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Waste management in Hong Kong: Feasibility of applying the Norwegian deposit return system for plastic bottles

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Declaration

I, Wai Kin Chung, declare that this thesis is a result of my research investigations and findings. Sources of information other than my own have been acknowledged and a reference list has been appended. This work has not been previously submitted to any other university for award of any type of academic degree.

Signature**:** .....

Date: .....

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Abstract

Materials become “waste” when they are discarded into wrong places. Much plastics waste is recyclable but ends up in landfills or dispersed into the environment. Hong Kong is one of the world’s megacities suffering from poor plastics waste management. PET bottle is a prominent category of landfilled plastics and attracted attentions of waste planners. Deposit return systems for plastic bottles have been seen as a potential solution for the plastic bottles waste. In this research, I investigate how deposit return systems could be used to improve the plastics waste management in Hong Kong. Since Norway is reputable with its high recovery rate of returnable beverage containers under a deposit return system, I explore the feasibility of applying the Norwegian deposit return system for plastic bottles in Hong Kong. The research questions are addressed qualitatively by interviews, which provide a comprehensive understanding of the plastics waste management in Hong Kong and the Norwegian deposit return system. Stakeholders in the Hong Kong recycling sector and two key players in the Norwegian deposit return system (Infinitum and Tomra Systems) were interviewed. I argue that applying the Norwegian tax-based policy framework is justified by Norway’s achievement, such as the high collection rate, supply of high-quality plastic bottles and its financial sustainability. Also, I found that reverse vending machines technologies are mature, and they are helpful to complement the deposit return system. However, I argue that Hong Kong needs adaptation for implementing a deposit return system because of the spatial limitations. For instance, I suggest that tiny and small retailer shops can opt-out to be collection spots. Instead, collection spots beyond retail stores shall be established, and higher engagement of the Hong Kong government will be needed.

Exchange rate[1]
HKD 1 = NOK 1.1706
NOK 1 = HKD 0.8539

[1] 21 According to Reuters’ exchange rate, assessed on 21 November, 2019 (23:17 GMT+1), available at https://www.reuters.com/markets/currencies

Glossary

CGSs = Community Green Stations

EPD = Environmental Protection Department (in Hong Kong)

HDPE = High-density polyethylene

HKHA = Hong Kong Housing Authority

MSW = Municipal solid waste

PET = Polyethylene terephthalate

PERO = Product Eco-Responsibility Ordinance

RVMs = Reverse vending machines

TOMRA = Tomra Systems

WRFP = Waste Reduction Framework Plan

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1. Introduction

1.1. Problem statement

Plastics waste management is a regional as well as a global environmental issue.
Since the 1950s, plastic material has been the fastest-growing product compared to other materials. However, what goes up must come down - a recent study estimates that 79% of the plastics waste ends up, either as landfills or dispersed into the environment, raising concerns about their environmental consequences (United Nations Environment Programme, 2018).

Located partly on an island and partly on the mainland, Hong Kong is one of the world's megacities with a population of more than seven millions. Handling the waste from the people living in such a metropole is a challenge. In 2017, approximately 5.66 million tonnes of solid waste were deposited in landfills (Environmental Protection Department [EPD], 2018) (Environmental Protection Department, 2018). The low recovery rates for municipal solid - (32%) and plastic waste (13%), respectively add pressure on the landfills which are approaching capacity limits. Therefore, improved management of waste in general, including plastic, is essential for a sustainable development in Hong Kong.

In the city, only three landfills are in place and one incineration facility for sludge treatment. Foreseeing the limited capacity of the landfills, the Hong Kong government proposed two temporary solutions: (1) to expand the current three landfills and (2) to construct a thermal waste-to-energy facility with a capacity to treat one-tenth of the municipal waste. This plant will be completed in 2024 as part of a long-term plan for the increased use of incineration to reduce the amount of waste and produce electricity. Still, these measures will not be enough to tackle the problems and both reduction in quantities and recycling are needed for sustainable short-term and long-term waste management.

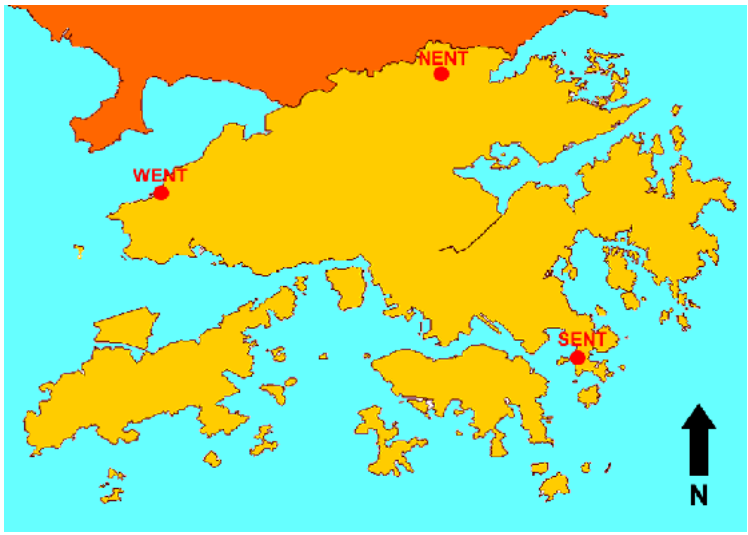

Figure 1 Locations of three operating landfills in Hong Kong

Yellow area represents Hong Kong's territory. Photo source: EPD (2016b)

As part of the efforts to reduce waste and increase recycling, Hong Kong's government introduced the use of deposit return systems and reverse vending machines (RVMs). A reverse vending machine is a device that accepts used (empty) beverage containers in exchange for cash. The current system for collection and recycling of plastic bottles based on voluntary separation, has only been partly successful. Furthermore, since 2013, China has imposed stricter import bans on waste, making economy of scale more challenging. As a result, the plastics waste market has also shrunk, reducing the recovery rate of plastics. Over half of the local plastics recycling firms are at risk of negative profits. On this background, I wish to study the possible benefits of a deposit return system using RVMs for plastic beverage containers in Hong Kong.

The concept of "reward-on-return" as an option for more sustainable waste has become popular among NGOs, breweries and retailers resulting in multiple new RVMs pilot schemes. In addition, a commercial-manufacturer working group representing a broad coalition of stakeholders commissioned the Deloitte Risk Advisory Firm to review the recycling status of the beverage containers in Hong Kong. Based on their report, the working group decided upon four main strategies; to reduce, redesign, recover and recycle single-use packaging. One of their initiatives is implementing a "cash-on-return scheme". Under a cash-on-return scheme, the consumers and bottle-collectors will be rewarded with a cash value for returning

empty containers. The cash-on-return scheme will be financed by levies on local producers and importers. The working group leans towards such a "return value system"[2].

Despite the working group favouring a non-depositing return scheme, depositing return schemes provide extra incentives for people to return bottles. Deposit return systems are a common form of reward-on-return schemes around the world (CM Consulting Inc & Reloop Platform, 2018). Systems in other countries, like South Korea and Germany, have been commonly examined for possible introduction in Hong Kong. Norway is also reputable with its high recovery rate of returnable beverage containers and information about the Norwegian deposit return system may be valuable for Hong Kong policymakers in deciding whether or not to introduce a similar method.

During the last decade, only a handful of studies comprehensively investigating Hong Kong's plastics waste management have been implemented. The Hong Kong Productivity Council, a government-subsidised consultancy published a research study in 2014 describing the system and difficulties in recycling plastics. The potential of the deposit return system, particularly with respect to the limited capacity of landfills, was not included.

My work aims to fill the gap in knowing how deposit return systems could be used to improve the plastics waste management in Hong Kong. It goes with the following research questions:

- How is plastics waste managed in Hong Kong? What are the difficulties in recycling plastic in Hong Kong?
- How have a deposit system for beverage bottles and RVMs been seen as a solution? What are the perceived challenges?
- What can be learnt from the case of Norway's deposit return system for Hong Kong? Is it feasible to apply the Norwegian model in Hong Kong?

