject has neither **control** over the collected information nor **awareness** of how the collected information is used.

Hence, approaching an unmanned retail shelf equipped with CCTV surveillance technology could expose users to information privacy risks. To avoid exposure to this potential information privacy risk, users might simply choose to not approach these unmanned retail shelves altogether. In doing so, these users can then avoid being recorded by the CCTV camera, thus not risk exposure to information privacy risks. Therefore, we argue that information privacy concerns caused by CCTV cameras would directly impact the customer approach rate of an unmanned retail shelf. Hence, we propose the following:

H1a: The presence of CCTV surveillance is negatively associated with customer approach rate

Compared to CCTV surveillance systems, which record and collect video data, sensor greeting bells do not collect data on a potential customer as he or she approaches it. Since no collection of personal information takes place, sensor greeting bells will not be perceived as a privacy risk by potential customers. Therefore, privacy concerns would not cause customers to avoid an unmanned retail shelf that implements only sensor greeting bells. On the contrary, the greeting message played by the sensor greeting bell when subjects walk by could act as an auditory cue that evokes a sense of social presence within subjects. This social presence could interest potential customers to stop at the retail shelf and further investigate. Hence, we propose the following:

H1b: The presence of sensor greeting bells is positively associated with customer approach rate

As discussed, the presence of sensor greeting bells may evoke a sense of positive social presence through a friendly greeting message. Besides gathering interest from potential customers and encouraging them to investigate, positive social presence may result in a decrease in negative emotions by satisfying subjects' need for association. This decrease could apply to the negative emotions within potential customers caused by the possibility of unauthorized secondary use and improper access to personal information by the retailer. Ultimately, the presence of sensor greeting bells would reduce negative emotions, causing potential customers to be less concerned about the information privacy risk they are exposing themselves to when a CCTV camera is present. This would reduce the information privacy concerns caused by the CCTV camera. Hence, we propose the following:

H1c: The negative effect the presence of CCTV surveillance has on customer approach rate is weaker when sensor greeting bells is also present

Customer Conversion Rate

We define the customer conversion rate as the proportion of subjects who willingly paid for the merchandise. We categorize subjects who had successfully paid for bottled water through WeChat Pay as converted customers. The customer conversion rate reflects the effectiveness of the retail environment in converting potential customers into paying customers. Conversion rate is a function of purchase behaviors at a retail shelf, which in turn reflects the trusting intentions of customers towards the said retail shelf.

Due to the unmanned and novel nature of the retail shelf, there could be greater uncertainty associated with the transaction and merchandise security of unmanned retail shelves. To mitigate the increased uncertainty, we investigate how surveillance technology can reduce both types of perceived security risks. We argue that video surveillance can address the increase in perceived security risk through an assurance mechanism. For example, a customer concerned about transaction security risk could choose to complete all transactions in front of the CCTV camera, such that a video record of the transaction is kept. The availability of video records will provide assurance to the customer that transaction disputes can be objectively resolved should they arise, thereby mitigating perceived transaction security risks. The presence of CCTV will also deter bad actors from tampering with the merchandise, thereby mitigating perceived merchandise security risks. Ultimately, the assurance resulting from the presence of the CCTV will mitigate increased uncertainty within customers that is a result of the novel nature of the unmanned retail shelf. The mitigation of this uncertainty will reduce perceived security risks and have a positive impact on purchase intentions and therefore the conversion rate. Hence, we propose that:

H2a: The presence of CCTV surveillance is positively associated with customer conversion rate

When a customer walks by an unmanned retail shelf that has a sensor greeting bell, the motion triggers the sensor greeting bell, causing an audio greeting message to be played. This allows a customer to experience customer service staff as being psychologically present. While this psychological presence is only experienced briefly, we argue that this effect is especially pronounced since social presence is effectively nil at an unmanned retail shelf otherwise. Thus, we expect that the presence of sensor greeting bells at these unmanned retail shelves results in higher levels of social presence. As discussed in the previous section, Gefen and Straub (2003) found in their study that social presence enhances consumer trust. As subjects place greater trust in the retailer, this will help to mitigate the increased uncertainty associated with the novel nature of the unmanned retail shelf. This would increase the conversion rate. Hence, we propose that:

H2b: The presence of sensor greeting bells is positively associated with customer conversion rate

From a conversion rate and purchase intention perspective, the goal of the retailer is to build consumer trust with respect to the consumer experience. As discussed in the previous section, this is a challenge in unmanned retail as compared to traditional retail due to the lack of interpersonal interaction.

