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An Experimental Contingent Valuation of Users' Attitudes towards a Crowd Management System

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Abstract

Smart city projects are being launched globally to enhance the well-being of citizens. Meanwhile, the value-added of the projects is not easy to evaluate due to the non-market nature of the public services provided. This study intends to investigate the attitudes of potential users of a Crowd Management System (CMS) to help with the decision-making on smart city projects. The CMS studied in this paper is applied in large-scale events to enable safe and efficient dissipation of event participants as one of the pilot Smart City projects in Hong Kong. It does so by providing real-time information on public transport for their return journeys when a large number of participants all finish their activities within a short time span. Reducing injuries of pedestrians can be achieved in major gatherings to improve safety. This paper presents an experimental analysis of users' attitudes towards the CMS with the Contingent Valuation (CV) method. A marathon event in Hong Kong was chosen for an on-the-spot survey of actual users as part of an experimental study. Subsequently a similar survey was carried out off-site among marathon runners not participating in that event (as a control group) for data reliability comparison. The Willingness-to-Pay value is also derived from the pooled samples to evaluate users' attitudes. Besides, the results indicate that runners' *perceived usefulness* and *online payment habit* significantly influence the stated Willingness-to-Pay (WTP) for the CMS in question.

Keywords Crowd Management System; Contingent Valuation method; Willingness-to-Pay; Information and Communication Technology; Smart City.

1. Introduction

In the arena of smart city development, crowd management is an important function of smart mobility with the advent and intensive application of Information and Communication Technologies (ICTs) (Kumar et al., 2018a). In high-density urban environment, major events with large crowd gatherings, such as firework displays, outdoor concerts, marathons, etc., are being held frequently every year. The orderly dismissing of the large numbers of participants is a critical task for the related event organizers and the authorities (Gong et al., 2018). Many factors affect the route choice behavior of event participants during evacuation (Moussaid et al., 2011; Zhu & Shi, 2016). Accurate and timely information acquisition influences the participants' decision on the use of alternative transportation modes when they leave a large-scale event venue (Kingshott, 2014). The usual route may be changed temporarily due to the event arrangement (e.g., police blockages and diversions). People cannot make efficient route planning without updated information. A wrong route choice may lead to waste of time, bad emotion, and unruly behaviors (e.g. climbing to surpass guardrails), which is very dangerous from the perspective of public safety (Johansson et al., 2008). Overcrowding and mismanagement of mass gatherings have led to a number of accidents and catastrophes, such as crushing, stampedes, injuries, and sometimes even life-threatening clashes every year (Kumar et al., 2018b). Because of complexities of the scene and dynamic crowd formation, effective management is one of the most vital tasks, which present big challenges to the responsible public agencies during large mass gatherings (Shen et al., 2018). Most of the traditional large-scale gatherings relied on professional observations and the intuition of duty staff when handling crowds with great densities (Martella et al., 2017). More recently, the increasingly popular utilization of Crowd Management Systems (CMS) creates a need for evaluating the users' attitudes to determine whether such systems and related ICT are worth spending scarce city resources.

The CMS studied in this paper is an archetypal pedestrian evacuation system. It detects and tracks participants' number and motion in real-time to provide information on possible alternative routes to the users to make appropriate choices. The estimated waiting time can be disseminated to users to avoid queue congestion at the end of large-scale events. In this research, CMS comprises of cameras, video analytic equipment, a real-time communication network, and an information dissemination system, etc. The monitoring of crowd characteristics, such as density measurement, flow counting, and accident detection are implemented using cameras and video analytics. The remotely-sensed data representing the dynamic effects caused by pedestrian congestion is then transmitted via the real-time communication network to a central monitoring station and publicized through an information dissemination system. The on-site electronic signboards provide location-based information services to the moving pedestrians. Meanwhile, the duty staff would monitor crowd flow and detect unforeseen circumstances with the CCTV surveillance cameras. Public safety improvement and injuries reduction may be achieved through estimating queue build-ups and detecting serious incidents automatically at strategic locations (where any disruption in the movement pattern will trigger an alarm).

This study focuses on the users' attitudes towards CMS through the estimation of the Willingness-to-Pay (WTP) for the facilitation and assistance provided in selecting means of public transport for their return journeys. Hong Kong was chosen as the investigation destination since crowd management plans have been unfolded by the government as a proof-of-concept project, which contributes to the smart city development. Both on-the-spot and off-site investigations were conducted to improve the reliability of the survey data. Contingent Valuation (CV) was applied to quantify users' perception into monetary terms with the single-bounded questionnaire approach. An econometric analysis using a parametric method will be carried out to derive the WTP. The critical factors affecting the WTP values through the two surveys and the pooled sample will also be examined in this paper.