Chapter 2 provides insight into the plastics wastes system in Hong Kong, also background and overview of the Hong Kong Waste management and the plastics recycling status. In order

[2] This paper defines "return value system" as a non-depositing system for containers. The customers do not need to pay deposits for containers on purchase. The returners will receive a monetary reward when they return empty containers.

to give a complete overview of the situation in Hong Kong, the responses of interviewed Hong Kong recyclers and NGOs are included in Chapter 2. This chapter summarises the existing reward-on-return schemes for plastic beverage containers in the metropole. It also highlights the current potential challenges for implementing a deposit return system in Hong Kong. Chapter 3 describes the methodology and methods used in addressing the research questions. Chapter 4 investigates the case of the Norwegian deposit return system. Empirical data from the Interviews of two main actors in the system (Infinitum and Tomra Systems) are presented. Infinitum is a non-profiting organisation operating the deposit return system in Norway. Meanwhile, Tomra Systems (TOMRA) is the largest reverse vending machine provider globally, headquartering in Norway. Chapter 5 analyses the Norwegian model and the feasibility of applying it in Hong Kong. Chapter 6 summaries the argument made in this thesis and recommends approaches to carry a deposit return system for plastic beverage containers.

2. Background

2.1. Hong Kong Waste Management Overview

Waste planning from 2000 to now

The Waste Disposal Ordinance, which provided a framework for managing waste from the point of arising to the final disposal, was enacted in 1980 (EPD, 2017b). The statuary Waste Disposal Plan, published in 1989, gave an agenda for the next 10-year plan to establish new facilities and shut down the outdated ones. Three new landfills and seven refuse transfer stations were built during these years. The Hong Kong government focused on pollution-control emphasizing construction of an efficient network to collect, transfer and discard the waste. At the end of the 1990s, a resource-saving rationale was also added emphasizing improved resource utilization.

In the subsequent decade, the Hong Kong government published the Waste Reduction Framework Plan (WRFP) in 1998 (Planning Environment and Lands Bureau, 1998). There are six main objectives in the WRFP: (1) to extend the useful life of our strategic landfills; (2)

to minimize the amount of waste produced that requires disposal; (3) to increase the waste recycling rate; (4) to promote education and awareness in the community of the true costs of waste management so that we can review how these costs are met; (5) to maximize the efficiency in waste management operations and minimize the costs associated with the collection, treatment and disposal of wastes; and (6) to help conserve the earth's non-renewable resources.

As one of the six goals, the lifespan of landfills has been a key concern in waste planning since the late 1990s. Hong Kong stopped the last incineration plant (Kwai Chung Incineration Plant) in 1997. After that, three strategic landfills were responsible for dealing with the municipal solid waste generated each day in Hong Kong. Extending the lifespan of the operating strategic landfills has been one of the primary objectives for waste management. Other than this pragmatic rationale, saving non-renewable resources has been included in the waste management objectives. It is a rather new conception in Hong Kong's environmental planning.

The EDP published a Policy Framework for the Management of Municipal Solid Waste (2005-2014) in 2005, as a subsequent blueprint in waste management. The 2005 policy framework outlines the Hong Kong government's visions and strategies for sustainable MSW management. Three policy tools were proposed in this framework: waste charging, producer responsibility schemes, and landfill disposal bans on biodegradable waste. However, just one of them has been implemented eventually – the producer responsibility schemes. Some forms of producer responsibility schemes were implemented after the Product Eco-Responsibility Ordinance was enacted in 2008. However, the waste charging and landfill disposal bans still have not been realized and implemented until now.

In 2012, the Hong Kong government issued the Hong Kong Blueprint for Sustainable Use of Resources 2013 -2022. It presented the foundation of vision and strategies for Hong Kong’s waste management for the next ten years. The Blueprint 2013-2022 touches some challenges, such as a limited waste-absorbing capacity. The Blueprint asserted that it is difficult to establish waste recycling industries because of the land scarcity and high cost. The Blueprint 2013-2022 indicates that the waste collection industry is efficient at collecting metal, paper and second-hand electrical and electronic products, which are more valuable. Meanwhile,

waste plastic, along with waste glass and food waste, have less commercial value. Collecting waste plastic is hard to be efficient in Hong Kong's business condition.

In the Blueprint 2013-2022, plastics waste management had not been prioritized. At time of its publication (2012), plastics (19%) was the third largest proportion in the composition of MSW in Hong Kong. The largest and second-largest were biowaste (44%) and paper (22%), respectively (Environment Bureau, 2012). Food waste was reasonably to become one of the foremost priorities to be tackled in waste reduction, instead of emphasizing plastics waste.

The Hong Kong government addresses the plastics waste by waste separation at source. The Blueprint 2013-2022 reported that over 80% of Hong Kong residents have recycling bins in their living area. Recycling bins are usually close to their living places. People can easily sort out plastic products and other recyclables, like metal cans and paper products.

Hong Kong still relies on landfilling to treat municipal waste. Reliance on landfilling will last at least until 2024 where a new incineration facility is expected to be completed. In 2000, the Hong Kong government started building a new generation of incinerators in 2000, claiming that they were much safer and had more stringent controls over emissions (EPD, 2000). In 2015, an incineration facility treating municipal waste, located in Shek Kwu Chau was finalized. The Integrated Waste Management Facilities, which include an incineration facility, are expected to be completed in 2024 (EPD, 2018b). The first stage of the operation is estimated to recover energy from 200 tonnes of waste per day.

Voluntary Source separation and three-coloured bins

There is no mandatory source separation of waste in Hong Kong. Source separation of waste is voluntary work for the citizens. Three-coloured bins are one of the featuring schemes of voluntary source separation. The Government began the three-coloured waste separation bins at housing estates, schools and public places as a follow-up of the Waste Reduction Framework Plan published in 1998. Since then, the three-coloured bins have been an important component of waste reduction and waste recycling instruments. The three-coloured bins target the wastepaper, aluminium cans and plastic bottles for recycling. Each colour represents one type of materials.

The provision of these bins is coordinated by several departments, including the Food and Environmental Hygiene Department, Leisure and Cultural Services Department and Agriculture, Fisheries and Conservation Department. These bins have been provided for free to housing estates by the Environmental Campaign Committee, under the promotion scheme of "Waste Recycling Campaign in Housing Estates".

Until the end of 2018, the Government has placed about 16,000 sets of waste separation bins across the city, including the public areas, schools, government's buildings, rural parks, and estates and commercial buildings which joined the source separation scheme (HKSAR Government [HKSAR], 2019a). According to the EPD, the recycling bins cover 80% of the citizens' living and working venues.

To promote recycling, the Hong Kong government launched a program on Source Separation of Domestic Waste in January 2005. The program aims to provide additional waste separation facilities on building floors and in other areas of housing estates. The government decided to target the Source Separation of Domestic Waste to 80% of the city's population participating in the program by 2010 (EPD, 2007). However, according to the newest reported progress, the population coverage was just 57.24% in 2017 (Environmental Protection Department, 2019b).

The statutory body responsible for administering Hong Kong's public housing programme, Hong Kong Housing Authority (HKHA), carries out the Source Separation of Domestic Waste Programme in all its estates. It sets up three-coloured bins across their estates. It is also responsible for promoting waste separation at source to their residents. The HKHA set up recycling collection counters and conducts promotional activities to incentivise the residents with cash or household groceries in exchange for waste recycling.

HKHA's population represents about one-third of the total Hong Kong population, but their plastic bottles are incomparable to the total plastic bottles disposed in the whole city. The HKHA collected about plastic bottles collected 2,042 tonnes of plastic bottles for recycling in a year (from 1 April 2017 to 31 March 2018) in its public housing estates. The number of plastic bottles collected rebounded in 2017/18 (Hong Kong Housing Authority [HKHA], 2019). Table 1 shows the number of plastic bottles collected for recycling from 2009/10 to

2017/18 (HKHA, 2018; HKHA, 2019). The population authorised to live in HKHA's public rental housing is 2,113,900, and the number of households is 778, 700 at 30 June 2019 (HKHA, 2019a).

Table 1 Plastic bottles collected annually for recycling by the Hong Kong Housing Authority from 2011 to 2019.

	2011/12	**2012/13**	**2013/14**	**2014/15**	**2015/16**	**2016/17**	**2017/18**
Plastic bottles (tonnes)	1584	1929	1812	1983	2223	1362	2042
Plastic bottles collected (tonnes per day)	4.3	5.3	5.0	5.4	6.1	3.7	5.6

Some single block buildings in older districts do not have any property management companies to carry out recycling programmes or setting waste recovery facilities. The government established a Community Recycling Network through the Environment and Conservation Fund for these residents. There are 17 Community Recycling Centres, two mobile community recycling projects and 50 collection points under the Community Recycling Network. Non-government organisations operate these recycling networks. In the last five years before 2019, the collection points had collected about 45 tonnes of waste plastics, along with other low-value recyclables such as waste glass (45 tonnes) and small electrical and electronic equipment (10 tonnes). The number of waste plastics collected through these networks is trivial compared to the total plastics waste landfilled in Hong Kong.

