Public Policy Research Funding Scheme

公共政策研究資助計劃

Project Number : 項目編號：	2020.A5.071.20A
Project Title : 項目名稱：	Performance-based Regulation of Mass Transit Railway's Reliability Performance 港鐵可靠性的績效監管
Principal Investigator : 首席研究員：	Professor WOO Chi Keung 胡志強教授
Institution/Think Tank : 院校 ／智庫：	The Education University of Hong Kong 香港教育大學
Project Duration (Month): 推行期 (月) ：	12
Funding (HK$) : 總金額 (HK$)：	586,040.00

Performance-based Regulation of Mass Transit Railway's Reliability Performance

港鐵可靠性的績效監管

Final Report for Project No. 2020.A5.071.20A funded by the Policy Innovation and Co-ordination Office (PICO) of Hong Kong Special Administrative Region

Prepared by Prof Woo Chi Keung

Department of Asian and Policy Studies, The Education University of Hong Kong

A. Executive summary

Abstract of the research

This final report documents an evidence-based policy analysis, whose primary goal is to develop a cost-based incentive scheme that strengthens the performance-based-regulation (PBR) of Mass Transit Railway's (MTR's) reliability performance. Motivating this analysis are the frequent travel delays encountered by Hong Kong residents, albeit the city's highly efficient and affordable public transportation system that serves a huge passenger volume of ~12.4 million per day. As the backbone of Hong Kong's public transportation, MTR accounts for ~47% of the daily total passenger volume. Hence, its service reliability is critical for Hong Kong's urban travellers, especially those with fixed arrival times for employment- and school-related commutes during a working weekday's rush hours.

To inform a future public debate on MTR's reliability performance, we estimate the economic cost of MTR customers due to train service disruptions. Using statistical modelling of telephone responses to a stated choice experiment (SCE) survey by ~1,559 respondents in Q4:2020, we estimate MTR passengers' willingness to pay (WTP) for avoiding a train service delay.

We use these WTP estimates to compute annual aggregate customer costs (HK$M) caused by MTR's service disruptions. These aggregate cost estimates help gauge whether the current fare rebates (fines) for MTR's disruptions are commensurate with customer costs. They are also a key input for a cost-based incentive scheme that can be readily implemented via MTR's fare adjustment mechanism. If adopted, the incentive scheme is expected to improve MTR's reliability performance, thanks to its better alignment of MTR's fines with customer cost of service disruptions.

Key findings

Our statistical analysis of the SCE survey data documents that (1) the disaggregate WTP estimates that ignore passenger characteristics are HK$21 to HK$37 for a 15- to 60-minute train service delay announced to occur in a 1-hour period; (2) increasing the period by one hour raises these estimates by ~HK$16; (3) accounting for passenger characteristics magnifies these estimates by ~18%; and (4) the aggregate WTP estimates are (a) ~HK$1.3 to HK$24.3 million, which are 1.3 to 4.9 times MTR's existing rebates for rush-hour delays, and (b) ~HK$0.51 to HK$9.6 million, which are 0.5 to 1.9 times for non-rush-hour delays.

Layman summary on policy implication and recommendation

The policy implication of our key findings is that aligning MTR's existing rebate scheme with aggregate WTP is likely to increase MTR rebates, thus reducing MTR's average fare level set by the existing fare adjustment mechanism (FAM). Such an alignment makes sense because it incentivizes MTR to pursue cost-effective measures to mitigate long service delays. Hence, our recommendation is to use this final report's reasoning and empirics to initiate a future public policy debate on MTR's existing rebate scheme.

行政摘要

研究摘要

這份研究報告記錄了一項循證政策分析 (evidence-based policy analysis)，其主要目的為發展一項成本誘因計劃 (cost-based incentive scheme)，以加強香港鐵路系統可靠性表現的績效監管（performance-based-regulation）。儘管香港擁有一個高效和價格相宜的公共交通系統以應付每天約 1,240 萬人次的客運量，香港市民仍經常面對行程延誤的情況。港鐵作為香港公共交通系統的骨幹，其每日總客運量約佔整體的 47%。因此，它的服務可靠性對於需要在繁忙時間定時上班和上課的出行人士至關重要。

為了給予將來有關鐵路系統可靠性表現的公眾討論提供基礎，這份研究旨在評估港鐵乘客因鐵路服務中斷而承受的經濟損失。研究團隊於 2020 年第 4 季度使用電話隨機抽樣方式，向 1,559 名受訪者進行敘述性選擇實驗 （stated choice experiment）調查，以估算港鐵乘客為避免鐵路服務延誤的支付意願 (willingness to pay, WTP)。 研究團隊亦利用 2000 年 1 月至 2020 年 6 月的月度數據進行乘客需求分析，以估算乘客為避免整體鐵路服務停頓的人均支付意願值。

研究團隊進一步使用這些支付意願值來計算因鐵路服務中斷而引起的年度整體乘客經濟損失（單位為 港幣百萬元）。這些整體乘客經濟損失估算有助於衡量當前因 “服務表現安排” 提供的票價優惠(罰款)與乘客經濟損失是否相稱。這一系列估算亦有助建立一個可於鐵路票價調整機制內實施的成本誘因計劃。如果採用這個令服務延誤事故罰款和乘客經濟損失扣連的成本誘因計劃，相信可改善鐵路服務的可靠性。

主要研究結果

這次研究的主要結果包括 四個要點：（1）使用不考慮乘客屬性的非集計模型估算， 對於持續一小時、每班車為時 15 至 60 分鐘的鐵路服務延誤之乘客支付意願值為

21 港元至 37 港元。（2）如服務受影響期間延長一小時，乘客支付意願值會增加約 16 港元。（3）如估算考慮乘客屬性，支付意願值會增加約 18%。（4）使用集計模型估算，（a）在繁忙時間出現的服務延誤，整體乘客支付意願值約為 130 萬港元至 2,430 萬港元。這估算是現時港鐵因服務延誤而回贈乘客票價優惠款額的 1.3 倍至 4.9 倍。（b）在非繁忙時間出現的服務延誤，整體乘客支付意願值約為 51 萬港元至 960 萬港元。這估算是現時港鐵因服務延誤而回贈乘客票價優惠款額的 0.5 倍至 1.9 倍。

研究項目對政策影響和政策建議的摘要

以上主要研究結果反映，根據整體支付意願調整港鐵現有按 “服務表現安排” 提供的票價優惠，應能增加與服務延誤相關的車費回贈，從而透過票價調整機制（fare adjustment mechanism）來降低平均票價。這樣的調整能提供誘因予港鐵採取具成本效益的措施來減少長時間服務延誤。因此，研究團隊建議使用這份研究報告所述的推論和實證，就港鐵現有的車費回贈計劃展開公共政策討論。

B. Final report

0. Overview and organization

As stated in the research proposal approved by PICO, this evidence-based policy analysis's main objectives are to (1) estimate the economic cost of Hong Kong residents affected by travel delays due to an MTR service disruption; and (2) design an incentive scheme to improve MTR's service reliability.

Our final report documents the analysis, thereby complying with PICO's reporting requirements and matching our research proposal's **task** descriptions. It proceeds as follows. Section 1 introduces our study. Section 2 states our study's main research questions. Section 3 presents our research methodology, whose implementation yields research results/findings discussed in Section 4. Section 5 discusses our study's policy implication and recommendation. Section 6 states the public dissemination held. Section 7 concludes.

1. Introduction

An international metropolis of Asia, Hong Kong is densely populated with ~7.5 million residents living in a small geographic area of ~1,100 km^2 (Census and Statistics Department, 2019). Its 2019 per capita GDP of ~US$49,000 rivals those of OECD countries (OECD, 2020). Like some mega cities of the world (e.g., Shanghai, Beijing, Singapore, Tokyo, London, Paris, New York, and Toronto), it has a vast public transportation system, comprising train *aka* Mass Transit Railway (MTR), bus, minibus, taxi, tram, and ferry (Woo et al., 2020). Figure 1 shows MTR accounts for ~47% of the system's daily volume of ~12.4M per day in 2019, thanks to its extensive network portrayed in Figure 2.

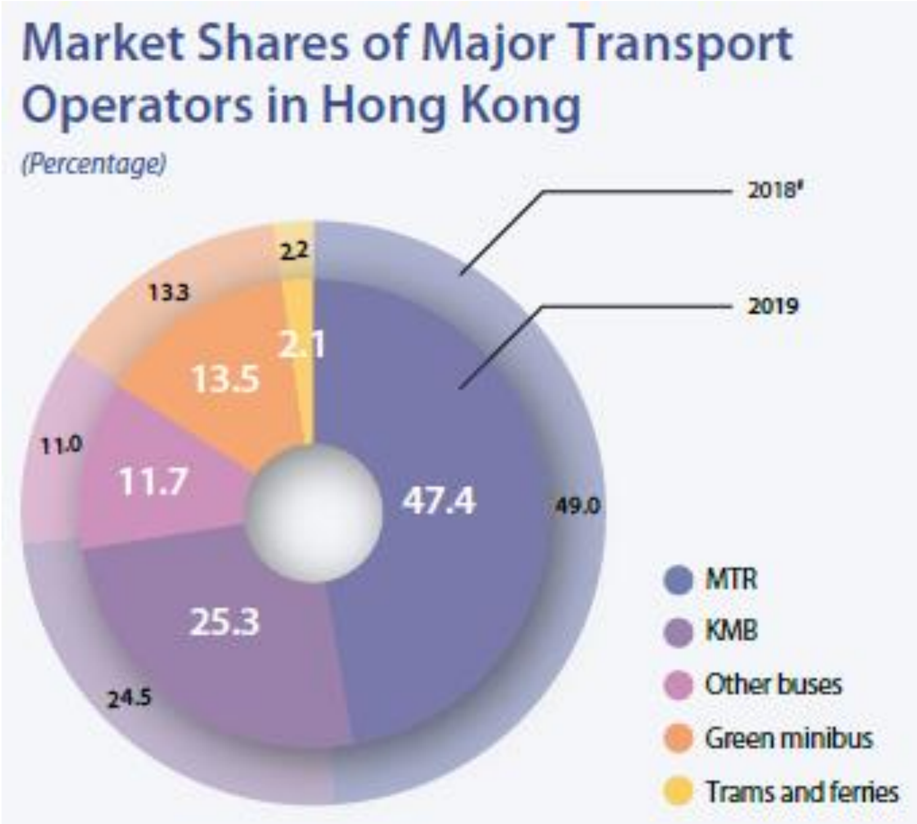

Figure 1. Market shares of major transport operators in Hong Kong; KMB = Kowloon Motor Bus, the largest privately-owned bus company in Hong Kong (Source: p.39 of MTR's 2019 Annual Report available at https://www.mtr.com.hk/en/corporate/investor/2019frpt.html)