Apart from disseminating departing transport information to the participants, the CMS provided nearly real-time information to the monitoring staff and emergency services center (Fig. 1). Fortunately, from the debriefing report, no incident happened through close monitoring of crowd movements in real-time during this particular event. Moreover, being a proof-of-concept exercise, no staff manpower change (including emergency services) was made in the deployment on the day, compared with similar events in the past. Hence, benefits accruing to the organizer side are not counted in this valuation exercise.

2. Literature review

2.1. Evolution of crowd management

Public transport has been facing serious challenges because of fast urbanisation with increasing population densities (Population Division, 2018). Frequent and large mass gatherings in the cities are usually extraordinarily crowded and often result in massive congestion on public transport systems (Johansson et al., 2012). A variety of approaches have been applied in the estimation of pedestrians' movement and density artificially, including the use of hand counters, distribution of wristbands, turnstiles at entry points and sampling in a small area, etc. All these measures entail substantial manpower deployment. Effective auxiliary facilities should be employed in crowd management especially during massive congestion (Bellomo et al., 2016). The accuracy requirement for detecting and tracking dynamic pedestrian movement presents a compelling need for a safe solution to be devised (Gayathri et al., 2017).

2.2. Crowd management based on ICT

With the advent of ICTs, public-transport services are more intelligent. From the passengers' viewpoint, real-time information provision is regarded as an essential service of public-transport affecting their satisfaction (Camacho et al., 2013). The location-based service is proposed as a credible measure in response to an emergency during large mass gatherings (Dalgleish et al., 2009). Although relevant technologies have made considerable progress, the ICTs' application directly related to crowd management is particularly insufficient (Martella et al., 2017). Crowd management techniques are meaningful to improve traffic efficiency facilitating the safety and comfort of pedestrians in major gathering scenarios (Abbott and Geddie, 2001). As depicted in a recent research by Martella et al. (2017), the availability of real-time information on the state of crowd is emphasized based on the experience of crowd managers.

The CMS in this research is an effective solution to the crowd management problem. It provides real-time information of the crowd and traffic state for pedestrian evacuation, including waiting time and route splits, etc., to influence users' traffic mode choices. The core modules deployed include the data acquisition, normalization, analysis and visualization units for the pedestrians and traffic. The number, speed, and flow of pedestrians are tracked with counting systems and sensors installed at the scene. CMS optimizes pedestrian flows and transport means to guarantee accessibility of public spaces of complex venues. The pollution induced by the related transportation means can be mitigated (Bellomo et al., 2016). Certain behaviors that may invoke dangerous congestion will be reduced with the tiresome waiting-time being cut down. The accident rate will be reduced. Besides, the enhancement of emergency response reduces the casualty during needed evacuation. The benefits depicted above are significant but intangible to the society and environment, which are reflected in the users' attitudes towards CMS.

2.3. Need for economic assessment

Apart from a technical feasibility study, an economic justification is critical for launching a smart city project (Neirotti et al., 2014). Despite being intangible posing measurement difficulties, the users' attitudes are useful indicators for the assessment of smart city projects (Belanche et al., 2016). However, few studies regarding CMS has revealed this aspect in the existing literature to-date (Kok et al., 2016; Ryan et al., 2015; Zitouni et al., 2016). For more flexible and accurate visualization, the smart phone Apps and the electronic signboards have become the common means of information dissemination. The popularity of smart mobile devices has driven consumers engagement in mobile technologies and applications (Tarute et al., 2017), and consumers are accustomed to paid-for downloads. The perceived value of the App installation (including electronic signboards) is intuitive and representative of the users' attitudes towards CMS.

In recent studies, CV is extensively used to value public goods for decision-making, including health services (Weimer et al., 2019), renewable energy projects (Paravantis et al., 2018) and counselling services (Kim et al., 2018), etc. As an effective method to evaluate scientifically, CV was applied in the transport area to reveal the potential benefits in monetary terms (Angell et al., 2018). A validity test associated with CV was conducted on private and public safety measures for accident analysis and prevention (Andersson et al., 2019). To quantify the benefits accruing from traffic efficiency and safety of CMS, this paper adopts an experimental CV approach to estimate the WTP based on an actual event in Hong Kong.

3. Methodology

CV as employed in this research is particularly applicable to evaluate the benefits of non-market goods or services (Carson and Hanemann, 2005). The WTP will be evaluated through an econometric analysis of the users' attitudes towards CMS. CV is an effective survey-based economic valuation technique based on the stated preference approach (Carson and Hanemann, 2005; Hanemann, 1994). The study of CV is usually carried out for a specific hypothetical scene with clear statement descriptions using several alternative questioning approaches (Boardman et al., 2017). The estimation of equivalent gains (or losses) entail separate questions being asked for analyzing the respondents' preference (Haab and McConnell, 2002). It elicits respondents' WTP or WTA (Willingness-to-Accept) making reference to the payment behavior reacting to hypothetical questions (Harris et al., 1989). WTP (or WTA) can monetize the value of obtaining (or losing) the benefits directly, such as time-saving, convenience, and environmental protection (Bateman et al., 2002). This study estimates the WTP as the proxy of the users' attitudes towards CMS.