2.2. Plastics recycling in Hong Kong

2.2.1. Plastics Recycling Status

In the flow of plastics waste recycling, local plastics waste generated by domestic households, commercial and industrial sectors will either be collected by contracted recyclables collector or by cleaners, scavengers and other public. The contracted recyclables collectors work for mobile collectors. The mobile collectors will sell the waste plastic to fixed collection shops or directly to recycling firms for subsequent processing. The plastics waste collected by mobile collectors and fixed collection shops will further go through a process of compression, or

value increasing processes such as shredding, washing and pelleting. Most of the plastics recyclables will be exported to other countries.

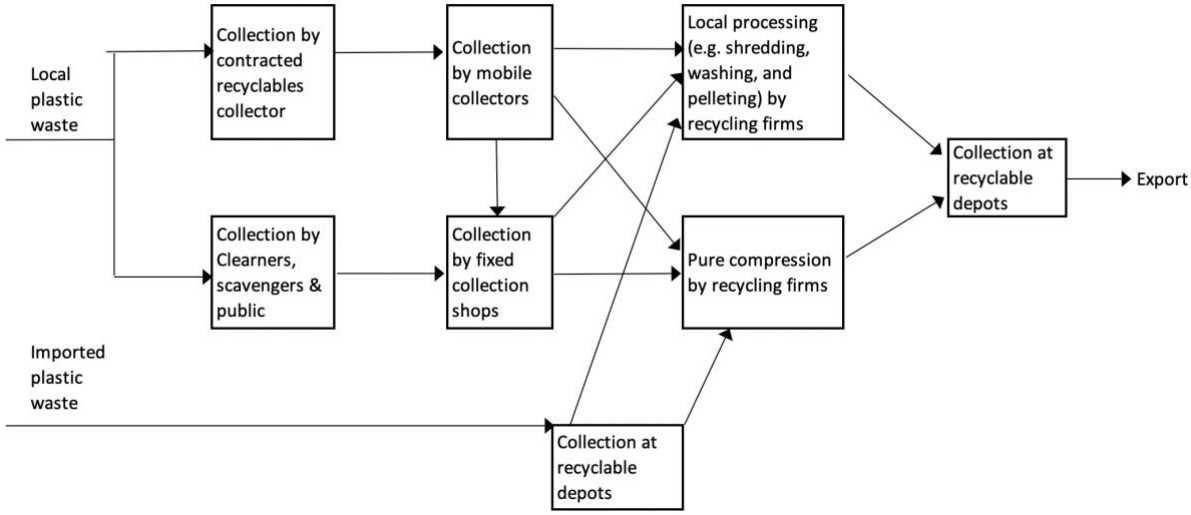

Figure 2 Flow diagram of plastic recycling in Hong Kong

Figure 3 Plastic bottles collection by an NGO in Hong Kong

The NGO collects PET bottles and HDPE bottles from the community, then sells the bottles to recycling firms for local processing. Photo source: author's photo

A few features are worth noting from the plastics waste statistics, as shown in Table 2. First, the compositions of the MSW landfilled for plastics waste remained steady in recent years, at about one-fifth of the MSW. The number of plastics landfilled remained stable from 2015 to 2017.

Table 2 Daily quantities of plastics waste landfilled, recovered and exported from 2012 to 2018

Average daily quantity (tonnes per day)	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Plastics waste landfilled (Percentage of plastics waste landfilled in municipal solid waste landfilled)	1826 (20%)	1866 (20%)	2015 (21%)	2183 (22%)	2132 (21%)	2124 (20%)
Recovered plastics waste (Recovery rate of plastics recyclables)	867 (32%)	665 (26%)	270 (12%)	257 (11%)	345 (14%)	317 (13%)
Exported plastics recyclables (Export rate of plastics recyclables)	844 (97%)	523 (78%)	227 (84%)	241 (93%)	326 (94%)	279 (88%)

The recovery rate of plastics recyclables dropped from 32% in 2012 to 26% in 2013 and declined further to 11% in 2015. In 2016 and 2017, the recovery rate of plastics recyclables increased slightly to 14% and 13%, respectively (EPD, 2014; EPD, 2015a; EPD, 2015b; EPD, 2016a; EPD, 2017a; EPD, 2018). The EPD attributes the decline in recovery rate of plastics recyclables to the market value of the waste, which was affected by the weak demand for raw plastic materials by the manufactures in Mainland China, the stricter import control of the plastics recyclables by Mainland China, and the decline in oil price (EPD, 2016a).

The recovery rate of the plastics recyclables dropped significantly since 2012, but the amount of the plastics waste landfilled did not expand proportionally. The recovery rate of plastics recyclables has taken some of the re-exported plastics waste into account. When the demand for the plastics recyclables in foreign markets was weaker, the re-export of plastics waste would subsequently diminish. In other words, the relatively high (above 30%) plastics recycling rate was boosted by the plastics waste re-export activities. The recovery rates of plastics recyclables were 15% since 2014. It shows that there is a considerable room to improve plastics waste management.

Table 3 PET plastic bottles landfilled and exported from 2012 to 2018

Average daily quantity (tonnes per day)	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
PET plastic bottles landfilled (Percentage of PET plastic bottles landfilled in total plastics landfilled)	80 (4.4%)	129 (6.9%)	132 (6.5%)	136 (6.2%)	158 (7.4%)	137 (6.5%)
Exported recyclable PET (Estimated recovery rates of PET bottles[3])	N.A. (N.A.)	N.A. (N.A.)	21.7 (14.1%)	11.2 (7.6%)	14.7 (8.5%)	10.0 (6.8%)

Averagely about 140 tonnes of PET plastic bottles were landfilled each day from 2013 to 2017 (EPD, 2014; EPD, 2015a; EPD, 2015b; EPD, 2016a; EPD, 2017a; EPD, 2018). PET plastic bottles are widely used as beverage containers. The weight of PET plastic bottles landfilled was far more than the weight of non-PET plastic bottles. In terms of weight, PET plastic bottles occupied about 4% to 7% of total plastics landfilled.

Figure 4 Voluntary weekend event for collecting plastics waste in Hong Kong's communities

Photo source: author's photo

[3] The recovery rates of PET bottles are estimated based on the exported recyclable weight and disposal weight of PET. This number of recovery rate tends to over-represent the actual recovery rate of local consumed PET beverage containers, because the exported recyclable may include re-exporting PET plastics waste.

2.2.2. Difficulties in plastics recycling

Overview of plastics waste recycling sector

The current plastics waste recycling sector is dominated by low-end processes. Most of the local plastic recyclers in Hong Kong only carry out waste collection, baling and export operations. Cleaning and pelletizing plastics waste can enhance the value. However, the local plastic recyclers seldom carry out these processes due to the high costs of land and labour. Fundamentally, plastic recycling in Hong Kong is a commercial-trading business.

The plastics waste business involves many small companies. In January 2019, 267 plastic recyclers were operating (Research Office Legislation Council Secretariat, 2019). A study on the recycling firms operating situation was recently published (Sino-Forest Applied Research Centre for Pearl River Delta Environment, 2018). The research team successfully surveyed 151 firms recycling either plastic or paper waste. Some results from the survey are highlighted for better understanding the private recycling industry in Hong Kong:

- *Fewer firm recycling plastics*: Among the 151 replied recycling firms, only 60 firms were running plastics waste business in 2018, which is less than the 67 recorded in the previous year.

- *More plastics waste treated*: On average in 2017, each firm treated monthly 79 tonnes of plastics, which were higher than the previous year's 69 tonnes by 13%. This increase was mainly due to several large-scaled firms purchasing more plastics waste outside Hong Kong.

- *Plastics waste originating from imported products dominates*: Plastics waste from abroad constituted 72% of the total amount recycled. It indicates that although the average amount of recycled plastics waste increased in 2017, local recycling may not have improved.

- *Non-sorted plastics dominates*: Among the 60 firms providing data, only 24 (40%) firms' input of plastics waste was completely sorted according to categories. The other 36 firms

accepted either partly sorted, entirely non-sorted and mixed plastics waste.