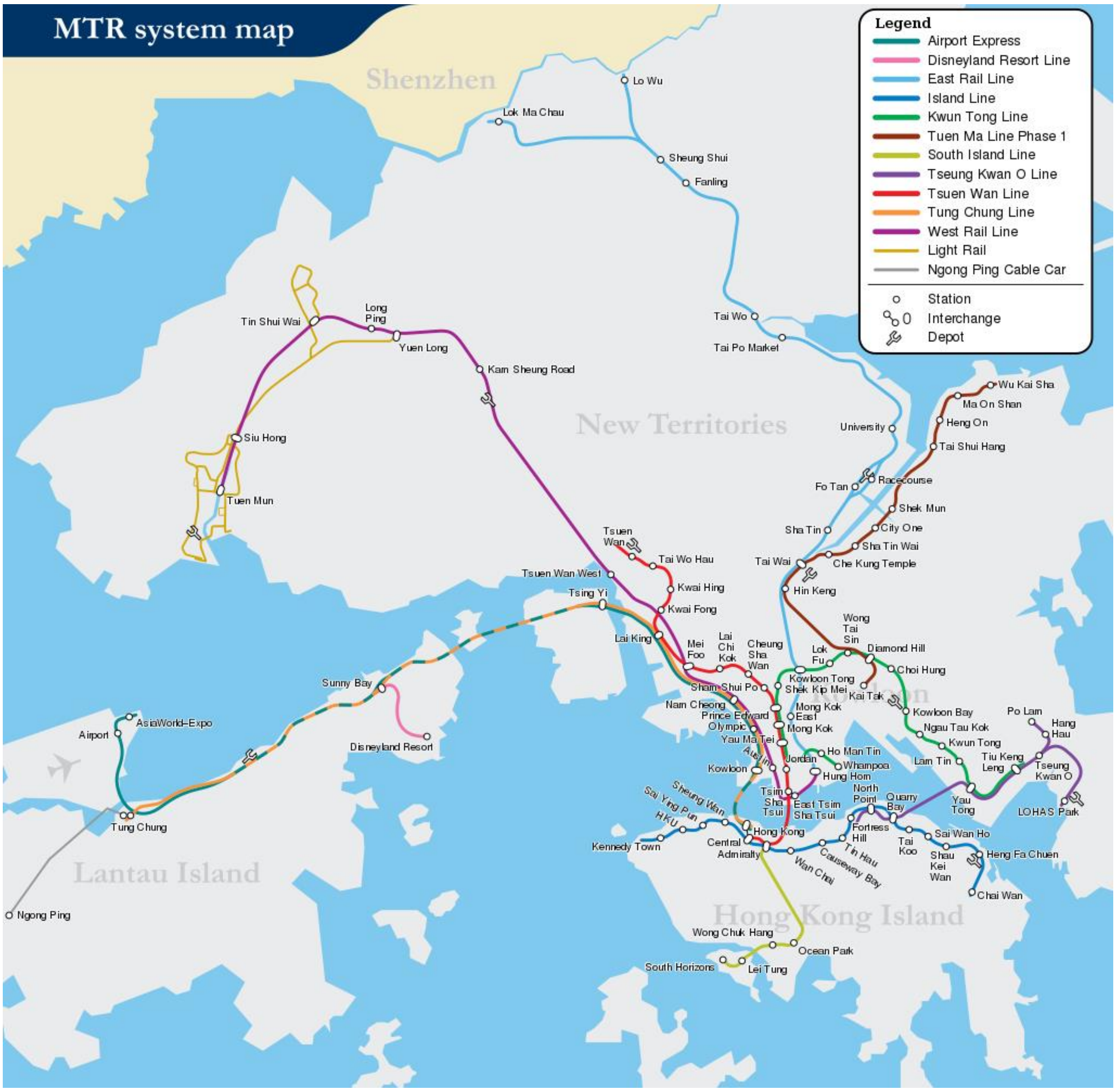

Figure 2. MTR's extensive network of train lines interconnecting stations widely dispersed across Hong Kong

Initiating our proposed research is **Task 1** that uses MTR's annual reports and other publicly available documents to analyse MTR's reliability performance. Table 1 shows that MTR exceeded the required and pledged targets in 2015-2019 based on the first four metrics. There were, on average, nine service delays of over 30 minutes per year in 2016 to 2019.

Table 1. MTR's annual reliability performance in 2015-2019

Reliability metric[1]	MTR lines excluding light rail	Required	Pledged	Actual				
				2015	2016	2017	2018	2019
Service delivery[2]	East Rail	98.5%	99.5%	99.9%	99.9%	99.9%	99.9%	99.8%
	West Rail	98.5%	99.5%	99.9%	99.9%	99.9%	99.9%	99.9%
	Others	98.5%	99.5%	99.9%	99.9%	99.9%	99.8%	99.9%
Passenger journeys on-time[3]	East Rail	98.5%	99.0%	99.9%	99.9%	99.9%	99.9%	99.8%
	West Rail	98.5%	99.0%	99.9%	99.9%	99.9%	99.9%	99.9%
	Others	98.5%	99.5%	99.9%	99.9%	99.9%	99.9%	99.9%
Train punctuality[4]	East Rail	98.0%	99.0%	99.9%	99.9%	99.9%	99.9%	99.9%
	West Rail	98.0%	99.0%	99.9%	99.9%	99.9%	99.9%	99.9%
	Others	98.0%	99.0%	99.8%	99.7%	99.7%	99.8%	99.8%
Train reliability[5]	East Rail	N/A	700,000	7,386,248	7,327,371	8,158,284	7,648,765	8,798,055
	West Rail	N/A						
	Others	N/A	N/A	2,861,014	3,964,527	5,202,676	3,472,084	3,400,912
Number of service delays of over 30 minutes[6]	All lines listed above	N/A	N/A	N/A	6	9	11	10

Notes: (1) The data for the first four metrics come from MTR's annual reports.
(2) Service delivery = annual number of actual train trips ÷ annual number of scheduled train trips.
(3) Passenger journeys on-time = annual number of journeys completed within 5 minutes of scheduled journey time ÷ annual number of scheduled journeys.
(4) Train punctuality = annual number of train arrivals within 5 minutes of scheduled arrival time ÷ annual number of train arrivals.
(5) Train reliability = annual number of car-km travelled before encountering a delay of over 5 minutes.
(6) The data source for this number is http://www.mtr.com.hk/en/customer/main/mtr_performance_achievements.html

Passenger costs due to such delays are presently unknown, thus motivating our estimation of the willingness to pay (WTP) to avoid an MTR service delay. The ensuing regression analysis untangles how an affected passenger's WTP may vary with the delay's attributes of time-of-use (TOU) (rush vs. non-rush hours), duration (D) (e.g., 2 hours between 08:00 to 10:00), and delay minutes (M) (e.g., 15 minutes in D hours).

Our WTP estimation's policy relevance is MTR's fare adjustment mechanism (FAM).[1] The FAM is a price cap formula that sets MTR's annual average fare level (HK$ per passenger carried) in year t at $P_t = (I_t - X)\, P_{t-1} + Z_t$, where I_t = annual escalation rate = 0.5 × CPI-based inflation rate + 0.5 × transportation sector's wage escalation rate; X = annual

[1] The FAM (http://www.mtr.com.hk/en/customer/main/fam2017.html) prevents MTR from: (a) price gouging enabled by its market dominance and passengers' price-insensitivity, and (b) using its regulated transport business to cross-subsidize unregulated businesses (Spulber, 1989). See Appendix A for a brief overview of MTR's corporate history and multiple businesses.

productivity target; and Z_t = annual adjustment factor based on MTR's fare affordability, reliability performance and profitability.[2]

Task 2 of our proposed research benchmarks MTR's FAM by reviewing a selected sample of price cap formulae used in various parts of the world, thereby gauging MTR's FAM's reasonableness according to international standards. It finds that Singapore adopts a similar version of MTR's FAM to set the city's public transportation fares (Looi and Tan, 2009). Ostensibly, MTR's FAM is the price cap formula commonly found in performance-based regulation (PBR) of network industries (e.g., electricity, natural gas, and telecommunication).[3]

Under the FAM, MTR can earn more profit if it achieves a productivity level above *X*. However, its profit declines with fare rebates triggered by service delays. These rebates reduce the average fare level via the *Z* factor for ***all*** MTR passengers, unlike the rebates shown in Appendix B that apply to ***affected*** passengers.

MTR's existing rebates range from HK$1M to HK$5M for service delays with *D* = 31-60 minutes to 3-4 hours.[4] Each additional hour beyond *D* = 4 hours imposes an incremental rebate of HK$2.5M per hour. Thus, a service delay with a 5-hour duration causes a total rebate of HK$7.5M (= HK$5M + HK$2.5M). While increasing with *D*, MTR's existing rebates ignore a service delay's TOU and *M*. Should MTR's rebates increase when tied to WTP estimates that move with the delay's attributes, the resulting fare level decline could enhance Hong Kong's economic efficiency (Parry and Small, 2009).

---

[2] http://www.mtr.com.hk/ch/customer/images/promotion/fam2017/fam2017_leaflet.pdf

[3] For details on the theory and practice of PBR, see Liston (1993), Laffont and Tirole (1993), Schmidt (2000), Gibson (2005), Vogelsang (2002, 2006), Joskow (2008), Sappington and Weisman (2010), and NREL (2018).

[4] A HK$1M rebate is about US$128K at Hong Kong's pegged exchange rate of US$1 = HK$7.8.

2. Objectives of the study

The study's main objectives are to (1) estimate the economic cost of Hong Kong residents affected by travel delays due to an MTR service disruption; and (2) design an incentive scheme to improve MTR's service reliability. Meeting these objectives, however, require answers to the research questions posted below.

2.1 Research questions

Motivated by the lack of WTP estimates for possible revision of MTR's existing rebate scheme, we answer two interrelated research questions:

- What are the disaggregate WTP estimates that move with a service delay's attributes and an affected passenger's characteristics? To obtain the answer, the paper conducts a stated choice experiment (SCE) to collect response data from 1,559 MTR users via a telephone survey completed in Q4:2020. It then performs a logit regression analysis to develop disaggregate WTP estimates, as similarly done by studies of electricity outage costs (Hartman et al., 1991; Woo and Pupp, 1992; Woo et al., 2014a) that inform PBR of electricity reliability (Schmidt, 2000; NREL, 2018).
- What is the aggregate WTP estimate for all passengers affected by a train service delay? This question's relevance is public transportation's regulation, scheduling, planning, pricing, and operation.[5] In the context of the FAM, large aggregate WTP estimates suggest raising MTR's existing rebates, which have been criticised as too small for long delays.[6]

[5] Large WTP estimates indicate strong aggregate demand for high service reliability, which can be met by adequate facilities, diligent operation and maintenance, and fast service restoration after a disruptive event. For further details, see Litman (2008), Baker et al. (2015), de Palma et al. (2017), Kou et al., (2017), Lai et al. (2017), Liu et al. (2017), Chow and Pavlides (2018), Hai and Yili (2018), Paramita et al. (2018), and Dell'Olio et al. (2018).