Through a pre-study on the scene of deployment of a CMS for a district marathon event, the single-bounded approach was considered to have better operability because of limited interviewing time available in the tight event schedule (Boyle et al., 1997). The single-bounded questioning approach was adopted to collect responses on WTP (Smith, 2000). It employs a questionnaire containing the referendum question "*Are you willing to pay $X* (*$X* being the bid value)" to derive the WTP according to a hypothetical and clearly described scenario (Bateman et al., 2002). The respondents just need to give a straightforward and simple *Yes*/*No* answer. The parametric logit method can be used to represent a particular population based on the sample to meet otherwise complicated mathematical assumption requirements (Relation, 2007). A bid function describing the relationship between WTP and relevant factors was generated with the econometric analysis to determine how WTP is influenced (Bateman et al., 2002).

In a binomial distribution, the dependent variable is the categorical response *Yes/No* to the elicitation question with a proposed bid. Hanemann (1989) advanced the notion that:

$$\Pr\ \{willing\ \ to\ \ pay\ \ X\} \Leftrightarrow \Pr\{true\ \ WTP >\ \ X\} \tag{1}$$

where X is the proposed amount for the respondent to vote. Then the probability of *Yes* (P_i) can be interpreted in an intuitive approach as follows:

$$P_i =\ \ Pr\ \ (Y = 1|\ \ X = x_i) \tag{2}$$

where x_i is set to be a list of bid values. The respondents will be asked whether they are willing to pay x_i for the service or product. Y is the depended variable taking values 1 or 0 for answering *Yes/No* respectively. A linear model can be interpreted as follows (Greene, 2012):

$$logit\ \ (P_i) = \alpha +\ \ \beta x_i \tag{3}$$

where α is the estimate on a set of explanatory variables, and β is the coefficient of bid value (x_i). Then the binary logistic model may be depicted as follows:

$$P_i =\ \ [1 + exp(-(\alpha -\ \ \beta\ \ x_i)]^{-1} \tag{4}$$

Hence, on the basis of discrete-response CV method (Hanemann, 1989), WTP can be estimated by:

$$E = (1/\hat{\beta}) *\ \ ln(1 + exp(\hat{\alpha})) \tag{5}$$

where E is the truncated mean WTP, and $\widehat{\alpha} = \boldsymbol{\mu}^T\ \boldsymbol{\vartheta}$ ($\boldsymbol{\vartheta}$ is the vector of explanatory variables with respect to the respondents, $\boldsymbol{\mu}$ is the vector of the corresponding coefficients of variables) (Haab and McConnell, 2002). $\hat{\beta}$ denotes the estimated coefficient of proposed bids.

4. The Experiment

4.1. Experimental setting

To enable the comparison of WTP for this new application of CMS, this research was conducted with a two-prong approach, i.e., both on-the-spot and off-site in two separate occasions. In the on-the-spot survey administered face-to-face, the interviewees were deemed to understand the functions of the

CMS clearly. The answers should be close to their true perception of the benefits of CMS. With no explicit assumption on population distribution to draw up the needed sample size, the off-site survey approach was also used to supplement and compare the WTP values obtained in the two separate but related surveys.

For the on-the-spot survey, an investigation team of 4 members was dispatched to carry out survey on crowd dispersing after a district marathon. It took place in Hong Kong on a Sunday morning in early 2017, and the number of participants was more than 15,000. The overall length of run was about 32 km. CMS was applied by the event organizers in crowd management to enable safe and efficient departure of the participants (including the runners and their supporters) from the venue end-point. Three transport modes were set up on site to dissipate the crowd, including coaches, ferries, and taxis leading to different destinations with interchange possibilities thereafter. Video analytic equipment was deployed to estimate the queuing time of each transport mode and feed real-time data into a central information dissemination system. From there the information was disseminated to the participants through an App installed in the user's smart phone (synchronized with physical electronic signboards mounted at strategic locations) to dissipate crowd efficiently from the venue (as shown in Fig. 1). The App (and the electronic signboards) of this CMS was out-sourced by the government to a private sector operator as a proof-of-concept exercise. The App installation was downloadable free of charge for the users. And the electronic signboards erected at the exit locations were meant for runners who did not carry phones during the marathon.