- *Collected polluted plastics waste*: More than half of the firms (52%) had received contaminated plastics waste while 42% did not face such problems and the remaining firms had no information about this issue.

- *Manual sorting dominates*: The reported 60 firms are categorised into four types of sorting procedures – "no sorting"(28%), "manual sorting only"(40%), "machine sorting only"(35), "with manual and machine sorting"(2%).

- *Rinsing of plastic waste is not common*: Forty-one firms (68%) did not have a washing process, four (23%) applied manual washing and five firms (8%) used machines.

- *Most do not shred the plastics waste*: Only ten firms (17%) had shredding processes. Eight of these ten firms would wash the plastics before shredding, while the other two firms did not.

- *Most do not pelletize the plastics waste*: Only eight firms conducted pelleting processes. The average investment on each pelleting machine was HKD 3,758,000, and the median was HKD 1,875,000.

The research concludes that most of the local recycling firms which deal with waste plastic have just employed simple manual sorting and packing. The collected plastics waste was exported to foreign recyclers. Over half of the local plastics waste recycling firms are under the risk of negative profits. Some of the firms discover that the potential profits in the plastic pellet market. These firms are investigating the way to balance running cost by purchasing oversea plastics waste. With a higher quantity of input, they could reduce the average production cost in pelletizing.

A vulnerable business with high costs of operation

Recycling plastics waste is costly in Hong Kong. The costs of recycling operation include land, salaries and insurance, and transportation. Cost of space is particularly high in Hong

Kong (Deloitte Risk Advisory, 2018). Recycling activities require space for separation at source, like in residential houses and commercial properties. Sorting and recycling facilities also require land. Locating recycling plants in remote areas could reduce the rent of land, but the transportation cost will increase. Plastics recyclables are light and bulky. Thus, compared with other recyclables, transportation cost is relatively more costly. A truck can normally carry 5.5 tonnes of cargo, but a full truckload of un-compressed plastic weighs about 0.5 to 0.8 tonnes (Hong Kong Productivity Council [HKPC], 2014).

The high operating costs make plastic recycling vulnerable to the market price fluctuation. As a result, investors are less interested in investing in better infrastructure to produce high value-added recyclable plastic from plastics waste. In some cases, the total cost of recycling is higher than the value of the product. For instance, the price of Polypropylene (PP) sheets is about HKD 1,000, but the total cost of shredding, cleaning, pelleting, and salaries required at least HKD 2,000. It is economically irrational to recycle PP sheets (HKPC, 2014).

Insufficient plastics waste input

The few local recyclers undertaking value-adding processes for plastics waste, i.e. shredding, pelleting, and cleaning, face difficulties in securing enough raw materials. One recycling manager revealed in a news interview that the plastics waste collected was far less than his plant's production capacity. While the company daily could process ten tonnes, they only receive two to three tonnes. "The one-month number of plastic bottles recycled from the environmental protection department is not sufficient to support one day's operation," the manager added (Lam, 2019).

Building plastic recycling facility by a beverage company

In spite of the many challenges in plastic recycling, the company, “Swire Beverages” (a division of Swire Pacific Limited), ALBA Group Asia Limited and Baguio Waste Management & Recycling Limited (Baguio) will start a joint venture recycling plastics waste in Hong Kong. The facility is expected to to process polyethene terephthalate (PET) and high-density polyethene (HDPE). The mechanical recycling facility will be located at “T6”, a plot

within the EcoPark. Baguio leased the plot from the EPD in late 2017 under a tender (Swire, 2019).

The plant, which is expected to start operating in the third quarter of 2020 can process the entire domestic volume of consumed PET beverage packaging plus HDPE personal care bottles. The joint venture foresees these two types of plastic products will be collectable in the near future. The facility is designed to include an infra-red sorting facility and production lines for food-grade PET flake and HDPE pellets.

2.3. Hong Kong government's recent initiatives

Producer Responsibility Schemes in Hong Kong

Producer responsibility schemes are important in Hong Kong's waste management strategy (EPD, 2019a). The Product Eco-Responsibility Ordinance (PERO) was enacted in July 2008. It targets to reduce the environmental impact of several types of products, which may include plastic shopping bags, vehicle tyres, electrical and electronic equipment, packaging materials, beverage containers and rechargeable batteries.

Producer responsibility schemes in the waste management in Hong Kong have been enforced on three products: plastic shopping bags, waste electrical and electronic equipment, and glass beverage containers. Producer responsibility scheme on shopping bags was realized by an environmental levy scheme, which is the only producer responsibility scheme for plastic products. It works as the first Producer responsibility scheme under the PERO. The levy was implemented since 7 July 2009 covering 3,000 retail stores in the first phase of the scheme. As a result of this initiative, number of plastic shopping bags disposed of at landfills dropped from 660 million in 2009 to 120 million in 2013.

The Hong Kong government now wishes to handle the plastic-bottle waste using a similar levy. The EPD therefore commissioned a study in October 2017 on the implementation of a producer responsibility scheme for plastic containers. The consultant affirmed the feasibility of the introducing such a levy particularly for plastic beverage and personal care products, which account for about 60% of the total volume of plastic containers. PET plastic containers

occupy a noticeable portion of landfilling plastics waste (around 6% -7%, see also Table 3). The EPD is going to implement a Reverse Vending Machine (RVM) Pilot Scheme to access its effectiveness to improve the recovery of plastic beverage containers (EPD, 2019a).

Community Green Stations

Community Green Stations (CGSs) has been a supportive measure for waste reduction and recycling at the district level. The government launches open tenders to recruit non-profit-making organization. The CGS operators have to provide various recycling programmes and educational activities to the public. They serve both recycling and educational purposes. The CGSs are required to connect with the housing estates and property management companies in their districts, thus to form a service network. The government is planning to set up one CGS in each of the 18 districts[4]. There are seven operating CGSs at the end of 3rd Quarter 2019.

CGSs set up public place collection points and deploy collection vehicles in their districts to collect recyclables, including paper, plastic, metals, electrical appliances, glass bottles, fluorescent lamps and tubes, rechargeable batteries, etc. CGSs collect plastic types 1, 2, 4, 5, 6 (PET, HDPE, LDPE, PP, PS respectively). They do not collect expanded plastics. The government stipulates the types of plastics to be collected. Plastic, paper, and metal are not the stations' primary targeting materials, despite the fact that CGSs provide collection services to residents who are willing to recycle these materials (Yau, 2019). The EPD treats them as valuable materials, which are supposed to be handled by the private recyclers in the market.

CGSs are not responsible in the housing estates and property management companies for valuable materials like metal, paper, and plastics. It is because other private or public recycling firms have already covered these types of materials. CGS also set up "street collection sites" occasionally. These collection sites serve the residences whose location might not be covered by the property management companies nor other government-tendered recycling collection site.

[4] The districts of Hong Kong are the 18 political areas into which Hong Kong is geographically and administratively divided.

Clean recycling is an inevitable challenge to CGSs. Since the recycling bins are self-service most of the time during the working hours, the cleanness of returned plastics depends on the returners. If the returners do not clean the plastics recyclables thoroughly, the stations could not prevent these materials from being mixed with other clean recyclables.

2.4. Time of debate – introducing deposit return systems and RVMs for plastic bottles

2.4.1. The decline of Hong Kong deposit return systems

Hong Kong local retailers used to employ deposit return systems extensively for glass bottles. Several factors contributed to the vanishing of deposit return systems, such as the declining of small groceries, the out-moving of beverage manufactures, and the popularization of alternative packaging. First, small groceries used to serve as the "bottle-banks", which is an important role for a deposit return system. However, these groceries diminished along with their roles as a bottle-bank. Besides, more local beverage manufacturers have relocated their bottling plants out of Hong Kong, such as to Mainland China. The increased transportation and retrieving costs discourage the manufacturers from maintaining deposit return systems in Hong Kong (EPD, 2010).

In addition, paper, plastic and aluminium became popular for beverage packaging. The market share of glass bottles dropped gradually. When the circulating glass bottles reduced to a certain level, the deposit return systems would become cost-inefficient for the beverage manufacturers. As a result, the Deposit return systems exist only for a few brands of glass beverages in Hong Kong.

At the time of the deposit return systems fading, the Hong Kong's beverage market is dynamic and continuously growing. Hong Kong market launched 1,052 million litres of drink in 2017. Bottle water occupied the largest share, with 37% of the sales volume. The second and third largest shares are Ready-to-drink Tea (22%) and Carbonates (20%) respectively. The demand for beverages sold in sealed single-use containers increased in recent years. The

total sales volumes witnessed a 12% growth from 2013 to 2017 (an absolute amount of 115 million litres).