[6] https://www.scmp.com/comment/letters/article/2160249/mtr-service-disruptions-require-bigger-stick-small-fines-long-delays

2.2 Answers to the research questions

Our answers are as follows:

- The disaggregate WTP estimates that ignore passenger characteristics are HK$21 to HK$37 for a 15- to 60-minute train service delay with D = 1 hour. Second, each incremental duration hour increases these estimates by ~HK$16. Third, accounting for passenger characteristics magnifies these estimates by ~18%.
- The aggregate WTP estimates are 1.3 to 4.9 times MTR's existing rebates for rush-hour delays and 0.5 to 1.9 times for non-rush-hour delays. Hence, aligning MTR's rebates with the aggregate WTP estimates likely reduces MTR's average fare level, thereby incentivising MTR to reduce long service delays.

2.3 Research contributions

Our study makes the following contributions to the transportation literature. First, it uses a newly developed SCE dataset to quantify demographically dependent WTP estimates that are presumably sensitive to a train service delay's attributes of TOU, duration hours, and delay minutes. Second, it complements WTP studies of train time reliability characterized by service suspension (Saxena et al., 2019), travel time's expected value and standard deviation, or schedule delay early and schedule delay late (e.g., Li et al., 2010; Kou et al., 2017). Third, it uses newly found WTP empirics to inform possible revision of MTR's rebates in obeyance of PBR's principle of incentive compatibility (Laffont and Tirole, 1993). Finally, its proposed approach can be modified for PBR of different modes of public transportation in Hong Kong or other major cities of the world.

3. Research methodology

This section corresponds to the proposed research's **Task 3** that uses the contingent valuation method via SCE to estimate the customer cost of an MTR service disruption. This task's research methodology is detailed in the subsections below.

3.1 SCE-based WTP estimation

Our use of SCE (Hoyos, 2010; Ortúzar and Willumsen, 2011; Carson et al., 2014) is necessitated by the lack of readily available market data for WTP estimation based on the microeconomic theory of demand.[7] Applications of SCE abound in transportation research. For example, Allard and Moura (2018) estimate the effect of transport transfer quality on intercity passenger mode choice. There are also studies on WTP for travel time reliability (e.g., Li et al., 2010; Kou et al., 2017). Additional studies can be found in a meta-analysis by Gruyter et al. (2019) of public transportation's amenity values of access, facilities, information, security, and environment. Further, there is one study on the WTP for avoiding train service suspension (Saxena et al., 2019). These SCE studies, however, do not report WTP estimates for service delays with varying attributes, the information necessary for determining whether MTR's existing rebate scheme should be revised.

3.2 Questionnaire design

Our SCE data collection begins with designing a survey questionnaire to obtain response data devoid of the following biases. First, response data can be biased due to survey fatigue caused by a long and complicated questionnaire (Layana and Lee, 2020). Second, they may contain strategic bias when respondents expect their responses to adversely affect service reliability and fares (Horowitz and McConnell, 2002). Third, they are not market-based and may suffer from hypothetical bias (Murphy et al., 2005). Finally, they may reflect a respondent's *status-quo* bias due to a strong preference for an existing situation (Hartman et al., 1991).

[7] Estimating the adverse effect of a service disruption on consumer welfare may use a demand regression based on a consumer's utility maximizing behaviour (Varian, 1992). For example, Woo (1994) uses the linear and log-linear demand specifications to calculate the exact compensating variation (Hausman, 1981) of Hong Kong's water supply suspension. For the case of a cost-minimizing firm, an input demand system is used, exemplified by Woo and Lo (1993) for Hong Kong's water supply suspension and Tishler (1993) for Israel's electricity supply interruption. Finally, market-based estimation can occur through discrete choice modelling of an electricity consumer's selection from a menu of reliability-differentiated service options (Caves et al., 1990).

Our survey questionnaire is the outcome of a design process that aims to address SCE data's potential biases. Appendix C is the English translation of our Cantonese (Hong Kong's local dialect) questionnaire used in a telephone survey of 1,559 MTR users conducted in Q4:2020 by Hong Kong Public Opinion Research Institute (PORI) (www.pori.hk),[8] a non-profit organization originated from the Public Opinion Programme of The University of Hong Kong and trusted by Hong Kong residents because of its political independence.

Our design process has four steps. First, a draft questionnaire is prepared to help a respondent recall his/her experience with MTR's service delays, thus mitigating the concern of hypothetical bias. It elicits a respondent's ratings of MTR's service quality, reliability, and affordability, which are useful data to account for the respondent's possible *status-quo* bias in stated choice data (Hartman et al., 1991). It uses closed-ended questions to obtain discrete choices that mimic market transactions, which is deemed the best practice of WTP estimation for an unpriced service attribute (Hoyos, 2010; Carson et al., 2014). Second, we improve the draft questionnaire's clarity and understanding based on the results from two focus groups, each containing ~10 MTR users. Third, we conduct a pilot test of the improved questionnaire, involving 50 MTR users to ensure that the telephone survey can be meaningfully completed in ~10 minutes. Finally, we use the pilot test results to correct wording ambiguities, yielding the final questionnaire in Appendix C.

3.3 Questionnaire structure

Guided by prior SCE studies for Hong Kong (Woo et al., 2014, 2015; Cheng et al., 2017), our questionnaire has four parts. Part 1 contains a self-introduction by the interviewer and an explanation of the survey's purpose. It assures the respondent of strict confidentiality of his/her information provided in the interview. It also informs the respondent that PORI is

[8] We cannot use in-person interviews due to our budget constraint and Hong Kong residents' general reluctance in participating in such interviews. We decide not to use an online survey because of self-selection bias caused by respondents who tend to be younger and more IT-savvy than non-respondents, as many MTR users are over 60 years old and possibly unfamiliar with internet-based surveys.

the survey administrator commissioned by the Hong Kong Education University, thereby mitigating a respondent's possible strategic behaviour that might arise, had the survey been conducted by an organization on the behalf of MTR or its majority (75%) shareholder – the Hong Kong Government.

Part 2 ascertains that the respondent is an adult MTR user who is at least 18 years old, thereby reducing SCE data's hypothetical bias caused by unfamiliarity with MTR service.

Section A of Part 3 elicits the respondent's ratings of MTR's service quality, reliability, and affordability. It also collects the respondent's data on (a) MTR usage pattern in the absence of Covid-19: number of trips per week and number of weekly trips with an inflexible time of arrival; (b) TOU period: rush hours (7:30 – 9:30 AM and 5 – 8 PM on weekdays) vs. non-rush hours (remaining hours of the week); and (c) experience with train delays that increased travel time by more than 5 minutes.

The first half of Section B of Part 3 uses questions to collect the respondent's data on (a) taking MTR at least once a month during rush hours; (b) stations of entry and exit for the most frequent MTR trip taken during rush hours, (c) importance of on-time arrival, and (d) response to a train service delay (e.g., awaiting the next MTR train, cancelling the trip, or taking another mode of transport). These questions help prepare the respondent to answer the following closed-ended question related to the TOU period of rush hours:

> Suppose you learn before embarking your MTR trip that there will be a train service delay of *M* minutes in the next *D* hours. If there is an alternative that can take you to the station of exit by your expected arrival time at $*W*, will you use it?

Setting $W = Y \times$ applicable MTR fare, this question places a respondent's discrete choice (yes, no, or unsure) in a familiar market environment, yielding credible data for WTP estimation described in Section 2.6.

The second half of Section B of Part 3 modifies the first half to obtain survey data related to a service delay in the TOU period of non-rush hours.

Part 4 collects a respondent's demographics because a respondent's WTP estimate is expected to vary with gender, age, education, income, and household size.

3.4 Service delay scenarios

Based on MTR's service delay history and existing rebate scheme, we characterize a service delay using TOU period = rush hours or non-rush hours, D = 1, 2, or 4 hours, and M = 15, 30, or 60 minutes. Following PBR of electricity reliability (Schmidt, 2000; NREL, 2018), this characterization helps develop WTP-based rebates for MTR's recorded service delays, thus making a rebate revision implementable within the FAM's existing framework.

As shown in Table 2, a full factorial design yields 18 service delay scenarios (= 2 TOU periods × 3 different duration hours × 3 different delay minutes), chosen herein to match MTR's history of train delays. As each respondent is asked to answer two closed-ended questions by TOU, our questionnaire has a total of 9 versions (= 18 scenarios ÷ 2 TOU-specific questions per questionnaire version).

Table 2. Service delay scenarios by questionnaire version

Time of use period	Two scenarios per questionnaire version	Nine questionnaire versions								
		A	B	C	D	E	F	G	H	I
Rush hours (7:30 – 9:30 am and 5 – 8 pm, working weekdays)	Duration hours (D)	1	1	1	2	2	2	4	4	4
	Delay minutes (M)	15	30	60	15	30	60	15	30	60
Non-rush hours (remaining hours of the week)	Duration hours (D)	1	1	1	2	2	2	4	4	4
	Delay minutes (M)	15	30	60	15	30	60	15	30	60
Cost multiplier used in the close-ended questions (Y)		1.5	2	3	1.5	3	5	1.5	5	10

Note: Our logit regression analysis uses $E = (Y - 1) F$ = dollars above MTR fare F for avoiding a service delay. The data for F are based on a respondent's frequent stations of entry and exit. Since F is respondent-specific, E's data are highly dispersed, facilitating our estimation of the logit regression's coefficients.

The remaining issue is how to set the *Y* value used in the closed-ended questions in each version of the questionnaire. We resolve this issue by first establishing a range of plausible *Y* values based on Hong Kong's taxi fare schedules.[9] We then assign these values to the questionnaire versions according to the severity of service delay scenarios.

As correctly noted by an insightful reviewer, the value of *Y* is affected by the cost and availability of alternative modes of transportation that depend on the number of tourists. As survey was done in 2020 when Hong Kong faced the Covid-19 outbreak, the number of tourists was almost zero. However, how to characterize the cost and availability of alternative modes of transportation is well beyond the intent and scope of this project. Hence, we can only rely on Hong Kong's taxi fare schedule to develop *Y*'s plausible values. Whether the survey results are applicable after the pandemic is currently unknown, chiefly because the pandemic is still ongoing at the time of writing.

3.5 Data collection

Dictated by budget constraint, our SCE data come from questionnaires completed by 1,559 randomly chosen MTR users in a telephone survey conducted in Q4:2020.[10] As our questionnaire has 9 versions, 173 (≈ 1,559 / 9) is the approximate number of respondents per version.

The telephone survey's overall response rate is 58.4%, which is considered relatively high because of Hong Kong residents' general reluctance in responding to surveys. Whether the sample of respondents is representative of Hong Kong's population is an empirical issue to be settled in Section 4.1.

[9] These schedules are available at https://www.td.gov.hk/en/transport_in_hong_kong/public_transport/taxi/taxi_fare_of_hong_kong/index.html

[10] We decide not to use online survey that may cause self-selection bias because Hong Kong's older residents MTR users tend to be less IT-savvy than younger residents.

3.6 Binary logit analysis

We assume that the random utility function of a respondent intending to take MTR can be approximated by the following linear equation with intercept β and random error ε:[11]

$$U = \beta + \beta_T T + \beta_D D + \beta_M M + \beta_E E + \varepsilon; \quad (1)$$

where $T = 1$ if weekday rush hours, 0 otherwise; D = duration hours; M = delay minutes; and $E = W - F = (Y - 1) F$ = incremental cost for achieving on-time arrival based on applicable MTR fare F.[12] For clear reference, we denote equation (1) as Model 1.