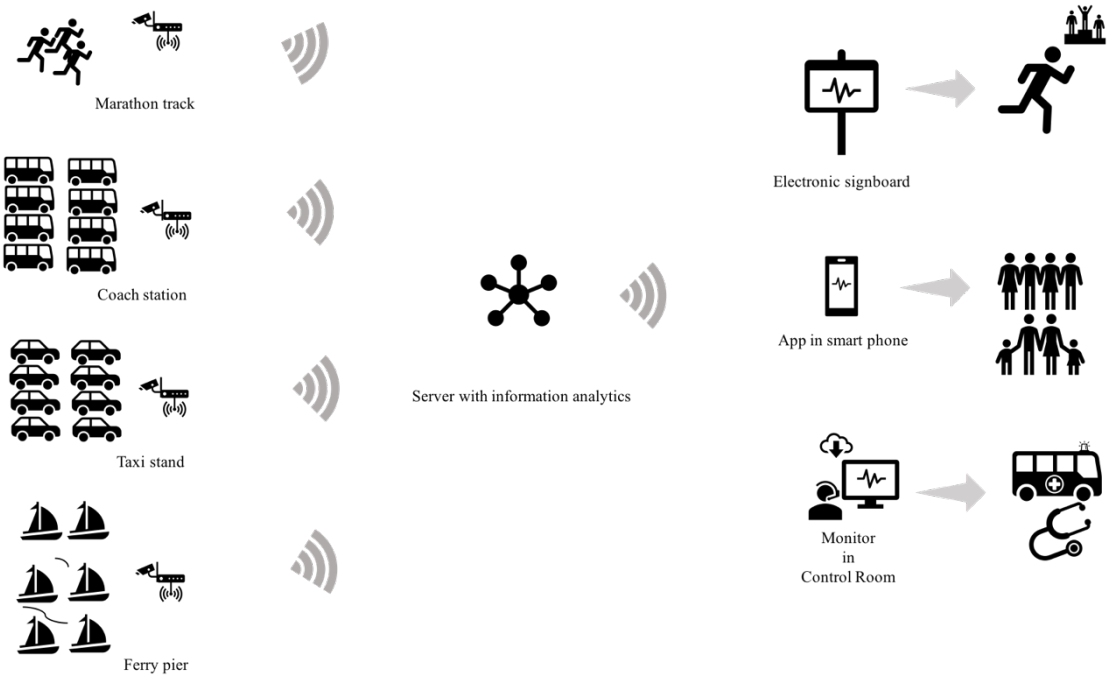

Fig. 1. The CMS in the marathon scheme of Hong Kong

For the off-site survey as a follow-up experiment, general marathon runners in Hong Kong were targeted. The survey was conducted with the assistance of an executive marathon coach, who distributed a slightly modified questionnaire (to reflect the off-site scenario) to his trainees (about 500 in total) who were familiar with the marathon scene and crowd dissipation situations in Hong Kong. Instead of verbal briefing possible during an on-the-spot survey, the modified questionnaire described the functions of the CMS to the marathon runners clearly. This survey design is fully justified in the CV methodology based on the usually hypothetical context posed to respondents (Haab and McConnell, 2002).

4.2. Survey description

A pre-testing was carried out through 23 face-to-face interviews with peers in the authors' office before the formal survey was carried out to ensure the clarity of all aspects of the questionnaire, especially the verification of three proposed bid values (HK$2, 5 or 10) for the elicitation question to derive the

estimation of WTP (Bateman et al., 2002). These values originated from the market price (around US$1, which is equivalent to HK$7.85) of most paid apps available in common mobile app stores at the time of the experiment. The said bid values were confirmed by the pre-test respondents as being appropriate for apps of similar nature. Questions on demographics (gender and age) and online payment habit were included in the anonymous questionnaire.

The on-the-spot survey was undertaken among the runners at the queues formed at a nearby public ferry pier, a taxi-stand and a coach terminal at the marathon end-point. The interviewees were having a rest after the marathon or leaving the marathon scene. The questions were spoken face-to-face in Chinese to the predominant Chinese participants by a random sampling approach. The organizer limited the pre-approved number of investigators to four, including three trained interviewers and one coordinator. The interviewers were trained about the contents of this survey in a briefing before the marathon. They were assigned to finish an equal number of questionnaires containing three alternative bids as allocated by the coordinator, targeting at different queues at various times to ensure randomness. The respondents were asked whether they were willing to pay a given amount (HK$2, 5 or 10) after being briefed on the functions of the App in a smart phone held by an interviewer, emphasizing that it was a hypothetical charge for downloading the App with the fictitious payment methods spelt out.

Being an unprecedented system in Hong Kong, many participants were not aware of the availability of the App or the electronic signboard, despite the organizer's prior promotion efforts. Hence, the interviewers explained the functions of the Apps with smart phones to the interviewees on the spot before eliciting their responses to the survey questions. Results of the on-the-spot survey indicated that the number of respondents being aware of the Apps themselves was only 2.87%, and the number of respondents noticing the electronic signboard information themselves was 10.34%. It is not uncommon for CV studies to make respondents aware of certain initiatives for the first time when conducting the surveys (Boardman et al., 2017).