Booming packaging waste comes with the thriving beverages market. PET packaging is the largest volume among the packaging volume by type in 2017. As shown in Table 4, the estimated recovery rate of PET bottles is 6.8% (Deloitte Risk Advisory, 2018). The actual recovery rate for locally consumed PET beverage containers is likely lower than 6.8%, because the exported recyclable may include re-exporting PET plastics waste.

Table 4 Disposable beverage packaging in Hong Kong, 2017

	PET	**Glass**	**Cans**	**Liquid Cartons**
Packaging volume by type, million units	1,394	47	340	374

Establishing a formal deposit return system and introducing RVMs have been suggested as a possible solution to the plastic packaging waste. Moreover, they also have been regarded as a step to promote recycling, which might help to ease the Hong Kong government to introduce bill on waste charge.

2.4.2. Government's intention to introduce deposit return systems and RVMs for plastic bottles

As early as in 2000, deposit return system for beverages was mentioned in a non-binding bill on reducing plastics waste in the Hong Kong Legislative Council. The stakeholders in Hong Kong plastic recycling industry used to omit the potential of deposit return systems. However, this measure was finally proposed by the government in 2018.

The Hong Kong government is planning to introduce municipal solid waste charging scheme in the future. Also, they need to improve the recycling infrastructure to encourage people reducing waste disposal. One of the complementary measures is a pilot scheme to assess the effectiveness of applying reverse vending machines (RVMs) in promoting the recycling of plastic beverage containers. An RVM is a device that allows consumers to feed in empty beverage containers for a refund of the prepaid deposit (HKSAR, 2018). It is usually equipped

with a scanning function, to recognize the barcodes on the containers to ensure that only qualified containers are accepted for refund. RVMs are commonly used in other cities as a tool to encourage the return of plastic beverage containers for recycling through a rebate system.

The EPD is conducting a consultancy study to examine the feasibility of introducing a producer responsibility scheme on plastic beverage containers and containers for personal care products. This consultancy study will indicate if the government should install RVMs across different locations and spots in Hong Kong. The government will consider whether to provide a rebate for every plastic beverage container returned, thus, to encourage the public to return the beverage containers.

2.4.3. Strategies and actions called by an industry initiative work group

Single-Use Beverage Packaging Working Group (previously known as the Municipal Solid Waste Management Working Group) started an initiative in 2017. It is about the management of single-use beverage packaging, which aims to ordinate various stakeholders in Hong Kong to manage the waste issue of single-use beverage packaging. The Working Group consists of the entities in the beverage industry, governmental organization, trade associations, and other interested parties.

The Working Group meets to assign consultancy to research on how to handle with single-beverage packaging and its related waste issue. This management of single-use beverage packaging covers various measures, such as import, reduction, collection, separation, and processing, etc. That assigning research aims to find out suitable solutions to minimize the single-use packing discarded to landfills, as well as encouraging recycling (Single-Use Beverage Packaging Working Group, 2017). Deloitte Risk Advisory was commissioned by the Working Group to perform the research, which was published in December 2018. Based on the consultancy research, the Working Group called for four main strategies and actions (Single-Use Beverage Packaging Working Group, 2018):

1. Reduce single-use packaging
2. Redesign single-use packaging

3. Recover single-use packaging
4. Recycle single-use packaging

The Working Group indicates that their participants support using 100% PET for plastic bottles and eliminating the use of PVC labels, multi-layered PET, biodegradable plastics and compostable plastics. It suggests that using a single type of plastic for plastic bottles and liquid cartons, as well as improving its quality, are critical.

Their report also suggests that legislation is needed to make the progress predictable. Legislation could create a fair platform for both locally produced and imported drinks and prevent the shift of packaging material from recyclable to which is not recyclable.

The Working Group supports the government's plan for a Reverse Vending Machines System for plastic bottles. The potential migration to another beverage packaging should be considered and regulated along with the RVM Scheme. The Working Group suggests a cash-on-return reward.

According to the Working Group, the capacity of the recovery system should be able to deal with about 130 tons of beverage packaging per day. The redemption position can be potentially on the government's community green stations, community recycling centres, private recycling shops and trucks, and upgrading of refuse collection points. Redemption services should cover the near retail points in or near country parks and beaches. This will reduce litter from single-use beverage packaging into nature.

2.4.4. Potential challenges for deposit return systems

One of the supporting arguments for deposit return systems suggests that economic incentive encourages people to return the consumed containers. Re-establishing a deposit return system for beverage containers is an initiative for some environmentally concerned entities. Nevertheless, there were reservations and worries about the application of deposit return systems, including the costs of transportation, storage, and anti-deception. Practical concerns raised by respondents are:

- *Returning Fraud*: One of the major potential challenges for a deposit return scheme is identifying and distinguishing the local and foreign bottles. Potentially, someone might cheat the system by forging the foreign bottles as domestic bottles. Preventive regulations and use of appropriate technologies will be needed to mitigate this challenge.

- *Dilemma of deposit value*: A high value of the deposit may tempt some people produce fake labels for bottles which are not included in the arrangement. Potentially PET bottles from foreign regions, for instance, Mainland China, may mix with registered PET bottles.

- *Return jam*: Inflows of bottles via RVMs are unevenly distributed in a day. Clearance and transportation could possibly be crowded at certain peak periods.

- *Long processing time*: Processing time of bottles return leads to long queues, thus discouraging some people from returning the items.

- *Overwhelming number of foreign bottles*: Many types of beverages are in the Hong Kong markets, especially for importing beverages. The importing beverages are more difficult to regulate than the locally produced beverages.

- *High business costs*: Among the business costs, the rents of retailers are expensive, especially in Hong Kong. The rent expenditure usually occupied a large proportion of the costs of a shop. In a limited area of the small groceries and convenience stores, a machine which can store for about 600 bottles might still be a discouraging approach.

- *High Transportation cost*: Transportation for a return system may be challenging too. The size of the storage area is negatively related the transportation cost because less room for storage implies more rounds of transfer will be needed. One of the respondents gave a hypothetical case to illustrate the potential heavy transportation cost (Yip, 2019):
    - The capacity of a machine = 600 compressed bottles
    - One round of transfer = HKD 100
    - Average transportation cost of a plastic bottle = HKD 0.17

One way to reduce the transportation fee would be storing multiple packs of compressed bottles to increase transportation efficiency. However, it would require retailers to spare more space for that. The opportunity cost of space usages should be included in the calculation. Besides, longer storage time will increase the cost of security and anti-deception. Since the bottles are assets with deposit value, there are chances to be stolen and to be returned for the second time somehow, even though the bottled have been compressed.

- *A high number of RVMs required*: There are 137 tonnes of PET bottles discarded to landfills every day (in 2017's number). If each PET bottle is 19 grams, approximately there are 7.2 millions of PET bottles discarded. Assuming the capacity of a machine is 600 compressed bottles, without extra storage spaces, the numbers of machines required in estimation (Yip, 2019):
    - If one round of transfer per retailers each day, 12000 machines will be needed.
    - If two rounds of transfer per retailers each day, 6,000 machines will be needed.

2.5. Existing reward-on-return schemes for plastic beverage containers

2.5.1. Pilot testing in Community Green Stations

The Eastern CGS and the Sham Shui Po CGS, which are both operated by an NGO, Po Leung Kuk, replied my interview invitation and accepted phone interviews respectively. Respondents from both CGSs indicated that they were testing RVMs at the time of the interviews. The EPD instructed the Community Green Stations to help assessing the functions of RVMs and the feasibility of introducing them.

Two interviews of CGSs' representatives were conducted on 16 May 2019 and 29 May 2019, respectively. At the time of the first interview, the workshop supervisor of Eastern Station revealed that they had been testing one RVM for two weeks. Since the testing time was still short, the respondent from Eastern Station could not provide any testing information within a short period. He just indicated that the EPD and other CGSs were testing different types of machines (Yau, 2019).

In the later interview, the operation manager of Sham Shui Po Station revealed that they were testing two machines from two different manufacturers (Cheung, 2019). Until the end of May, the performances of both machines were not yet stable, with problems like unable to recognize the PET bottles, incomplete compression which leads to occupying extra space in the storage cabinet.