We expect $\beta_T > 0$ because a rush-hour trip is more likely related to school and work commute and hence more important than a non-rush-hour trip. The marginal utility of D is $\partial U/\partial D = \beta_D < 0$, reflecting that an increase in D tends to reduce U. The marginal utility of M is $\partial U/\partial M = \beta_M < 0$, reflecting that an increase in M tends to reduce U. Finally, $\partial U/\partial E = \beta_E < 0$ is the marginal utility of incremental cost for achieving on-time arrival.

We estimate a binary logit regression to quantify the coefficients of the random utility function given by equation (1) (Hensher et al., 2015).[13] The statistical significance of the regression's coefficient estimates is based on respondent-clustered robust standard errors that are heteroskedasticity-consistent (Wooldridge, 2002).

Equation (1) assumes that U does not vary with $\boldsymbol{X}_j$, a row vector of respondent j's characteristics of (1) ratings of MTR's service quality, reliability, and affordability; (2) usage pattern (e.g., MTR lines used and trips taken per week), service delay experience, and weekly trips with inflexible arrival time; (3) planned response to a service delay (e.g., wait for MTR

[11] Our choice of equation (1) is the result of a two-step process used in our initial regression exploration. First, we assume a second-order quadratic approximation of an unknown function for U. Second, we use the likelihood ratio test to determine that the squared and interactive terms are statistically insignificant and can therefore be excluded as regressors.

[12] We use MTR's Trip Planner to estimate F based on a respondent's answer to the question on his/her most frequently used stations of entry and exit.

[13] We also use binary probit to estimate equation (1). The resulting coefficient estimates qualitatively resemble those reported in Section 4.3. Further, the WTP estimates based on the binary probit regressions are numerically close to those presented in Section 4.4.

service, use alternative means of transportation, or abandon the trip); and (4) demographics of gender, age, education, income, and household size.[14] Relaxing this restrictive assumption requires identifying the statistically significant factors that affect *U*. As (1) to (4) form a long list of possible factors, we use a stepwise procedure based on the criterion of *p*-value < 0.2 to identify an initial list of the likely elements of $\boldsymbol{X}_j$. The final list is found using the size, sign, and statistical significance of each element's coefficient estimate. For clear reference, we denote this expanded version of equation (1) as Model 2.

3.7 Disaggregate WTP estimates

For easy exposition, we use Model 1 to illustrate the calculation of an MTR user's WTP estimate that moves with a service delay's attributes. To do so, we first find $\Delta U = (\beta_D D + \beta_M M) < 0$ is the user's utility reduction caused by $D > 0$ and $M > 0$. As $\partial U/\partial E$ is the marginal utility of *E*, we then find the monetized value of ΔU:

$$C \quad = \quad \Delta U \,/\, (\partial U/\partial E) \;=\; (\beta_D D + \beta_M M\,) \,/\, \beta_E. \qquad (2)$$

We use $C > 0$ to measure an MTR user's WTP because it represents the maximum amount that the user is willing to pay to avoid a *M*-minute service delay in a *D*-hour period.

As respondent *j*'s WTP is a nonlinear function of the statistically significant elements of $\boldsymbol{X}_j$ under Model 2, the average WTP estimate for a service delay scenario is the weighted average of that scenario's respondent-specific WTP estimates. Each respondent's weight aims to correct the possible sampling bias of our SCE dataset, see Section 3.1 below.

3.8 Aggregate WTP estimates

Consider a service delay on MTR's line *k* (e.g., *k* = East Rail). Line *k*'s aggregate WTP is $A_{Tk} = N_{Tk}\, C$ for period *T*, where N_{Tk} = number of passengers using line *k* during *D* hours of

[14] The identification process does not consider household income because Table 3 shows that income data are only available for 72% of the 1,559 survey respondents, far less than the 98% availability of education data. Further, the positive correlation between income and education mitigates the need for income data in explaining variations in the choice data.

period T; and C = WTP per passenger based on equation (2). As the resulting estimate is line-specific, a systemwide estimate is the weighted average of the line-specific estimates. These weights are line-specific shares of MTR's total passenger capacity.

Since hourly data for line k's ridership are unavailable, we use publicly available data to estimate N_{Tk}. We begin by recognizing that the Hong Kong Transport Department publishes monthly passenger volumes by public transportation mode.[15] We then find V = average of monthly MTR passenger volumes in 2018, the most recent year *sans* the unusual ridership declines caused by Hong Kong's social movement that began in June 2019,[16] and the Covid-19 outbreak that began in January 2020.[17]

We allocate V into hourly numbers by MTR line and TOU period based on train frequency data published by MTR. This allocation is empirically reasonable because MTR's train frequency in a TOU period is designed to match that period's passenger volume.

To initiate the allocation process, we calculate the variables listed below:

- MTR's daily 19 hours of operation based on MTR's quarterly service report.[18]
- MTR's monthly total number of operation hours = 19 operation hours per day × 30 days per month = 570.
- K_{1k} = line k's monthly capacity in the rush hour period = daily number of operation hours in the period × (60 minutes / minutes per train) × 19.5 working weekdays × capacity per

[15] The Monthly Traffic and Transport Digest is available at https://www.td.gov.hk/en/transport_in_hong_kong/transport_figures/monthly_traffic_and_transport_digest/index.html

[16] On 9 June 2019, an estimated one million people taking to the street to oppose the Hong Kong Government's proposed bill which would permit the extradition of alleged offenders from Hong Kong to Mainland China for trial. Despite the extradition bill's indefinite suspension announced on 15 June 2019, the initially peaceful protests morphed into the social movement that according to MTR's 2019 annual report (p.37) had caused ~6% year-to-year decline in MTR's annual ridership.

[17] Covid-19 is a global pandemic, severely damaging Hong Kong's economy. Relative to the first half of 2019, MTR's ridership plunged ~30% in the first half of 2020, chiefly because of fear of infection and the Hong Kong Government's suppression responses to Covid-19's surging spread, including cross-border travel restriction, business and school closure, public event cancelation, shortened operating hours of restaurants and entertainment venues, no access to public facilities like museums and libraries, limit on group gatherings (≤ 4 persons), social distancing (≥ 1.5 meters), and home isolation.

[18] http://www.mtr.com.hk/archive/ch/pdf/mtr_service_newsletter_q1_2020.pdf

train.[19] The daily number of operation hours is 5 for $T = 1$ that denotes the rush hour period. The capacity per train is 3,750 passengers for the East Rail line that uses 12-car trains and 2,500 passengers for other lines that use 8-car trains.[20]

- $K_1 = \Sigma_k K_{1k}$ = monthly total capacity in the rush hour period.
- K_0 = monthly total capacity in non-rush hours, whose calculation resembles K_1's.

We use $K = (K_0 + K_1)$ to calculate the total capacity in the month; $k_T = K_T / K$ = monthly capacity share in period T; and $V_T = k_T V$ = monthly number of passengers in period T.

As V_T is an aggregate value for all MTR lines, it is further allocated into line-specific values. To do so, we first calculate L_{Tk} = line k's total capacity in period T = line k's monthly number of operation hours in period T × (60 minutes / minutes per train) in period T × capacity per train. For $T = 1$, the monthly number of operation hours is (5 hours × 19.5 working weekdays) = 97.5 hours. For $T = 0$, the monthly number of operation hours is 472.5 (= 570 – 97.5). Using $R_{Tk} = L_{Tk} / \Sigma_k L_{Tk}$ = line k's share of the systemwide capacity in period T, we find $V_{Tk} = R_{Tk} V_T$, the monthly number of passengers using line k in period T.

We can now find H_{Tk} = hourly number of passengers using line k in period T. As V_{Tk} is the monthly line-specific number of passengers, H_{Tk} is V_{Tk} divided by period T's monthly number of operation hours. After obtaining H_{Tk}, we use $N_{Tk} = D H_{Tk}$ as the estimated number of line k's affected passengers.

However, calculating the incremental number of affected passengers due to the spill-over effect is infeasible due to the lack of passenger volume data for all lines during a given line's delay duration. To be sure, one can assume the incremental number is a fraction of the directly affected customers (e.g., 50% of N_{Tk}). Since the assumption lacks supporting data, it

[19] Hong Kong's number of public holidays is 18 in 2020, implying an average of 1.5 holidays per month. As there are typically 21 weekdays in a month, we assume 19.5 (= 21 – 1.5) is the average number of working weekdays in a month.

[20] The numbers of cars per train come from https://www.mtr.com.hk/en/corporate/operations/detail_worldclass.html

may be seen as subjective, arbitrarily inflating the aggregate WTP estimates. Hence, we decide to ignore the spill-over effect, thereby providing conservative aggregate WTP estimates for initiating the process for a moderate revision of MTR's existing rebate scheme.

4. Research results/findings

This section corresponds to our proposed research's **Task 4** of data analysis. Presented in the subsections below are this task's results and findings.

4.1 Representativeness of survey respondents

Table 3 assesses the representativeness of the sample of survey respondents. All differences between the survey and population shares are within 10 percentage points, suggesting that the sample is reasonably representative of the Hong Kong population. To further address the issue of sampling bias, we use SPSS's raking method to produce the weights used in estimating the population average of disaggregate WTP estimates.[21]

Table 3. Representativeness of the sample of survey respondents

Demographic variable	Number of usable observations	Value	Sample share	Population share	Sample share – Population share
Gender	1,559	Male	43.4%	47.0%	-3.6%
		Female	56.6%	53.0%	+3.6%
Age group	1,532	18 – 34	24.8%	23.9%	+0.9%
		35 – 49	21.3%	25.8%	-4.4%
		50 – 64	25.3%	28.9%	-3.6%
		65 or above	28.6%	21.5%	+7.1%
Education level	1,532	Primary or below	15.5%	18.9%	-3.4%
		Secondary	41.4%	46.6%	-5.2%
		Tertiary or above	43.1%	34.5%	+8.6%
Household size, excluding domestic helper	1,474	1	8.7%	7.4%	+1.3%
		2	20.6%	20.6%	+0.1%
		3	24.3%	26.0%	-1.7%
		4	29.2%	26.6%	+2.5%
		5	11.4%	12.8%	-1.4%
		6 or above	5.8%	6.6%	-0.8%
Income	1,224	Under $15,000	21.7%	20.0%	+1.7%
		$15,000 – $29,999	21.4%	25.0%	-3.6%
		$30,000 – $59,999	30.7%	30.3%	+0.4%
		$60,000 or above	26.1%	24.6%	+1.5%

Note: The population data come from Hong Kong's Census and Statistics Department. Specifically, the gender and age distributions of the Hong Kong population are from Mid-year population for 2019, the educational distribution is from Women and Men in Hong Kong - Key Statistics (2019 Edition), the household size and income distributions are from Quarterly Report on General Household Survey (Third Quarter 2020).