In the later off-site survey, an additional question requesting respondents to rate the perceived usefulness of the CMS for large scale events based on a 0-10 Likert scale. Detail descriptions of both the App and electronic signboard were included in the questionnaire in case the respondents did not experience any CMS before (unlike the on-the-spot survey, they did not have the opportunity to see the actual CMS at work). This additional question would allow the researchers to gauge the respondents' understanding of the written descriptions. Other than that, the same questions were delivered to the marathon trainees on-line. And it was also made clear to the respondents that the CMS was provided free of charge to all participants and that the value for which they were asked about was purely hypothetical. The total number of participants was 337. With all protest responses (not responding to some questions) eliminated from the samples, the valid sample size was reduced to 256 in the off-site survey.

5. Results and analysis

5.1. Survey results

The use of logistic regression requires that there is no multicollinearity among the independent variables. This is evident from the demographics of the interviewees, who participated in the event on a random basis due to their voluntary enrolment from all over Hong Kong. However, for the parametric analysis to be conducted below, linearity of independent variables and log odds need to be assumed.

The pooled sample size was 511, with 430 valid questionnaires returned. According to Mitchell & Carson (2013), the valid pooled samples (430) can roughly represent the population of Hong Kong. In the on-the-spot survey, the sample size of valid responses was 174 collected from a departing crowd from the scene after a single morning running session. The interviewees who refused to answer or did not finish the questionnaire were not counted in the effective sample size. With 256 valid samples of the off-site survey, the valid pooled sample size (430) was nearly equally split in each proposed bid. The definitions of the co-variates are depicted in Table 1, and the demographic data is shown in Table 2. Within the valid pooled samples (430), the number of respondents who agreed with a given value (WTP) (with *Yes* answer to the elicitation) was 116 (27.0%). The elicitation results are shown in Table 3.

Table 1. Descriptive co-variates

Variables	Definition	Description
Gender	Dummy variable.	1 = *Male*; 2 = *Female*
Age	The age range of the respondent.	1 = *Below 15;* 2 = *16~25;* 3 = *26~35;* 4 = *36~45;* 5 = *46~55;* 6 = *56~65;* 7 = *Above 66*
Runner or not	Whether the respondent is a marathon runner; Dummy variable.	1 = *Yes*; 0 = *No* & *Not sure*
App Use	Whether the respondent has used the App; Dummy variable.	1 = *Yes*; 0 = *No* & *I have no idea*
Usefulness of App	A score on the usefulness of the App if used.	0 = *Not useful at all* to 10 = *Extremely useful*
Electronic Signboard Noticed	Whether the respondent has ever noticed some large on-site electronic signboards; Dummy variable.	1 = *Yes*; 0 = *No*
Usefulness of Electronic Signboard	A score on the usefulness of the electronic signboards if noticed.	0 = *Not useful at all* to 10 = *Extremely useful*
Online Payment Habit	Whether the respondent has the habit of downloading priced Apps into mobile phone; Dummy variable.	1 = *Yes*; 0 = *No* & *I have no idea*
Perceived Usefulness of CMS	The respondents' perceived usefulness of CMS in large-scale events	0 = *Not useful at all* to 10 = *Extremely useful*
Bid	The proposed bid values to be voted.	*HK$2; HK$5; HK$10*

Table 2. Demographic of samples

Variables	Classification	Pooled Sample		On-the-Spot Sample		Off-site Sample	
		Frequency	Percent (%)	Frequency	Percent (%)	Frequency	Percent (%)
Gender	*Male*	268	62.3	116	66.7	152	59.4
	Female	162	37.7	58	33.3	104	40.6
Age	*16~25*	51	11.9	48	27.6	3	1.2
	26~35	108	25.1	63	36.2	45	17.6
	36~45	113	26.3	35	20.1	78	30.5
	46~55	104	24.2	24	13.8	80	31.3
	56~65	51	11.9	4	2.3	47	18.4
	Above 66	3	0.7	0	0	3	1.2
Runner or not	*Runner*	393	91.4	142	81.6	251	98.0
	Not runner	37	8.6	32	18.4	5	2.0
Valid Sample Size		430		174		256	