Cheung (2019) further indicated some potential concerns. He informed that some residents had delivered more than a hundred bottles per trip to the station. If that happens in the future, the RVMs in station will be full at once or twice return by the residents. If the collection of the bottles solely relies on RMVs, clearances of the machines have to be often. In his opinion, RVMs will be more suitable for other public locations than the community green stations, in a sense that other public locations will enable the passengers to return the bottles right after finishing the bottles outdoor. It is less cost-effective if CGSs only rely on RVMs to collect the plastic bottles.

In responding to the question that how much time is required to complete a return for one bottle, Cheung (2019) estimates that it will take 20 to 30 seconds for scanning and compressing one bottle before the next bottles could be put into the machine.

2.5.2. Pilot RVMs schemes launched recently

A government-funded testing project – RVMHK

In addition to the pilot testing schemes under the EPD, a small government-funded testing project, RVMHK (the project's name in Chinese literally means "rewards for returning bottles") started in 2018. This testing project is funded under the Recycling Fund, which was set up by the EPD in 2015, aiming to foster and assist the development of recycling industries. This project is led by "Environmental Association Limited", a company affiliated to a local non-profit organisation "Ways for Plastic Recycling".

The project is conducting a trial programme to collect community recyclables with the adoption of RVM and point redemption scheme (EPD, 2019c). The trial program thus will be used to analyse the business viability and collection efficiency of such collection model. An

approximate amount of HKD 2,500,000 was approved for this project. In the first stage of the project, ten machines have been installed across Hong Kong. Their locations include shopping mall, residential estates, a sport centre, and commercial buildings.

A beverage manufacturer-initiated scheme – Vsmart Recycling Incentives

Vitasoy, a leading local beverage manufacturer, launched Vsmart Recycling Incentives, a recycle program combining recycling, charity and technology, in April 2019. People who return 30 plastic beverage containers via Vitasoy's reverse vending machines, can exchange for either one beverage of Vitasoy or a donation of HKD 7.5 (approximately equal to the price of a beverage) to a charitable organisation in Hong Kong. The RVMs will accept most of the PET beverage bottles which contain 1.5 litres or less. Returners have to wash the plastic bottles thoroughly and keep the labels. The barcodes on the labels are needed for recognition (Vitasoy, 2019).

There are six RVMs launched by Vitasoy at the end of September 2019. Five of them are located on educational institutions' campuses. One is situated in a shopping mall. People can choose whether to redeem a beverage of Vitasoy or to donate for once on the RVMs when they return 30 bottles within six months. The reward beverage can be redeemed via Vitasoy's specific smart vending machines, which are next to Vitasoy's RVMs or at some other locations. In total there are 19 smart vending machines and six RVMs. Vitasoy informed that they would promote the smart vending machines and RVMs gradually, but they have not specified their timetable of expanding this RVMs program (Topick, 2019).

A beverage manufacturer-initiated scheme - Recycling Green Point

In January 2019, Watsons Water, a leading Hong Kong bottled water manufacturer, announced it was going to introduce 400 water bottle RVMs (HK01, 2019). The machines can collect up to 1,000 bottles of all brands of drinking water with volumes ranging from 23 centilitres to 1.8 litres. Twenty-one machines have been installed until the end of September. According to Watsons Water, the collected bottles would be recycled and used for a number of plastic products, such as shopping bags, umbrellas, and windbreakers, etc. Consumers can redeem an HKD 50 instant discount upon purchase of HKD 600+ at PARKnSHOP (a local

chain supermarket) with 25 Green Points from April to Dec 2019. The Green Points can be earned according to the following rules, Table 5:

Table 5 Green Points rewards per bottle

Every bottle of below brand recycled	**No. of Green Points received**
Watsons Water – Plastic Water Bottle (1.8L or below)	5
Other Brands – Plastic Water Bottle (1.8L or below)	1

A beverage manufacturer-initiated scheme - Tap, Return & Earn

"Tap, Return & Earn" is a redemption and educational scheme launched by a leading local beverage manufacturer Swire Coca-Cola HK (SCCHK) in September 2019. The scheme aims to "help drive community recycling, sustainable lifestyles and raise public awareness about municipal waste management" (Octopus, 2019). The scheme partners with an electronic payment service company, Octopus Card Limited and World Green Organization. Ten machines will be installed in various locations, which include shopping malls, a pier, and a university. The machines will accept plastic beverage bottles of any brand with capacity from 33 centilitres to two litres. The plastic bottles must not be deformed or damaged, no liquid can be left inside; and the product barcode must be present. Otherwise, the machines may reject the bottles.

Every plastic beverage bottle returned can exchange for HKD 0.2 cash rebate via e-payment platform Octopus. Octopus is a popular local electronic payment platform in Hong Kong's mass transit system and shops. Each Octopus card could obtain no more than HKD 10, which is equivalent to 50 plastic bottles.

Summary of the four pilot RVMs scheme

In Table 6, information about the four pilot RVMMs are presented.

Table 6 Summary of the four pilot RVMs scheme

	RVMHK	**Vsmart Recycling Incentives**	**Recycling Green Point**	**Tap, Return & Earn**
Organizing institution(s)	An NGO	A beverage manufacturer	A beverage manufacturer	A beverage manufacturer, a NGO, an electronic payment company
Materials type	Plastic beverage bottles and cans with a database-registered barcode	All brands of plastic beverage bottles	All brands of drinking water's plastic bottles	All brands of plastic beverage bottles
Size of containers	Unspecific	≤ 1.5 L	230 mL to 1.8 L	330 mL to 2 L
Reward of return	Scores for gifts	Stamps for beverages of its brand or charity donation	Sores for gifts	Cash rebate via e-payment
Limitation for maximum number of returns	None	None	None	Maximum 50 plastic bottles for one Octopus card
Number of machines (until now)	10	6	21	10

Despite that the existing pilot RVMs schemes are far from reaching conclusive analyses, a crucial deficiency is spotted. These pilot schemes' scales are small, which come with a limitation of overloading capacities. There are at least four pilot RVMs schemes launched in this year by non-governmental bodies. One is an NGO with government funding, while three are beverage manufacturers. All these schemes have few RVMs installed. Among the four schemes, "Recycling Green Point" has the highest number of RVMs (currently 21 machines in total). The rest have no more than ten machines. These machines are easily overloaded when installed at population-dense or high-traffic locations.

The pilot scheme, RVMHK, has one RVM installed at a shopping mall, Tai Po Mega Mall. From June to August 2019, that machine had been often out of service. One of the reasons is that the machine was full, and no immediate clearance was available (Anonymous, 2019). The responsible cleaning contractor does not work on holidays. In weekdays, it was also impossible to request clearance soon after the machine was full. Shopping malls usually have heavy traffic. A single machine at a shopping mall is easy to fill up all its capacity. The total number of the installed RVMs by the four schemes is 47. They are "a drop in the ocean of plastic bottles". The frequent out-of-service or malfunction discouraged the residents from using the machines.

2.6. Geographical and socio-demographic comparison

In order to evaluate if Norwegian experiences on the recycling of liquid metal and plastic containers can be useful in a Hong Kong setting, I present in Table 7 some geographical and socio-demographic statistics (Census and Statistics Department [CSD], 2018; CSD, 2019; Deloitte Risk Advisory, 2018; HKSAR, 2019b; Norway, 2019; Statistics Norway [SN], 2017; SN, 2019a; SN, 2019b).

Table 7 Geographical and socio-demographic statistics for Hong Kong, Oslo and Norway

	Hong Kong	**Norway**	**Oslo, Norway**
Population (at the year-end of 2018)	7,468,400	5,328,200	681,000
Total land area (square kilometres)	1,107	365,094	426
Population density (people per km^2)	6,746	15	1,599
Median annual household income (before tax, in 2017)	HKD 392,400	NOK 648,000	NOK 604,000
Beverages in PET bottles volume (units in 2017)	1,394,000,000	545,397,194	

Geographical and socio-demographic statistics of Hong Kong and Hong Kong reinforce the grounds to analyse to what extent that two regions are comparable. Hong Kong is a population-dense city with more than 7.4 million people, which exceed the total population of

Norway. However, Norway has a far greater land area than in Hong Kong. In this case, in Norway it is likely to be easier to acquire land for waste-industrial development, including building and operating production facilities for running a deposit return system. Infinitum (a non-profiting organisation operating the deposit return system in Norway. See also section 4.2.) currently owns three production facilities in Trondheim, Fetsund, and Narvik, which spread across Norway from the Northern to the Southern region.