[21] Details of this method are available at https://community.ibm.com/HigherLogic/System/DownloadDocumentFile.ashx?DocumentFileKey=17fd2f0b-7555-6ccd-c00c-5388b082161b&forceDialog=0

4.2 Descriptive statistics

Panel A of Table 4 reports that 62% of the survey respondents pay the adult fare. Panel B shows that the average ratings for MTR's current service and reliability are around 4.1, above the mid-point of a 6-point Likert scale. About 51% of the respondents find MTR fares affordable.

Panel C indicates that 72% of the respondents have at least one rush-hour trip per month. For these rush-hour users, the average importance rating of on-time arrival is 4.71, and the applicable fare is HK$9.36 per trip.

Panel D indicates that 90% of the respondents have at least one non-rush-hour trip per month. For these non-rush users, the average importance rating of on-time arrival is 4.05, and the applicable fare is HK$8.00 per trip.

Panel E indicates that the average number of trips per week is ~5.7, of which ~4.4 have inflexible arrival time. The average weekly number of service delays is ~0.11, mirroring MTR's relatively high service reliability shown in Table 1. About 5% of the respondents indicate trip cancellation in response to a rush-hour service delay, below the ~11% for a non-rush-hour service delay. Finally, respondents are more likely to use the Kwun Tong Line, Tsuen Wan Line, and Island Line than other MTR lines.

Panel F reports the relative frequency of responses to closed-ended questions by service delay scenario. As expected, the percent of "yes" responses tends to be higher for rush hours than non-rush hours, rise with duration hours and delay minutes, and decline with the cost multiplier.

Table 4. Descriptive statistics for MTR-related survey data

Panel A: Fare type

Variable	Number of observations	Mean	Standard deviation	Minimum	Maximum
Adult = 1 if adult fare; 0 otherwise	1,559	0.62	0.48	0	1
Senior = 1 if senior fare; 0 otherwise	1,559	0.29	0.45	0	1
Student = 1 if student fare; 0 otherwise	1,559	0.06	0.25	0	1

Panel B: Ratings of MTR service's quality, reliability, and affordability

Variable	Number of observations	Mean	Standard deviation	Minimum	Maximum
Quality: 1 = very poor, …, 6 = excellent	1,548	4.10	1.22	1	6
Reliability: 1 = very poor, …, 6 = excellent	1,551	4.06	1.30	1	6
Affordability = 1 if affordable, 0 otherwise	1,495	0.51	0.50	0	1

Panel C: A rush-hour user's rating of on-time arrival importance and applicable fare based on the user's most frequent trip's stations of entry and exit

Variable	Number of observations	Mean	Standard deviation	Minimum	Maximum
Rush-hour user = 1 if at least one rush-hour trip per month; 0 otherwise	1,559	0.72	0.45	0	1
On-time arrival: 1 = unimportant, …, 6 = very important	1,117	4.71	1.37	1	6
Applicable fare	1,076	9.36	7.61	1.5	110

Note: The last two rows are based on responses by respondents who use MTR service during the rush hours.

Panel D: A non-rush-hour user's rating of on-time arrival importance and applicable fare based on the user's most frequent trip's stations of entry and exit

Variable	Number of observations	Mean	Standard deviation	Minimum	Maximum
Non-rush-hour user = 1 if at least one non-rush-hour trip per month; 0 otherwise	1,559	0.90	0.30	0	1
On-time arrival: 1 = unimportant, …, 6 = very important	1,383	4.05	1.57	1	6
Applicable fare	1,289	8.00	7.02	1.5	110

Note: The last two rows are based on responses by respondents who use MTR service during the non-rush hours.

Panel E: Number of trips per week, service delay experience, trip cancellation, and MTR line usage

Variable	Number of observations	Mean	Standard deviation	Minimum	Maximum
Number of trips per week	1,549	5.74	5.04	0	50
Number of trips per week with inflexible arrival time	1,476	4.42	4.73	0	50
Number of service delays per week	1,529	0.11	0.39	0	3
Rush-hour cancellation due to service delay = 1 if yes; 0 otherwise	1,559	0.05	0.21	0	1
Non-rush-hour cancellation due to service delay = 1 if yes; 0 otherwise	1,559	0.11	0.32	0	1
East Rail Line = 1 if used, 0 otherwise	1,559	0.21	0.41	0	1
West Rail Line = 1 if used, 0 otherwise	1,559	0.14	0.34	0	1
Kwun Tong Line = 1 if used, 0 otherwise	1,559	0.43	0.50	0	1
Tsuen Wan Line = 1 if used, 0 otherwise	1,559	0.33	0.47	0	1
Island Line = 1 if used, 0 otherwise	1,559	0.33	0.47	0	1
South Island Line = 1 if used, 0 otherwise	1,559	0.03	0.18	0	1
Tseung Kwan O Line = 1 if used, 0 otherwise	1,559	0.16	0.36	0	1
Tung Chung Line = 1 if used, 0 otherwise	1,559	0.10	0.30	0	1
Tuen Ma Line = 1 if used, 0 otherwise	1,559	0.07	0.26	0	1

Pane F: Relative frequency of responses by respondents who have indicated using MTR in a TOU period to closed-ended questions by service delay scenario

Description				Relative frequency			
TOU period	Duration hours (*D*)	Delay minutes (*M*)	Cost multiplier (*Y*) in Table 2	Number of responses	Yes	No	Unsure
Rush hours (7:30 – 9:30 am and 5 – 8 pm, weekdays)	1	15	1.5	113	52%	40%	8%
	1	30	2	129	63%	33%	4%
	1	60	3	120	59%	36%	5%
	2	15	1.5	111	64%	33%	3%
	2	30	3	118	54%	42%	4%
	2	60	5	128	44%	49%	7%
	4	15	1.5	123	54%	44%	2%
	4	30	5	115	43%	54%	3%
	4	60	10	118	31%	63%	7%
Non-rush hours (other hours of the week)	1	15	1.5	137	55%	42%	2%
	1	30	2	154	56%	41%	3%
	1	60	3	150	50%	46%	4%
	2	15	1.5	139	52%	46%	2%
	2	30	3	144	52%	45%	3%
	2	60	5	153	44%	53%	3%
	4	15	1.5	140	46%	53%	1%
	4	30	5	142	37%	61%	2%
	4	60	10	126	28%	68%	4%

4.3 Binary logit regressions

Table 5 shows that Model 1's McFadden pseudo-R^2 is 0.0299, reflecting a parsimoniously specified regression's fit typically found for a large sample of cross-sectional data. All of Model 1's slope coefficient estimates have the expected signs. Except for the regressor of delay minutes, these estimates are statistically significant (p-value ≤ 0.05).

Table 5. Binary logit regressions by specification; heteroscedasticity-consistent standard errors clustered by respondent in ( ); statistically significant (p-value < 0.05) coefficient estimates in **bold**

Variable	Model 1	Model 2
Number of observations	2,360	2,232
McFadden pseudo R^2	0.0299	0.0511
D = Duration hours	**-0.1509** (0.0371)	0.2651 (0.1392)
M = Delay minutes	-0.0034 (0.0027)	-0.0043 (0.0029)
T = 1 if delay occurs during rush hours, 0 otherwise	**0.2282** (0.0848)	**0.1982** (0.0884)
E = Incremental cost for achieving on time arrival	**-0.0096** (0.0021)	**-0.0094** (0.0025)
Intercept	**0.5183** (0.1355)	**0.5534** (0.1425)
$D \times X_1$, where X_1 = 1 if MTR fare type is adult, 0 otherwise)		**-0.1259** (0.0488)
$D \times X_2$, where X_2 = Age (years)		**-0.0049** (0.0013)
$D \times X_3$, where X_3 = Education (years)		**0.0154** (0.0060)
$D \times X_4$, where X_4 = Rating of MTR reliability (1 = very poor, …, 6 = excellent)		**-0.0480** (0.0161)
$D \times X_5$, where X_5 = 1 if MTR service is affordable, 0 otherwise		**-0.1780** (0.0436)

We now turn our attention to Model 2, whose McFadden pseudo-R^2 is 0.0511. Its slope coefficient estimates largely corroborate the story told by Model 1's. The estimated marginal utility of duration hours is $\partial U/\partial D$ = 0.2651 – 0.1259 × Fare type – 0.0049 × Age + 0.0154 × Education – 0.0480 × Reliability rating – 0.178 × Affordability rating.

Based on equation (2), the estimated $\partial U/\partial D$ leads us to infer that a respondent's WTP tends to increase when the respondent pays the adult fare, is an older adult, is less educated, and views MTR service reliable and affordable. This inference makes sense because older and less educated folks in Hong Kong tend to see MTR more positively than younger and more educated folks, some of whom may dislike MTR's allegedly unhelpful role during the 2019 social movement.[22]

[22] Available at https://www.youtube.com/watch?v=YgYuRGre6AA, the South China Morning Post's documentary movie chronicles Hong Kong's 2019 social movement.

4.4 Disaggregate WTP estimates

Table 6 reports the disaggregate WTP estimates for avoiding a service delay. For Model 1, these estimates range from HK$21 to HK$84 per delay. As expected, they tend to increase with *D* and *M*. For Model 2, the disaggregate WTP estimates range from HK$25 to $99 per delay, or ~18% larger than those for Model 1. Hence, a respondent's demographics and views of MTR service matter in our WTP estimation.

Table 6. Disaggregate WTP estimates for a service delay (HK$ per passenger event) by regression specification; all estimates statistically significant at the 5% level

Duration hours (*D*)	Delay minutes (*M*)	Model 1	Model 2
1	15	21.04	24.77
1	30	26.33	31.23
1	60	36.91	44.68
2	15	36.79	43.22
2	30	42.08	49.54
2	60	52.66	62.45
4	15	68.28	80.23
4	30	73.58	86.43
4	60	84.16	99.08

As part of **Task 4**, we assess Table 6's empirical reasonableness by considering the WTP estimates of HK$21 to HK$45 for service delays with *D* = 1 hour. Our assessment finds these disaggregate WTP estimates empirically reasonable based on the following explanations:

- After including the average fares of HK$8.0 to $9.4 per MTR trip shown in Table 4, the total amount that a respondent is willing to pay to complete his/her intended trip is about HK$30 to HK$50, approximately equal to the average taxi fare for a relatively short ride of 2 to 4 km.
- The WTP estimates of HK$30 to HK$50 bound Hong Kong's minimum wage of HK$37.5 per hour. Hence, the amount that a respondent is willing to pay for avoiding a service delay that lasts one hour closely reflects Hong Kong's minimum wage.

4.5 MTR rebates vs. aggregate WTP estimates

Table 7 reports MTR's existing rebates that only depend on duration hours. In contrast, the aggregate WTP estimates vary with TOU, duration hours, and delay minutes.

The estimates in Table 7 are 1.3 to 4.9 times MTR's existing rebates for rush-hour delays and 0.5 to 1.9 times for non-rush-hour delays. The key takeaway from Table 7 is that the MTR's existing rebates are far less than the aggregate WTP estimates for long service delays.