In the pooled samples, male respondents accounted for 62.3%, and the main age range was 26 to 55 (75.6%), matching the general marathon participants' characteristics. However, the interviewees who have ever noticed the on-site electronic signboard account for 25.8%, and just 5.1% have used the App，justifying the necessity to set up the electronic signboard in the marathon running event as stated above. The low rate of App usage is an apparent limitation of the on-the-spot part of the research. As shown in Table 3, the acceptance rate decreases with the rising of the proposed bid values, with the highest percentage (38.1%) for the lowest bid value (HK$2). And consistent with the decreasing acceptance rate shown in Table 3, the estimates of *Bid* depicted in Table 4 are highly significant, demonstrating the impacts of proposed bid values on the WTP. Also, the estimates of *Usefulness of App* have positive signs in all three models, which show that the respondents have a positive perception of the CMS. The responses of the on-the-spot respondents are well expected, since a proportion of them saw the signboard, but the off-site respondents did not. Incidentally, the mean perceived usefulness score of the off-site respondents towards the CMS was 6.97 (the score range is 1~10 from *Little* to *Extremely*), indicating their general understanding of the written descriptions for the online survey.

As shown in Table 4, the significance levels of all the 3 models are lower than 0.05 in the likelihood ratio test, which suggest that the overall model fits well (Bentler and Bonett, 1980). A more precise statistical significance ($p<0.001$), however, is not achieved.

Table 3. The elicitation results of the valid samples

Proposed Bid Level V_j (HK$)	Pooled Sample			Contingent Valuation Survey[a]					
				On-the-spot Sample			Off-site Sample		
	No. of sub-sample (N_j)	Yes (n_j)	Yes (%)	No. of sub-sample (N_j)	Yes (n_j)	Yes (%)	No. of sub-sample (N_j)	Yes (n_j)	Yes (%)
2	139	53	38.1	43	16	37.2	96	37	38.5
5	147	41	27.9	75	22	29.3	72	19	26.4
10	144	22	15.3	56	7	12.5	88	15	17.0
Total	430	116	27.0	174	45	25.9	256	71	27.7

[a]The chi-square test of independence ($\chi^2 = 5.92$) is lower than the critical value (5.99) at $df = 2$ and $p =$ 0.05, indicating the on-the-spot and off-site samples are not statistically different.

Table 4. Estimation of the coefficients in logit models

Variable	Pooled Model		Contingent Valuation Survey[d]			
			On-the-spot Model		Off-site Model	
	Estimate-I ($\hat{\beta}_j$)	Std. Err.	Estimate-II ($\hat{\beta}_j$)	Std. Err.	Estimate-III ($\hat{\beta}_j$)	Std. Err.
Gender[b]	0.134	0.236	0.036	0.410	0.402	0.316
Age	0.046	0.094	0.234	0.185	0.020	0.145
Runner or not[b]	0.530	0.480	0.631	0.609	0.275	0.965
App Use[b]	−0.959	0.895	−3.914	6.263	−0.958	1.062
Usefulness of App	0.177*	0.112	0.728	1.234	0.200*	0.124
Electronic Signboard Noticed[b]	0.141	0.418	0.546	0.918	0.149	0.615
Usefulness of Electronic Signboard	-0.053	0.062	0.043	0.160	−0.121	0.096
Online Payment Habit[b]	0.447*	0.236	0.762**	0.375	0.206	0.322
Perceived Usefulness of CMS[a]	-	-	-	-	0.252***	0.073
Bid (HK$)	−0.147***	0.037	−0.190***	0.069	−0.141***	0.047
Constant	−1.238*	0.702	−1.779**	1.079	−2.960**	1.460
No. of observations	430		174		256	
$LR\ \chi^2$ [c]	30.28***		18.90**		36.62***	

[a] The variable of *Perceived Usefulness of CMS* is only applied in the modelling of off-site samples, not in the modelling of on-the-spot and pooled samples.

[b] Dummy variable.

[c] The likelihood ratio test on the Pooled Model ($\chi^2 = 30.28, p <$ 0.001), On-the-spot Model ($\chi^2 = 18.90, p <$ 0.05), Off-site Model ($\chi^2 = 36.62, p <$ 0.001) indicates that the models fit well with statistical significance.

[d]Chow test for the estimates of the on-the-spot and off-site samples presents $LR\ \chi^2 = 7.38$ and $p = 0.6892$, indicating that no coefficient of the parameters tested differs by group significantly, except for occasional differences probably caused by sampling variability.

* Statistically significant at 0.1 level.