Respondents from the Community Green Stations and recycling firms in Hong Kong all share concern for the applicability of foreign models in Hong Kong. Population density is one of the concerns. A denser population could mean returning spots might be over-crowded, and fewer spaces are available for accommodating the machines and returned containers. The population density of Hong Kong (6,746 people per km^2) is incomparable to that of Norway (15 people per km^2). Hong Kong is a city, while Norway is a spacious country.

However, we could take a look at Oslo, the capital of Norway, as well. Close to one-tenth of the Norwegian population lives in the Oslo municipality. In addition, Oslo is the center in Norway for shopping as well as public - and private sector activities. The population density of Hong Kong is 4.2 times than that of Oslo. The ratio of population densities between Hong Kong and Oslo is far smaller than that between Hong Kong and Norway.

It is worth noting that the median annual household income before tax in Hong Kong is lower than that of Norway, but their difference is not huge. Hong Kong and Norway are both high-income states. This similarity potentially makes the two regions more comparable, regarding to the economic rationale.

In summary, Hong Kong is different from Norway in multiple geographical and socio-demographic aspects. Hong Kong has a larger population than Norway, but Hong Kong is far less spacious than Norway. Potentially, it could raise challenges that of the costs of operating a deposit return system will be higher than in Norway. However, it is still reasonable to study the Norwegian model because Oslo is also a population-dense city which has adopted the deposit return system. In this case, the operating system in Oslo might be transferable to Hong Kong. Besides, population-density is not the only factor, neither a decisive factor in determining the success of a deposit return system. The dense population could be a positive

factor. For instance, a shorter distance from depositories to recycling factories might potentially reduce transport costs.

3. Methodology and Methods

The research questions are addressed qualitatively by interviews. Interviews serve to extract information about the knowledge, opinion, and idea of the stakeholders and key players in the plastics waste recovery industry. The key objective of this research is to study the feasibility of applying the Norwegian deposit return system for plastic bottles in Hong Kong. Two crucial dimensions will be needed to figure this out. Firstly, in this study I will highlight the plastics bottles recycling status in Hong Kong and the potential challenges of establishing a deposit return system. Secondly, I will try to interpret and describe the case of Norwegian deposit return system. In the discussion section, I will infer the feasibility of such an application by reviewing some characteristics of Hong Kong and Norway. Literature and third-party data will be drawn to support the argument.

3.1. Data collection

Background study[5]

To investigate the plastics waste management in Hong Kong, I interviewed three operators in recycling sector in Hong Kong. The interviewed stakeholders are an entrepreneur of a recycling firm, a project manager of a government-funded project for expanded plastic recycling, and a manager of a non-profit recycling organization. All these interviews are conducted in face-to-face and in a semi-structured way. Semi-structured interviews enable the respondent to elaborate on the answers freely. Relevant questions could be raised subsequently. Interviews' main themes are understanding: (1) How are the plastics waste managed in Hong Kong; (2) What are the difficulties in plastics waste recycling; and (3) The feasibility of introducing a deposit return system in the city. These interviews extract experience of the front-line operators, who know well about the situations of the plastic

[5] The responses of the interviewed stakeholders are included in Chapter 2 to give a complete overview of the situation in Hong Kong. See also appendix 1 and appendix 2 for the interview guides.

recycling sectors. They could provide me with a better understanding off the recycling industry, the difficulties in plastic recycling, the challenges that Hong Kong is facing, and how do they judge the feasibility of introducing a deposit return system.

Next, I interviewed two managers of two Community Green Stations, respectively. Community Green Stations are government-funded facilities performing recycling and educational functions. One of the stipulated duties of Community Green Stations is collecting several recyclables from the district residences. The station-operators have to work according to the tender instructions offered by the government. The managers of Community Green Stations could inform me about their experience in collecting plastics recyclables and engaging the residents to participate. At the time of this research started, there were six operating Community Green Stations in Hong Kong. I sent interview invitations to the six earliest opening Stations by emails, excluding the latest Kwai Tsing Community Green Station, which just started to provide service in November 2018. Two stations replied and were able to arrange phone interviews.

I also interviewed two respondents who have experience in participating one of the RVMs pilot schemes in Hong Kong. RVMHK is one of the recent pilot RVMs schemes launched by a NGO. This project has a promotional Facebook page. I observed, in August 2019, some users reporting challenges when using the machines. To inquire their experiences on the RVMs pilot scheme, I sent a total of ten messages through Facebook Messenger stating the research purposes and invited the receivers to answer several questions. Among the ten, two Facebook users responded and shared their experience with the pilot RVMs scheme. The communications took place using the Facebook Messenger in text. Besides, an un-successful interview invitation was also sent to the organizer of RVMHK by email.

Norwegian case study

To understand the Norwegian deposit return system, I interviewed representatives from Infinitum, the operator of the deposit return system in Norway, and TOMRA, a manufacturer of reverse vending machines (RVMs):

- Infinitum is the cornerstone of the deposit return system. The company is responsible for registration, collection and processing of recyclables of the deposit return system for cans and plastic bottles.
- TOMRA is a leading RVMs manufacturer commanding a 75% global market share (TOMRA, 2019a). The company also is a major partner with Infinitum in Norway's beverages deposit return system.

Both interviews were unstructured interviews. The respondents from Infinitum explained their roles and specific operational experience in the Norwegian deposit return system, as well as features of the Norwegian deposit return system. TOMRA provided a tour of RVMs exhibition along with an interview. The respondents from TOMRA introduce the functions of RVMs and their knowledge of observed customer behaviours. The results of these interviews enable me to depict a fuller picture of the deposit return system in Norway.

3.2. Data Analysis

Data collected in interviews include objective facts and subjective opinions. The idea and opinions provided by respondents are not necessarily coherent to what is happening in the real world. Their roles of the respondents might constrict their interpretation. For example, the recyclers might overstate the difficulties they are facing or the perceived challenges about the deposit return system. The respondents from the operational side of deposit return system might underestimate the drawback of the deposit return system. Therefore, the empirical data collected in my interviews are presented in the Result section to highlight they belong to respondents' idea and information. Inferences will be made after comparison of the Norwegian case and comprehensive overview of Hong Kong's situation. The responses of the interviewed stakeholders are included in Chapter 2 to compose the overview of the situation in Hong Kong. It is because a more comprehensive overview is crucial for inferring how feasible to apply the Norwegian model in Hong Kong.

4. Results

4.1. Norwegian deposit return system development

Norway's environmental policies on waste

Norway is not a member of the European Union (EU), but it affiliates to the EU via its membership of the European Economic Area (EEA). The environmental policies of Norway are highly coherent to the EU decisions and policies. That means most of the rules adopted by the EU, which related to the European Internal Market, would be applied in the members of EEA (Bugge, 2014). For instance, the European Commission's Directive 2008/98/EC on waste is highly relevant to the waste policies in Norway.

There are two laws regulating waste issues. The Pollution Control Act provides the legal basis for the municipalities. Each municipality has its autonomy to organize the collection of household waste. A national organisation, "Avfall Norge", has a role in assisting the municipalities in dealing with solid waste issues. Avfall Norge assembles about 95% of Norway's municipalities and a corresponding number of private companies in the waste sector. Most municipalities implemented sorting of waste at source strategies for the households (Bugge, 2014). The Product Control Act is another tool to address the problems of littering and waste reduction. It regulates the packaging waste by establishing producer responsibility systems, including the beverage containers.

Legal development

The 1974 Bottle Deposit Regulations implemented the 1974 temporary act, which required a minimum refundable deposit on all beverage containers. This regulation came because the Ministry of Finance in 1974 failed to ask all Norwegian breweries to voluntarily increase the deposits from NOK 0.30 to 0.50 and from NOK 0.70 to 1.00 for containers below and above 50 centilitres, respectively. The common-bottle-stock system could not be maintained because not all bottlers followed the Ministry of Finance's advice. The cash in the return system would 'leak out' when bottles with a lower deposit could receive a higher refund (Jørgensen, 2011).

The environmental tax on non-refillable beverage containers was introduced in 1974 (Ministry of Finance, 2007). The beverage packaging tax that was implemented in 1994, consisted of a basic tax and an environmental tax. For single-use packaging, the basic tax is mandatory. Meanwhile, the environmental tax is payable for the packaging based on the achieved return rate. The performance-based tax aims to encourage the manufacturers to work for a higher return rate. The tax also associates with the deposit refund system and the EPR schemes. If the return exceeds 95%, the environmental tax is exempted totally.