The implementation of sensor greeting bells evokes a social presence that is expected to enhance consumer trust. CCTV surveillance systems, on the other hand, improve consumer trust through an assurance mechanism. As observed by Wood et al. (2006), one of the benefits of surveillance was that citizens could expect their rights to be respected because they were protected by accurate records. As discussed, accurate records could then reduce perceived transaction security risk.

In situations where both CCTV surveillance and sensor greeting bells are implemented, we argue that the triggered greeting message from the sensor greeting bell would help CCTV surveillance provide even stronger assurance that transaction disputes can be objectively resolved. While CCTV surveillance provides assurance that retailers have the data and thus the ability to objectively resolve transaction disputes, it does not assure customers that the retailer will utilize the video data impartially. When sensor greeting bell is also present, the triggered welcome greeting played enhances consumer trust through social presence. This enhanced consumer trust helps assure customers that video data is not only collected but will also be used objectively in the event of a dispute. We argue that this would lead to increased mitigation of perceived transaction security risk and ultimately increase the conversion rate. Hence, we propose the following:

H2c: The positive effect the presence of CCTV surveillance has on customer conversion rate is stronger when sensor greeting bells is also present

Customer Theft Rate

We define the customer theft rate as the proportion of subjects who chose to take bottled water from the shelves without making any payment. We categorize subjects who took merchandise without making payment as thieving subjects. Customer theft presents a significant problem for retailers financially, both in terms of shrinkage costs and required investment in additional retail security. Increases in shoplifting have been attributed to modern retailing practices—for example, open displays and self-service (Bannister 1979; D'Alto 1992), and a retail setting which provides opportunities for shoplifting coupled with low risks of apprehension (Ekblom 1986; Lo 1994; Shapland 1995).

An unmanned retail shelf with neither formal nor informal surveillance could represent a modern retail setting with almost zero risk of apprehension. With no onsite staff nor surveillance interventions, there would be neither witnesses nor evidence that could incriminate an offender. According to deterrence theory, this low risk of apprehension would substantially increase the likelihood of theft.

By introducing CCTV surveillance systems, a form of formal surveillance, into the unmanned retail environment, potential shoplifters will find it riskier to commit shop theft since their actions will be captured and recorded by the CCTV. So long as the recorded video data is properly managed, it could be used by law enforcers at any point in the future, either as information used to identify violators or as the evidence required to incriminate suspects. This threat will increase potential violators' perceived apprehension risk, and correspondingly increase perceived certainty of punishment, from near-nil levels. According to deterrence theory, the rate of commission of a particular offense varies inversely with the certainty of punishment for that crime (Gibbs 1968), thus it follows that the implementation of the CCTV would reduce the likelihood of theft. Thus, we propose the following:

H3a: Presence of CCTV surveillance is negatively associated with theft rate

In this study, we also introduced a second technological intervention, which is a sensor greeting bell that triggers a greeting message whenever a subject walks by the unmanned retail shelf. The sensor greeting bell acts as a form of informal surveillance by fostering positive social control through the greeting message. Since the greeting message is triggered upon subjects passing by the shelf, it would cause subjects to perceive that the greeting message was triggered because the unmanned retail shelf system was aware of the subjects' presence. This then increases the subject's perceived apprehension risk and certainty of punishment. Additionally, the positive social control exerted by the greeting message would heighten subjects' awareness of potential legal repercussions for even petty offenses such as shoplifting, and therefore the expected severity of punishment associated with the crime. The increase in perceived certainty and expected severity of punishment leads to a deterrence effect on criminal intent. This in turn reduces the likelihood of theft. Thus, we propose the following:

H3b: Presence of sensor greeting bells is negatively associated with theft rate

While both CCTV cameras and sensor greeting bells increase the subject's perceived apprehension risk, the true effectiveness of CCTV cameras as a deterrent lies within the surveillance gaze described in the previous section, which induces a 'state of conscious and permanent visibility' within subjects. On the contrary, the sensor greeting bell achieves informal surveillance through positive social control, which pressures subjects into abiding by social norms, making them less likely to engage in deviant behaviors. We argue that the two mental states are mutually exclusive, meaning that the positive psychological state induced by the sensor greeting bell's friendly greeting message might interrupt the state of constant intensive surveillance that CCTV cameras might otherwise induce. Hence, combining formal and informal surveillance could in practice lead to lower effective deterrence.