Table 7. Aggregate WTP estimates for a service delay (HK$)

Panel A: Rush-hour period

Duration hours (*D*)	Delay minutes (*M*)	MTR rebate	Model 1		Model 2	
			WTP	WTP ÷ MTR rebate	WTP	WTP ÷ MTR rebate
1	15	1,000,000	1,290,010	1.29	1,518,704	1.52
1	30	1,000,000	1,614,351	1.61	1,914,781	1.91
1	60	1,000,000	2,263,035	2.26	2,739,431	2.74
2	15	2,000,000	4,511,355	2.26	5,299,830	2.65
2	30	2,000,000	5,160,038	2.58	6,074,817	3.04
2	60	2,000,000	6,457,405	3.23	7,657,899	3.83
4	15	5,000,000	16,745,599	3.35	19,676,324	3.94
4	30	5,000,000	18,045,419	3.61	21,196,868	4.24
4	60	5,000,000	20,640,153	4.13	24,299,267	4.86

Panel B: Non-rush-hour period

Duration hours (*D*)	Delay minutes (*M*)	MTR rebate	Model 1		Model 2	
			WTP	WTP ÷ MTR rebate	WTP	WTP ÷ MTR rebate
1	15	1,000,000	511,789	0.51	602,520	0.60
1	30	1,000,000	640,466	0.64	759,657	0.76
1	60	1,000,000	897,821	0.90	1,086,823	1.09
2	15	2,000,000	1,789,803	0.89	2,102,617	1.05
2	30	2,000,000	2,047,157	1.02	2,410,080	1.21
2	60	2,000,000	2,561,866	1.28	3,038,141	1.52
4	15	5,000,000	6,643,531	1.33	7,806,247	1.56
4	30	5,000,000	7,159,213	1.43	8,409,496	1.68
4	60	5,000,000	8,188,629	1.64	9,640,320	1.93

5. Policy implication and recommendation

In this report, we document disaggregate WTP estimates that are demographically dependent and move with a service delay's attributes. Further, we use aggregate WTP estimates to show that MTR's existing rebate scheme likely understates the total cost incurred by MTR passengers affected by a service delay. Specifically, these estimates are 1.3 to 4.9 times MTR's existing rebates for rush-hour delays and 0.5 to 1.9 times for non-rush-hour delays. Hence, the MTR's existing rebates are far less than the aggregate WTP estimates for long service delays.

The preceding finding's policy implication is that aligning MTR's existing rebate scheme with aggregate WTP for long service delays is likely to increase MTR rebates that in turn reduce MTR's average fare level. Such an alignment makes sense because it incentivizes MTR to pursue cost-effective measures to mitigate long service delays.

Our proposed alignment is readily implementable through revising MTR's existing rebates. This revision entails using the aggregate WTP estimates to set rebates that vary with a service delay's attributes of TOU periods, duration hours and delay minutes.

Based on Model 2's empirics in Table 7, Table 8 is an example of MTR's revised rebates found by converting the aggregate WTP estimates into numbers in HK$000. The last two columns of Table 8 present the incentives for MTR's reliability improvement to reduce long delays. The incentive amounts range from HK$0.5 million to HK$1.75 million for rush-hour delays with 1-hour duration. They can be as much as HK$15 million to HK$19 million for rush-hour delays with 4-hour duration.

Table 8. Example of MTR's revised rebates that vary with a service delay's attributes of time of use periods duration hours, and delay minutes

Duration hours (*D*)	Delay minutes (*M*)	MTR's existing rebate	MTR's revised rebates based on Model 2's aggregate WTP estimates in Table 7		Incentive = revised rebate - existing rebate	
			Rush-hour period	Non-rush-hour period	Rush-hour period	Non-rush-hour period
1	15	1,000,000	1,500,000	600,000	500,000	-400,000
1	30	1,000,000	2,000,000	750,000	1,000,000	-250,000
1	60	1,000,000	2,750,000	1,000,000	1,750,000	0
2	15	2,000,000	5,000,000	2,000,000	3,000,000	0
2	30	2,000,000	6,000,000	2,400,000	4,000,000	400,000
2	60	2,000,000	7,500,000	3,000,000	5,500,000	1,000,000
4	15	5,000,000	20,000,000	7,500,000	15,000,000	2,500,000
4	30	5,000,000	21,000,000	8,500,000	16,000,000	3,500,000
4	60	5,000,000	24,000,000	10,000,000	19,000,000	4,000,000

We would be remiss had we ignored the alignment's potentially adverse impact on MTR's profit caused by the implementation cost of mitigation measures. Offsetting the negative profit effect is a proposal that the FAM should permit cost recovery after a regulatory prudence review. However, this proposal is a significant departure from PBR via a price cap formula. Further, the proposal may have weak public support for the following reasons. First, Hong Kong residents may see the proposal as a ploy by MTR to justify fare increases. Second, they may contend that MTR is highly profitable and should pay for the implementation cost. Finally, they may consider that reducing MTR's long service delays is a reliability improvement that they rightfully entitle. Hence, PBR of MTR's service delays based on the WTP of affected passengers is likely controversial in a public debate on how to revise MTR's existing rebate scheme.

6. Details of the public dissemination held

This section corresponds to the proposed research's **Task 5** of disseminating key findings and policy implications. Because of the Covid-19 pandemic, conference attendance did not occur due to such challenges as social gathering regulation, public event cancellation, cross-border travel restriction, and mandatory quarantine. Hence, our public dissemination to date comprises:

- An international webinar held on 23 April 2021 by The Chartered Institute of Logistics and Transport.
- Submission of two research papers to refereed journals. As these papers are being reviewed, their acceptance is currently unknown.

Going forward, future conference attendance is uncertain because of Covid-19's likely persistence in the coming months and lack of funding after this project's completion date of 31 May 2021.

7. Conclusion

Thanks to PICO's Public Policy Research Funding Scheme, our study is an evidence-based policy analysis that has successfully achieved its objectives stated its funding application. Supporting our claim of success are the WTP estimates reported in Section 5 and the policy implication and recommendation in Section 6. In conclusion, we look forward to the initiation of a future public debate on possible revision of MTR's existing rebate scheme, thereby improving Hong Kong's public transportation system's economic efficiency for a clean and sustainable future.

References

Allard, R.F., Moura, F., 2018. Effect of transport transfer quality on intercity passenger mode choice. Transportation Research Part A: Policy and Practice 109, 89-107.

Baker, G., Cave, M., Gordon, C., 2015. How should transport be regulated in 2015? Department of Transport, New Zealand, https://www.transport.govt.nz/assets/Uploads/Our-Work/Documents/Regulation-2025-How-should-transport-be-regulated-in-2025-Research-Reports-on-Specified-Topics.pdf

Carson, R.T., Czajkowski, M., Hess, S., Daly, A., 2014. The discrete choice experiment approach to environmental contingent valuation. Edward Elgar, Cheltenham, UK.

Caves, D.W., Herriges, J.A., Windle, R.J., 1990. Customer demand for service reliability in the electric power industry: a synthesis of the outage cost literature. Bulletin of Economic Research 42, 79–121.

Census and Statistics Department, 2019. Hong Kong Statistics. Available at https://www.censtatd.gov.hk/hkstat/index.jsp (accessed on 20 July 2020).

Cheng, Y.S., Cao, K.H., Woo, C.K., Yatchew, A., 2017. Residential willingness to pay for deep decarbonization of electricity supply: contingent valuation evidence from Hong Kong. Energy Policy 109, 218-227.

Chow, A.H.F., Pavlides A., 2018. Cost functions and multi-objective timetabling of mixed train services. Transportation Research Part A: Policy and Practice 113, 335-356.

de Palma, A., Lindsey, R., Monchambert, G., 2017. The economics of crowding in rail transit. Journal of Urban Economics 101, 106-122.

Dell'Olio, L., Ibeas, A., de Ona, J., de Ona, R., 2018. Public transportation: Quality of service. Elsevier, Amsterdam, Netherlands.

Gibson, S., 2005. Incentivising operational performance on the UK rail infrastructure since 1996. Utilities Policy 13(3), 222-229.

Gruyter, C.D., Currie, G., Truong, L.T., Naznin, F., 2019. A meta-analysis and synthesis of public transport customer amenity valuation research. Transportation Reviews, https://doi.org/10.1080/01441647.2018.1461708

Hai, Y., Yili, T., 2018. Managing rail trasit peak-hour congestion with a fare-reward scheme. Transportation Research Part B: Methodological 110, 122-136.

Hartman, R.S., Doane, M.J., Woo, C.K., 1991. Consumer rationality and the status quo. Quarterly Journal of Economics 106(1), 141-162.

Hausman, J.A., 1981. Exact consumer surplus and deadweight loss. American Economic Review 74(1), 662-676.

Hensher, D.A., Rose, J.M., Greene, W.H., 2015. Applied choice analysis. Cambridge University Press, Cambridge, UK.

Horowitz, J.K., McConnell, K.E., 2002. A review of WTA/WTP studies. Journal of Environmental Economics and Management 44, 426-447.

Hoyos, D., 2010. The state of the art of environmental valuation with discrete choice experiments. Ecological Economics 69, 1595–1603.

Joskow, P.L., 2008. Incentive regulation and its application to electricity networks. Review of Network Economics 7(4), 547-560.

Kou, W., Chen, X., Yu, L., Qi, Y., Wang, Y., 2017. Urban commuters' valuation of travel time reliability based on stated preference survey: a case study of Beijing. Transportation Research Part A: Policy and Practice 95, 372-380.

Laffont, J.J., Tirole, J.,1993. A theory of incentives in procurement and regulation. The MIT Press, Cambridge, USA.

Lai, Y.C., Lu, C.T., Lu, C.L., 2017. Comprehensive approach to allocate reliability and cost in passenger rail system design. Transportation Research Record 2608, 86-95.

Layana, M.C., Lee, J.G., 2020. Respondent fatigue in estimates of the cost of white-collar crime: implications from willingness-to-pay surveys. Criminal Justice Policy Review 31(9), 1366–1389.

Li, Z., Hensher, D.A., Rose, J.M., 2010. Willingness to pay for travel time reliability in passenger transport: A review and some new empirical evidence. Transportation Research Part E: Logistics and Transportation Review 46(3), 384-403.

Liston, C., 1993. Price cap versus rate-of-return regulation. Journal of Regulatory Economics 5(1), 25-48.

Litman, T., 2008. Valuing transit service quality improvement. Journal of Public Transportation 11(2), 43-63.

Liu, D., Du, H., Southworth, F., Ma, S., 2017. The influence of social-psychological factors on the intention to choose low-carbon travel modes in Tianjin, China. Transportation Research Part A: Policy and Practice 105, 42-53.

Looi, T.S., Tan, K.H., 2009. Instituting fare regulation. Journeys. Available at https://www.ptc.gov.sg/docs/default-source/publications-and-papers/looi_fareregulation.pdf (accessed on 20 July 2020).

MTR, 2020. Annual Report 2019. Available at https://www.mtr.com.hk/en/corporate/investor/2019frpt.html (accessed on 20 July 2020).

Murphy, J.J., Allen, P.G., Stevens, T.H., Weatherhead, D., 2005. A meta-analysis of hypothetical bias in stated preference valuation. Environmental and Resource Economics 30(3), 313-325.