** Statistically significant at 0.05 level.

*** Statistically significant at 0.01 level.

5.2. WTP evaluation

In this research, eliciting WTP values was based on the binary data and the descriptive co-variates in CV survey (McFadden and Leonard, 1993). The monetized values represent the users' attitudes towards the perceived time-saving, convenience, safety and other related benefits brought to the participants by the CMS. With the parametric method depicted in the previous Methodology section (Eq. 1-5), three binary logistic regression models of WTP were generated based on the on-the-spot, off-site, and pooled samples (Table 4). The truncated mean WTP (mean derived by discarding the high and low ends of a probability distribution) can be calculated with equation (5) (Hanemann, 1989). The results of WTP are shown in Table 5. A lower WTP estimate (HK$3.41)[1] was obtained from the

[1] Exchange rate: US$1 = approx.. HK$7.85 in August 2018.

on-the-spot survey compared with a slightly higher WTP estimate (HK$4.17) calculated with the off-site survey data. A WTP value (HK$4.51) was obtained from the pooled model using all 430 valid samples. As the first pilot CMS in Hong Kong, unfamiliarity with it may contribute to the deviation of the estimation between the on-the-spot and off-site models (Duives et al., 2018). Whilst the 95% confidence interval for the WTP of the on-the-spot survey (HK$2.98 to HK$3.77) overlaps with that of the off-site survey (HK$3.24 to HK$5.41), and the pooled samples yield a 95% confidence interval as HK$3.69 to HK$5.44 (see Table 5), it is a reasonable compromise to adopt HK$3.69, which is almost the midpoint of the overlapped region, as the estimated WTP for the CMS, with preferred conservatism in the benefit valuation.

Table 5. Estimation of Willingness-to-pay for the CMS

Survey	Truncated Mean WTP HK$ (US$) [a]	95% confidence interval HK$ (US$) [a]
On-the-spot	3.41 (0.434)	2.98~3.77 (0.380~0.480)
Off-site	4.17 (0.531)	3.24~5.41 (0.413~0.689)
Pooled	4.51 (0.574)	3.69~5.44 (0.471~0.69)

[a] US$ are presented in parentheses, US$1=HK$7.85.

5.3. Result analysis

In the co-variate analysis, the on-the-spot modeling shows that *online payment habit* of downloading priced Apps plays an important role in affecting WTP significantly. Whether respondents were accustomed to the online payment mode is believed to affect the users' value perception towards the information system positively. This aspect is confirmed by the survey results. Although the interviewees who had online payment habits to download priced Apps were relatively fewer (37.4%) compared with those not having the habit (62.6%) in the on-the-spot survey samples, the relative odds (odd ratio) in the on-the-spot model indicates that users with online payment habit are 2.14 times as likely to be willing to pay a proposed bid value than ones who were not habitual payer. It reflects users' consumption habits on information systems influence their acceptance of CMS positively. Consumption habits often affect the consumer preference and purchasing behaviors on similar commodities (Holbrook and Hirschman, 1982). The online payment mode is developing fast with information systems and may become a more habitual behavior in the near future. Security enhancement would further improve the popularization of this consumption mode, and CMS will also receive corresponding higher recognition.

The *perceived usefulness* score in the off-site survey is correlated with WTP positively as an influential factor. As demonstrated in Davis' research (1989), perceived usefulness is one of the fundamental determinants of users' acceptance of information technology. In the off-site survey, the respondents' perception was based on the description in the questionnaire. Since the off-site WTP is higher than the WTP obtained in on-the-spot survey, and the off-site WTP is affected by the respondents' perceived usefulness, this experiment demonstrates the possibly different results obtainable in face-to-face surveys, when compared with surveys based on written descriptions of a CMS. The demographic factors' being not influential to the WTPs in both surveys may be attributed to the homogeneous characters of marathon participants in relation to CMS use. Runners made up a significant share of the interviewees (91.4%) in the pooled sample. Despite their differences in age and gender, no statistically significant difference amongst demographic variables was discernible in their WTPs attributable to a CMS which helps to dissipate participants after an actual or hypothetical running event.

The reason for pooling the 2 samples (on-the-spot sample and off-site sample) together is to enable further analysis based on a combined sample. This is legitimate since chi-square test of independence (Kanji, 1993) on the data in Table 3 fails to reject the null hypothesis that the two samples are not different at $p = 0.05$. This result indicates that the two groups of samples are not different statistically and can be regarded as coming from the same population. Both samples are general marathon runners, so they are intrinsically similar.

In addition, the Chow test (Chow, 1960) is conducted to test the difference between the on-the-spot and off-site samples simultaneously (see Table 4). The likelihood-ratio chi-square statistic is calculated at 7.38 with $p = 0.6892$, revealing that the differences in coefficients to the independent variables between the on-the-spot and off-site samples are not statistically significant. The direct or indirect effects of group membership on the WTP do not exist significantly. The apparent differences between different sample groups are small enough to be attributable to sampling errors.

Summarizing the implications, the WTP point estimates are within reasonable vicinity of each other, and the 95% confidence intervals have vast overlapping areas. These indicate that the 3 models are yielding reasonably close estimates of WTP. The on-the-spot estimate is on the slightly lower end, as not many participants had actual experience of CMS use when interviewed face-to-face. The off-site approach yields slightly higher estimates of WTP when those respondents answered the survey questions based on a written description of the CMS. This experimental approach is useful in demonstrating that contingent valuation may be carried out either face-to-face or through a clear written description of the scenarios.