In the context of our study, a subject that passes by an unmanned retail shelf with CCTV would experience a negative emotion since he or she would be subjected to the intense psychological pressures of being watched once he or she is aware of the presence of the CCTV, either through noticing the prominently placed CCTV itself or seeing the signboard stating that the area is under CCTV surveillance. However, if at this time, a friendly greeting message is played by a sensor greeting bell, the positive emotion that is induced by the greeting message would counteract the negative emotion that is induced by the psychological pressures of being watched. This effectively alleviates the psychological pressures of being watched within the subject, which results in the CCTV having a weaker deterrence effect on criminal intent. Therefore, we propose that:

H3c: The negative effect the presence of CCTV surveillance has on theft rate is weaker when sensor greeting bell is present

Methodology

The hypotheses proposed in the present study were tested through a field experiment with a 2×2 full-factorial between-subjects design (i.e., CCTV surveillance system \times sensor greeting bell). We selected 24 locations within the university town, with 6 hostel locations for each of our 4 treatment groups. Within each of the 4 treatment groups, 3 male hostel locations are only accessible to male students of that treatment group while 3 female hostel locations are only accessible to female students of that treatment group. We captured the interaction of each subject with the unmanned retail shelf using video cameras (hidden cameras are used for the control group and informal surveillance treatment group), including the number of subjects who walked past and approached the unmanned retail shelf. This information can be then used to calculate the approach rate and conversion rate.

Experimental Setup

Our field experiment will be conducted using unmanned retail shelves that would primarily sell bottled water by partnering with a local bottled water company. Each unmanned shelf would be assigned to one of the four treatment conditions, 1. Formal surveillance with CCTV only 2. Informal surveillance with sensor greeting bell only 3. Both CCTV and sensor greeting bell 4. Control.



Figure 2. Unmanned Retail Shelf with 4-Step Payment Instructions through QR Code

Figure 2 shows an unmanned retail shelf under the third treatment condition, where both the sensor greeting bell as well as CCTV are present. For the CCTV treatment, the CCTV camera will be mounted above the shelf but remains prominent due to its size and contrast with the white walls. In addition, a signboard explicitly stating that the area is under CCTV surveillance is placed next to the retail shelf at eye level. The CCTV camera is active 24/7 during our experiment. For the sensor greeting bell treatment, the bell will be placed under one of the shelves below eye level, such that it can only be heard and not seen. The bell's motion sensor activates a welcome message whenever a subject walks by the unmanned retail shelf.

We plan to deploy and supply these unmanned retail shelves with bottled water for a period of 3 weeks and collect CCTV video data, payment data and inventory data for each unmanned retail shelf. We plan to extract the number of subjects (traffic count) within the video clips using an implementation combining DeepSort and YOLO algorithms (Zhang et al. 2019). We plan to extract total approaching subjects (approach count) through manual labeling of the relevant video clips.

Conclusion

We expect this paper to make three potential contributions. Firstly, while there have been numerous studies that have explored the impact of electronic surveillance on employees at the workplace (Ball 2010), to our knowledge, there have been no empirical studies focusing on the impact of CCTV surveillance on consumer behavior in retail environments. Secondly, this study empirically tests the effectiveness of surveillance methods in the deterrence of deviant behavior through a controlled experiment. This contributes to the surveillance research stream that had previously been limited to understanding the impact of surveillance technology on deviant behavior through interviews (Gates 2010; Gill 2007) and surveys (Lindblom and Kajalo 2011). Thirdly, this study provides a useful reference for decision-making by retailers for the specific case of implementing surveillance technology to improve economic outcomes for unmanned retail shelves. While formal surveillance methods such as CCTV cameras are much more effective at reducing theft rate as compared to informal surveillance methods such as sensor greeting bells, it does not necessarily lead to the most favorable economic outcome for the retailer.

One limitation of our study is generalizability of our results due to the demographic samples available. The proposed field experiment takes place in China, which has some unique characteristics regarding retailing and privacy, thus the data were collected from only Chinese subjects. Since privacy is a result of the impacts of cultural, social, and physical settings (Hong and Thong 2013), the differences in cultural characteristics between China and the Western world mean the results might not generalize to subjects in the West.

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