NREL, 2018. Next-generation performance-based regulation. National Renewable Energy Laboratory, https://www.nrel.gov/docs/fy18osti/70822.pdf (accessed on 20 July 2020).

OECD, 2020. Level of GDP per capita and productivity. Available at http://stats.oecd.org/index.aspx?DataSetCode=PDB_LV (accessed on 20 July 2020).

Ortúzar, J., Willumsen, L.G., 2011. Modelling transport. Wiley, West Sussex, UK.

Paramita, P., Zheng, Z., Haque, M.M., Washington, S., Hyland, P., 2018. User satisfaction with train fares: a comparative analysis in five Australian cities. PLOS | one, https://doi.org/10.1371/journal.pone.0199449

Parry, I, W., Small, K, A., 2009. Should urban transit subsidies be reduced? American Economic Review, 99:3, 700-724

Sappington, D.E.M., Weisman, D.L., 2010. Price cap regulation: what have we learned from 25 years of experience in the telecommunication industry. Journal of Regulatory Economics 38(3), 227-257.

Schmidt, M.R., 2000. Performance-based ratemaking: Theory and practice. Public Utilities Reports Inc., Arlington VA, USA.

Saxena, N., Rashidi, T.H., Auld, J., 2019. Studying the tastes effecting mode choice behavior of travelers under transit service disruptions. Travel Behaviour and Society 17, 86-95.

Spulber, D. F., 1989. Regulation and markets. The MIT Press, Cambridge, USA.

Tishler, A., 1993. Optimal production with uncertain interruptions in the supply of electricity: Estimation of electricity outage costs. European Economic Review 37, 1259-1274.

Transport and Housing Bureau, 2017. Public transport strategy study. Available at https://www.td.gov.hk/filemanager/en/publication/ptss_final_report_eng.pdf (accessed on 20 July 2020).

Varian, H.R., 1992. Microeconomic Analysis, 3rd ed. Norton, New York.

Vogelsang, I., 2002. Incentive regulation and competition in public utility markets: A 20-year perspective. Journal of Regulatory Economics 22, 5-27.

Vogelsang, I., 2006. Electricity transmission pricing and performance-based regulation. The Energy Journal 27(4), 97-126.

Woo, C.K., Pupp, R.L., 1992. Costs of service disruptions to electricity consumers. Energy 17, 109–126.

Woo, C.K., Lo, K.W.K., 1993. Factor supply interruption, welfare loss and shortage management. Resource and Energy Economics 15, 339-352.

Woo, C.K., 1994. Managing water supply shortage: interruption vs. pricing. Journal of Public Economics 54, 145-160.

Woo, C.K., Ho, T., Shiu, A., Cheng, Y.S., Horowitz, I., Wang, J., 2014. Residential outage cost estimation: Hong Kong. Energy Policy 72, 204–210.

Woo, C.K., Cheng,Y.S., Law, A., Zarnikau, J., Ho, S.T., Leung, H.Y., 2015. Consumer support for a public utilities commission in Hong Kong. Energy Policy 76, 87-97.

Woo, C.K., Liu, Y., Cao, K.H., Zarnikau, J., 2020. Can Hong Kong price-manage its public transportation's ridership? Case Studies on Transport Policy 8, 1191-1200.

Wooldridge, J.M., 2002. Econometric analysis of cross section and panel data. The MIT Press, Cambridge MA, USA.

Appendix A. Brief overview of MTR

Initially wholly owned by the Hong Kong government, MTR began operation in late 1979 of the then Tsuen Wan and Kwun Tong lines. After its initial public offering in 2000, MTR is now a publicly traded company (0066.HK) listed on the Hong Kong Stock Exchange, with the Hong Kong government as the majority (75%) shareholder. In 2007, it merged with the government-owned Kowloon-Canton-Railway that operated the East Rail line.

According to in its 2019 annual report (p.2), "[i]n the 40 years since our service operations started, MTR has grown with the people of Hong Kong to become a critical component of the transport infrastructure, as well as the creator of new integrated communities above and near stations." MTR today has (a) businesses inside Hong Kong (e.g., transport, property development and management, and property rental); and (b) businesses outside Hong Kong (e.g., property development in China and train operation service in China, Europe, and Australia).

The top part of Table A1 shows that during 2015-2019, ~40% of its total revenue comes from its domestic transport business. The bottom part shows MTR's passenger volume of over four million per weekday. MTR's average revenues range from HK$8.73 to 9.40 per passenger (US$1.11 to 1.21 at the pegged exchange rate of US$1 ≈ HK$7.8), sufficient to cover average operating costs of HK$4.63 to 5.99 per passenger to yield average operating profits of HK$3.41 to 4.37 per passenger.

Table A1. MTR's corporate statistics in 2015-2019

Variable	2015	2016	2017	2018	2019
Total revenue (HK$M)	41,701	43,841	48,444	53,870	54,504
Domestic transport revenue (HK$M)	16,916	17,655	18,201	19,490	19,938
Total profit (HK$M)	13,138	10,348	16,885	16,156	12,092
Earnings per share (HK$)	2.22	1.74	2.83	2.64	1.94
Domestic passenger volume (M/weekday)	4.57	4.60	4.77	4.86	4.66
Average revenue (HK$/passenger)	8.73	9.06	9.10	9.26	9.40
Average operating cost (HK$/passenger)	4.63	4.73	4.93	4.89	5.99
Average operating profit (HK$/passenger)	4.10	4.33	4.17	4.37	3.41

Note: The decline in domestic passenger volume in 2019 was due to social movement triggered by Hong Kong's ill-fated extradition bill.

Append B. Examples of reliability performance and fare rebate

Table B1. Summary of reliability metrics and fare rebates based on a sample of selected train operators' websites and annual reports available in August 2020

City	Train Operator	Daily passenger volume (millions)	Totally government owned?	Adopted reliability metrics listed below the table	Pledges based on reliability metrics?	Fare rebates for service disruptions?
Hong Kong	Mass Transit Railway (MTR)	~4.50	No	A	Yes	Yes
Shanghai	Shanghai Metro	~10.16	Yes	None	No	Yes
Taipei	Taipei Mass Rapid Transit (MRT)	~2.10	Yes	B	Yes	Yes
Singapore	Mass Rapid Transit (MRT)	~3.40	Yes	C	Yes	Yes
Seoul	Seoul Metropolitan Subway	~7.20	No	None	No	Yes
Tokyo	Tokyo Metro	~17.90	No	None	No	No
London	Docklands Light Railway (DLR)	~0.34	Yes	D	Yes	Yes
	London Underground	~5.00	Yes	E	Yes	Yes
Paris	Paris Metro	~4.20	Yes	None	No	No
Munich	Munich U-Bahn	~1.10	Yes	G	No	Yes
New York	New York City Subway	~5.60	Yes	G	No	No
Chicago	Chicago 'L'	~0.73	Yes	None	No	No
San Francisco	Bay Area Rapid Transit (BART)	~0.41	Yes	G	Yes	No
Los Angeles	Los Angeles Metro Rail	~0.34	Yes	G	Yes	No
Montreal	Montreal metro	~1.40	Yes	I	No	No
Toronto	Toronto Subway	~1.58	Yes	F	Yes	Yes
Melbourne	Metro Trains Melbourne (MTM)	~0.45	No	G	Yes	Yes
Sydney	Sydney Metro (MTS)	~0.06	No	E	Yes	No

(A) Service delivery = annual number of actual train trips ÷ annual number of scheduled train trips; passenger journeys on-time = annual number of journeys completed within 5 minutes of scheduled journey time ÷ annual number of scheduled journeys; train punctuality = annual number of train arrivals within 5 minutes of scheduled arrival time ÷ annual number of train arrivals; train reliability = annual number of car-km travelled before encountering a failure that causes a delay of over 5 minutes.
(B) Number of failures per million km travelled; million km travelled per service delay of more than 5 minutes.
(C) Million km travelled per service delay of more than 5 minutes.
(D) Number of delays of more than 30 mins per million km travelled.
(E) Percentage of total arrivals within 5 minutes of scheduled time.
(F) Average of excess journey time and total loss of customer hours.
(G) Number of delays of over 60 minutes; percent of total arrivals within 1 minute before or 5 minutes after the scheduled time.
(H) Major incidents = delay of 50 or more trains; service delivered = percentage of scheduled trains that are provided during peak hours; additional platform time = average time customers spend waiting beyond scheduled train time; additional train time = average time customers spend onboard a train beyond scheduled train time; passenger journeys on-time = percentage of customers' trips completed within 5 minutes of scheduled time; mean km travelled between failures that cause delays of over 5 minutes; terminal on-time performance = percentage of trains arriving at their destination terminals as scheduled.
(I) Number of delays of five minutes or more.

Table B2. Summary of fare rebates

City	Train Operator	Description
Hong Kong	Mass Transit Railway (MTR)	$1 million for train service disruption of 31 minutes to an hour, with higher rebates for longer disruption durations. The resulting total rebate reduces MTR's average fare level for all MTR passengers, unlike the rebates listed below that are only given to affected passengers.
Shanghai	Shanghai Metro	Ticket fare to be refunded for delay of more than 15 minutes.
Taipei	Taipei Mass Rapid Transit (MRT)	Fare discounts based on frequency of use in a calendar month: 30% discount if used 51 times or more; 25% discount if used between 41-50 times; 20% discount if used between 31-40 times; 15% discount if used between 21-30 times; 10% discount if used for 11-20 times.
Singapore	Mass Rapid Transit (MRT)	Fare refund of delayed or disrupted trips to be approved case by case and made within 14 days of incident date.
Seoul	Seoul Metropolitan Subway	Fare refund for train delays and cancellations within 7 days of incident.
London	Docklands Light Railway (DLR)	Refunds that must be claimed within 28 days of delays over 15 minutes and are only for customers not using a Freedom pass, 60+ pass, Veterans pass, or aged 11 and under.
	London Underground	
Munich	Munich U-Bahn	• Ticket compensations based on amount of delay time: 25% if delayed more than 60 minutes; 50% if delayed more than 120 minutes. • Season ticket holders entitled to lump sum compensation for each delay of 60 minutes or more but no compensation of trips of less than 4 euros. • Possible overnight accommodation for passengers if train is cancelled or delayed and cannot seek other replacement transportation on the day of disruption.
Toronto	Toronto Subway	Reimbursement of the cost of a single fare if over 15 minutes delay in departure, en route, or time of arrival.
Melbourne	Metro Trains Melbourne (MTM)	Fare rebates for ticket holders with passes valid for 28 days and at least 10 days usage in the month: (1) Reliability rebate • Value of one daily ticket if the Metro delivers less than 98% of its scheduled services in a calendar month. • Value of two daily tickets if the Metro delivers less than 95% of its scheduled services in a calendar month. (2) Punctuality rebate • Value of one daily ticket if on time train arrivals are less than 90% of total arrivals. • Value of two daily tickets if on time train arrivals are less than 86% of total arrivals. (3) Other rebates • Full compensation if there is notice of cancelled service more than three times a week and not replaced by bus services. • Full compensation for train line suspensions of over two hours without bus service replacement.