6. Conclusion

This paper depicts an experiment to estimate the users' attitudes towards a CMS which is perceived to enhance the safety and convenience of participants in major events. CV is applied for the first time to evaluate the WTP of the CMS deployed in a district marathon to alleviate traffic congestion when transport needs heighten in a short period. Application and generalization of such CMS may be directed towards large-scale events, such as in mega shopping centers, transport hub and entertainment complexes, for sports events and celebrations. An econometric model of CMS has been developed to make users' attitudes quantifiable with the identification of *online payment habit* (for the on-the-spot and pooled samples) and *perceived usefulness* (for the off-site sample) as the critical parameters. Besides, useful experience for estimating users' attitudes has been gathered from this study in the smart city arena, which is characterized by non-market benefits in most situations due to the free public service being offered to citizens. The on-the-spot survey together with the off-site survey have yielded good indications for future CV research on CMS, in that different WTP results within acceptable limits are obtainable. Whilst supplementary in nature, these two types of survey approaches may be consolidated to derive a pooled estimate. When more samples are obtained with further similar experiments, it will be possible to generalize the relative magnitudes of WTP values derived from face-to-face and off-site surveys.

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Appendix: Survey Questionnaire on the Crowd Management System

(This is a translated version; original questionnaire in Chinese)

This anonymous survey is for a publicly-funded research at the xxxx University and is not related to the organizer of the event. The objective is to evaluate the potential benefits of a Crowd Management System to potential users. Since the App and electronic signboards are provide free of charge for users in this or similar future events, the questions related to payment are HYPOTHETICAL.

[Standard Verbal Explanation to each interviewee: Smart cities provide time-saving facilities to residents. For example, the Hong Kong Government has developed a smart Crowd Management System (CMS) via an App (synchronized with electronic signboards erected at the exit locations) for installation in smart phones by participants in this Marathon event, which provides real-time information on the crowd and exit transport, and display the estimated waiting times for various transport modes shown for leaving the venue after finishing the event. Here is how it works (interviewers demonstrating the screens showing display information using their own smartphones).]

Please answer the following questions:

Part A: Background of respondent

1. What is your gender?

A. Female B. Male

2. What is your age range?

A. Under 15; B. 15~25; C. 26~35; D. 36~45; E. 46~55; F. 56~65; G. Above 66

3. Have you ever participated in marathon or similar activities as a runner[2]?

A. Yes B. No

Part B: The following questions are designed for understanding your attitudes towards CMS about the perceived benefits (in equivalent money value) provided by the App and electronic signboards.

4. **a**. Have you ever used the App in your smart phone for checking the real-time information of the exit transport and queuing in the running event (or similar activities)?

A. Yes, I used it.
B. No, I have not used it.
C. I have no idea about the App being provided

b. If your answer of **4-a** is **A**, pls. give a score: _____on the usefulness of the App, ranging from 0 to 10.

(0 represents *Not useful at all*; 1= *little help* ◄——► *Extremely helpful* = 10)

5. **a**. Have you ever noticed some large on-site electronic signboards for real-time display of the estimated waiting times for various transport modes shown for leaving the venue after finishing the event?

A. Yes, I noticed them.
B. No, I did not notice them.

b. If your answer of **5-a** is **A**, pls. give a score: _____on the usefulness of the on-site electronic signboard, ranging from 0 to 10.

(0 represents *Not useful at all*; 1= *little help* ◄——► *Extremely helpful* = 10)

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[2] This question was ticked by the interviewer, and there is another choice: *C. Not distinguishable from outlook* in the on-the-spot survey.

6. CMS help users with checking the real-time information of the crowd and exit transport, and display the estimated waiting times for various transport modes shown for leaving the venue after finishing the event.[3]

Pls. give a score: _____on the usefulness of the CMS (with the smart phone Apps and the electronic signboards as the common means of information dissemination, ranging from 0 to 10).

(0 represents *Not useful at all*; 1= *little help* ◄——► *Extremely helpful* = 10)

7. If you can easily get the real-time information of the crowd and exit transport for leaving the event venue by using CMS through an App in your smart phone (synchronized with on-site physical electronic signboards mounted at strategic locations) mentioned above, are you willing to pay one-time ***HK$ 2.0***[4] (Assuming payment methods: Octopus Card, Credit Card or Apple Pay, etc.) for a single use?

A. Yes B. No

8. As a consumer, do you have the habit of downloading priced App into your mobile phone?

A. Yes B. No C. I have no idea about it

——————— **End: Thank You!** ———————

[3] This question only appeared in the questionnaire of the off-site survey, not in the on-the-spot survey.

[4] Three versions of questionnaire respectively correspond to HK$2, 5 and 10 as the proposed bid values to be voted in the survey.