Appendix C. English translation of the Cantonese questionnaire used in the 10-minute SCE telephone survey

Part 1: Introduction

Hello, I am *name*, an interviewer from the Hong Kong Public Opinion Research Institute commissioned by the Hong Kong Education University to conduct a survey on people's views on MTR usage experience and train service disruption. Could you spare about 10 minutes to let us know your views?

◯ Yes
◯ No → End of interview

Thank you for agreeing to be interviewed. Your phone number was randomly generated by our system. All information you provide to us will be kept strictly confidential and used for aggregate analysis only. To ensure data quality, our conversation will be recorded for internal reference. All data containing personal identifiers as well as the recording will be destroyed within six months upon project completion. If you have any enquiries concerning this interview, please call my supervisor *name* at xxxx-xxxx.

Shall we begin?

Part 2: Selection of respondents

[S1] Are you a Hong Kong resident aged 18 or above?

◯ Yes
◯ No → End of interview

[S2] Excluding the Light Rail, do you normally take MTR at least once per month when there were no COVID-19 infections?

◯ Yes
◯ No → End of interview

[S3] Are you an employee of the MTR Corporation?

◯ Yes → End of interview
◯ No

Part 3.A: Service satisfaction, usage pattern and service disruption experience

Perception of MTR service

[Q1] Please rate MTR's current train service on a scale of 1 to 6, with 1 meaning very poor and 6 meaning excellent.

◯ ___ (1 – 6)
◯ Don't know / hard to say
◯ Refuse to answer

[Q2] Which of the following MTR fares do you use? (Unrelated to the payment method such as Octopus, single journey tickets, City Saver, Monthly Pass, etc.) (Read out the answers)

◯ Adult
◯ Elderly
◯ Student
◯ Person with disabilities
◯ (Do not read out) Free (e.g. dependants of employees)
◯ Refuse to answer

[Q3] Do you consider the cost of your MTR trips affordable?

◯ Yes
◯ No
◯ Don't know / hard to say
◯ Refuse to answer

[Q4] Please rate MTR's current service reliability on a scale of 1 to 6, with 1 meaning very poor and 6 meaning excellent.

◯ ___ (1 – 6)
◯ Don't know / hard to say
◯ Refuse to answer

MTR usage pattern

I will now ask about your MTR usage pattern. If your current pattern is greatly affected by COVID-19, please answer these questions based on the situation back in January when Hong Kong did not have confirmed COVID-19 cases.

[Q5] How many MTR trips do you usually take per week? Please note that a round trip should count as two trips. An approximate number would do. (Read out the ranges only if necessary)

◯ About ___ trips
◯ 0 – 2 trips
◯ 3 – 4 trips
◯ 5 – 9 trips
◯ 10 – 14 trips
◯ 15 – 19 trips
◯ 20 – 29 trips
◯ 30 trips or more
◯ Don't know / hard to say
◯ Refuse to answer

[Q6] Of these *N* trips taken per week, how many must have on-time arrival? (Read out the ranges only if necessary)

◯ None of the trips
◯ About ___ trips
◯ All except about ___ trips
◯ All trips

- ◯ 0 – 2 trips
- ◯ 3 – 4 trips
- ◯ 5 – 9 trips
- ◯ 10 – 14 trips
- ◯ 15 – 19 trips
- ◯ 20 – 29 trips
- ◯ 30 trips or more
- ◯ Don't know / hard to say
- ◯ Refuse to answer

[Q7] Do you take MTR more often during weekday rush hours (7:30 – 9:30 am and 5 – 8 pm) or during non-rush hours and weekends?

- ◯ Weekday rush hours
- ◯ Non-rush hours (including weekends)
- ◯ Don't know / hard to say
- ◯ Refuse to answer

Train service disruption experience

I will now ask about your experience with MTR train service disruption. Through news media and station announcements, MTR regularly publicizes service disruptions caused by equipment failures or accidents that increase travelling time by over 5 minutes or even cause service suspension.

[Q8] How often did you encounter such service delays or suspensions? If necessary, please think about the situation back in January when Hong Kong did not have confirmed COVID-19 cases. (Read out the answers if necessary)

- ◯ Never
- ◯ Less than once a year
- ◯ Once a year
- ◯ Once every six months
- ◯ Once every three months
- ◯ Once every two months
- ◯ Once a month
- ◯ Twice a month
- ◯ Once a week
- ◯ Twice a week
- ◯ More than twice a week
- ◯ Other: ____________________
- ◯ Don't know / hard to say
- ◯ Refuse to answer

Part 3.B: Respondent choices under train service disruption by time of use period

Weekday rush hours

I will now ask a series of questions related to an MTR trip during weekday rush hours (7:30 – 9:30 am and 5 – 8 pm).

[Q9] Do you take MTR during weekday rush hours at least once a month? If necessary, please think about the situation back in January when Hong Kong did not have confirmed COVID-19 cases.

◯ Yes
◯ No → Skip this scenario
◯ Don't know / hard to say → Skip this scenario
◯ Refuse to answer → Skip this scenario

Now please think about your most frequent MTR trip during weekday rush hours. Are you ready? (If the respondent says there are multiple such frequent trips, say "Out of these trips, please pick the most recent one.")

[Q10] What is the station of entry?

◯ ____________________
◯ Don't know / hard to say
◯ Refuse to answer

[Q11] What is the station of exit?

◯ ____________________
◯ Don't know / hard to say
◯ Refuse to answer

[Q12] How important is on-time arrival at *station of exit*? Please rate on a scale of 1 to 6, with 1 meaning not important at all and 6 meaning extremely important.

◯ ___ (1 – 6)
◯ Don't know / hard to say
◯ Refuse to answer

[Q13] Suppose you learn before going to *station of entry* that there will be a **service delay** in the next *D* hours, causing an extra *M* minutes to arrive at *station of exit*, while road traffic will stay normal. Will you continue taking MTR and accept the *M*-minute delay, switch to another mode of transport, or postpone or cancel the trip? (If switching, which modes of transport?) (Accept more than one answers)

☐ Continue taking MTR
☐ Switch to bus
☐ Switch to minibus
☐ Switch to residents' bus
☐ Switch to tram
☐ Switch to Light Rail
☐ Switch to taxi
☐ Switch to private car or motorcycle
☐ Switch to ferry
☐ Switch to cycling
☐ Switch to walking
☐ Other: ____________________
☐ Postpone or cancel the trip
☐ Don't know / hard to say
☐ Refuse to answer

[Q14] Depending on the importance of on-time arrival at *station of exit* you just mentioned, you may decide to continue taking MTR and accept the *M*-minute delay, switch to another mode of transport, or postpone or cancel the trip. If there is an alternative to MTR that can take you to *station of exit* by your expected arrival time at $*W* (or *Y* times the applicable MTR fare), will you use it?

◯ Yes
◯ No
◯ Don't know / hard to say
◯ Refuse to answer

[Q15] Now instead of service delay, suppose you learn before going to *station of entry* that there will be **no train service** in the next *D* hours, while road traffic will stay normal. If there is an alternative to MTR that can take you to *station of exit* by your expected arrival time at $*W* (or *Y* times the applicable MTR fare), will you use it?

◯ Yes
◯ No
◯ Don't know / hard to say
◯ Refuse to answer

Non-rush hours

Now I will repeat the questions asked just now, but they are about an MTR trip during non-rush hours or weekends instead.

[Q16] Do you take MTR during non-rush hours or weekends at least once a month? If necessary, please think about the situation back in January when Hong Kong did not have confirmed COVID-19 cases.

◯ Yes
◯ No → Skip this scenario
◯ Don't know / hard to say → Skip this scenario
◯ Refuse to answer → Skip this scenario

Now please think about your most frequent MTR trip during non-rush hours or weekends. Are you ready? (If the respondent says there are multiple such frequent trips, say "Out of these trips, please pick the most recent one.")

[Q17] What is the station of entry?

◯ ____________________
◯ Don't know / hard to say
◯ Refuse to answer

[Q18] What is the station of exit?

◯ ____________________
◯ Don't know / hard to say
◯ Refuse to answer

[Q19] How important is on-time arrival at *station of exit*? Please rate on a scale of 1 to 6, with 1 meaning not important at all and 6 meaning extremely important.

◯ ___ (1 – 6)
◯ Don't know / hard to say
◯ Refuse to answer

[Q20] Suppose you learn before going to *station of entry* that there will be a **service delay** in the next *D* hours, causing an extra *M* minutes to arrive at *station of exit*, while road traffic will stay normal. Will you continue taking MTR and accept the *M*-minute delay, switch to another mode of transport, or postpone or cancel the trip? (If switching, which modes of transport?) (Accept more than one answers)

☐ Continue taking MTR
☐ Switch to bus
☐ Switch to minibus
☐ Switch to residents' bus
☐ Switch to tram
☐ Switch to Light Rail
☐ Switch to taxi
☐ Switch to private car or motorcycle
☐ Switch to ferry
☐ Switch to cycling
☐ Switch to walking
☐ Other: ____________________
☐ Postpone or cancel the trip
☐ Don't know / hard to say
☐ Refuse to answer

[Q21] Depending on the importance of on-time arrival at *station of exit* you just mentioned, you may decide to continue taking MTR and accept the *M*-minute delay, switch to another mode of transport, or postpone or cancel the trip. If there is an alternative to MTR that can take you to *station of exit* by your expected arrival time at $*W* (or *Y* times the applicable MTR fare), will you use it?

◯ Yes
◯ No
◯ Don't know / hard to say
◯ Refuse to answer

[Q22] Now instead of service delay, suppose you learn before going to *station of entry* that there will be **no train service** in the next *D* hours, while road traffic will stay normal. If there is an alternative to MTR that can take you to *station of exit* by your expected arrival time at $*W* (or *Y* times the applicable MTR fare), will you use it?

◯ Yes
◯ No
◯ Don't know / hard to say
◯ Refuse to answer

Part 4: Demographic data

[DM1] Gender (Can be determined by the interviewer)

◯ Male
◯ Female

[DM2] What is your age? (Read out the ranges only if necessary)

◯ ___
◯ 18 – 34
◯ 35 – 49
◯ 50 – 64
◯ 65 or above
◯ Refuse to answer

[DM3] What is your educational attainment? (The highest level attended, regardless of whether you have completed the course, and including whatever course you are attending)

◯ Primary or below
◯ Lower secondary (Secondary 1 to 3)
◯ Upper secondary (Secondary 4 to 7 / DSE / Yi Jin)
◯ Tertiary: non-degree course (including diploma / certificate / sub-degree course)
◯ Tertiary: bachelor degree course
◯ Tertiary: postgraduate school or above
◯ Refuse to answer

[DM4] What is your family size excluding domestic helpers?

◯ ___
◯ Refuse to answer

[DM5] What is your monthly family income? (Read out the ranges)

◯ Under $15,000
◯ $15,000 – $29,999
◯ $30,000 – $59,999
◯ $60,000 or above
◯ Don’t know / hard to say
◯ Refuse to answer