The Product Control Act of 1976 prescribes how return and deposit schemes for products could be set up with minimal environmental impacts. The Act was updated in 1999, which further outline a formal regulation of deposit and return systems. That section was incorporated into chapter six of the waste regulation 2004.

The initial concern in the law was focusing on reduced uncontrolled litter-disposal. However, since the 1980s, the importance of waste reduction and waste recovery were also acknowledged. The 1981 Pollution Control Act includes protection from pollution and waste. It outlines the fundamental rules to handle different types of waste properly. According to Bugge (2014, p.3), "the act provides the local and central authorities with the necessary tools for promoting recycling, re-use, and use of the waste as an energy resource, and the safe handling and destruction of waste." Waste reduction and waste recovery have been an addressing goal, which stated in the Pollution Control Act from 1981 (Bugge, 2014). The Ministry of the Environment brought up much focus on resource use, product design and composition, and recycling, with the impact from the 1987 Brundtland report.

The Norwegian government formulated a comprehensive waste policy which was presented in its annual white paper on Environmental Policy and the Status of the Environment for 1999/2000. It targeted to suppress the growth in the waste generation, which should be lower than the economic growth, and final disposing waste should be reduced to 25% of waste generated within 2010. Its policy addressed producer responsibility as one of the major elements.

Origin of the deposit return system

Deposit systems for beverage containers have a long history in Norway. Norwegian bottlers and brewers started to run deposit programs before the 1900s (Jørgensen, 2011). The deposit programs were set up because the bottlers and brewers could save the cost in producing new bottles by reusing bottles. There was a period when all bottlers and brewers re-used their bottles using various deposit systems. The research of Jørgensen (2011) does not state the definite time of this period. Still, some examples show that the Brewers equipped an adequate capacity to store the empty bottles for reusing bottles, like Frydenlund Brewery in Oslo. This brewery built a new empty-bottle storage building in 1936, which could store a million empty bottles.

Until the 1970s, glass was still the major beverage container material in the world, and Norway was no exception. Norway's geography is a long and narrow in shape. The people disperse across the country. Distributing and collecting the heavy glass containers was a challenge to expand the local distribution chains because it was costly. Disposable beverage containers provide an incentive for the breweries by seeing a chance to reduce distribution costs (Jørgensen, 2011).

Norway was inspired by the deposit system for single-use bottles in Sweden. The Swedish Returpack was established much earlier than Norway, in 1984. The idea to introduce a similar system was discussed in the period between 1989 and 1996 among the political and research arenas. The Norwegian Pollution Control Authority and Ministry of the Environment approved Norsk Resirk Ltd in 1996. Norsk Resirk was formally established on 11 November 1996 (Eik, 2005). The Resirk system was launched in 1998. And it changed its name to Infinitum in 2014.

Norsk Resirk operated based on a mandate given by the Norway Ministry of Environment. The mandate literally means to "establish and operate a non-profit deposit and recycling system for one-way beverage and soft drink containers which (1) has a high objective in recycling, 90-95% long term; and (2) is environmental, competition-neutral and cost-efficient" (Eik, 2005, p.6). The retailers and breweries owned Norsk Resirk in a 50-50 ratio. The current stakeholders are shown in Table 8.

Table 8 Percentage of stakes of current Infinitum's Owners

Companies	**Percentage of stakes**
Norwegian Federation of Petrol Dealers (Virke Kiosk og Bersin)	1.5%
Grocery Manufactures' Service Office (Daglivareleverandørens Servicekontor)	7.5%
Federation of Norwegian Food and Drink Industry (NHO Mat og Drikke)	7.5%
Coop Norway (COOP Norge AS)	15.0%
Norwegain Association of Wholesale Grocers (Dagligvarehandelens Miljøforum AS)	33.5%
The Norwegian Brewers' Service Office (Bryggeri- og Drikkevareforeningens Servicekontor AS)	35.0%

The modern deposit return scheme in Norway was established in the background of rising waste awareness and the conception of producer responsibility. Former Norway Minister of Environmental Affairs, Thorbjørn Berntsen pointed out in an interview by Infinitum that the Brundtland Commission Report published in 1986 raised an international debate on the environment and the attention to waste: "*It was clear that waste, and in particular hazardous waste, was an urgent problem. For as long as humans have lived, waste has been an issue, but now it was given a completely different level of importance*"(Infinitum, 2018, p.32) Besides, the concept of putting the responsibility on the producers was introduced. Norway had had a reliable deposit-return system for glass bottles for almost a century. "Because they were costly enough for it to be rational for the breweries," said Thorbjørn Berntsen (Infinitum, 2018, p.32). Ultimately, he believed that a deposit return system plus a performance-hooked environmental levy would be the solution.

In Berntsen's opinion, plastic bottles and cans are able to handle a high levy. It is because cans and plastic bottles are light. Thus, they are less discouraging for people to carry back the container even after a distant trip (Infinitum, 2018). Infinitum echoes with Berntsen and states that an extremely high levy on cans and bottles made the subsequent progress passing on to today's system easier.

4.2. Modern deposit return scheme in Norway

Norway's deposit return scheme is a deposit return system plus a performance-hooked environmental levy. The essence of this deposit return scheme is that the industry can enjoy a lower environmental tax when the performance of collection is satisfactory.

Two types of tax are payable on beverage packaging: environmental tax and basic tax. The taxes are calculated per packaging unit. The basic tax is payable if the packaging cannot be used again in its original form. Dairy beverages are exempt from the basic tax. Packaging covered by an approved return scheme is subject to a lower environmental tax rate depending on the return percentage. A return percentage of at least 25 per cent is required in order to be eligible for the reduced rate. If the return percentage is 95 or more, the tax will cease to be payable. All retailers selling returnable beverages are obliged to accept back empties. An overview of environmental taxes is presented in Table 9.

Table 9 Environmental tax rates in Norway, 2019

	Basic Tax (per unit), NOK	**Environmental Tax (per unit), NOK**
Glass and metal	1.21	5.88
Plastic	1.21	3.55
Cardboard	1.21	1.45

There was used to be a deposit return system covering refillable glass bottles and PET bottles, operated by Rentpack. However, since the use of refillable bottles was diminishing, and the return system became costly. Refillable glass bottles and PET bottles have been removed from the deposit system since 2014 (Papineschi et al., 2019).

Today, the deposit return system operated by Infinitum covers two types of metal cans (aluminium and steel) and two types of plastic bottles (PET and HDPE). Most plastic containers are in PET. HDPE is a type of plastic, which is used in semi-transparent and white bottles with better protection for the contents. For instance, HDPE is used for some types of freshly squeezed juices, which are recycled through the return scheme. The system excludes milk products, fruit and vegetable juices, dietetic products and products exclusively for infants.

Table 10 Deposit rate for cans and bottles containers

	Volume < 0.5 litres	**Volume ≥ 0.5 litres**
Deposit (on and after 1 September 2018)	NOK 2	NOK 3
Deposit (before 1 September 2018)	NOK 1	NOK 2.50

The current deposit rates are NOK 2 and NOK 3 for containers in a volume less than 0.5 litres and a volume equal or greater than 0.5 litres respectively. Before 1 September 2018, the deposit rates were NOK 1 and NOK 2.50 for the two sizes of containers (Infinitum, 2019b).

Consumers can return the beverage containers to any of the registered collection points, such as retailing stores via RVMs or manual collection. At the time they return the containers via RVMs, consumers will receive a receipt which could be cashed out from cashiers or used to pay for the goods. Consumers may also choose to donate the refunded deposits to charity.

Retailers can register with Infinitum to be a collection point with an RVM. The machine reads the bar code on the beverage containers and issues a deposit note to the customer. Retailers enjoy free transporter collection for the empties, which will be sent for recycling at an Infinitum production facility. Infinitum clears the empties twice monthly. Based on the return data, Infinitum issues a clearing statement for the deposited empties and a handling fee. In addition to the deposit refund per empty, the retailers receive a handling fee of NOK 0.2 per cans and NOK 0.25 per plastic bottle (Infinitum, 2019a).

Achievement of the Norwegian deposit return scheme

Infinitum (previously named as Norsk Resirk) was established in 1999. As shown in figure 5, almost every year, it was recorded a growth in the number of items collected.

It is worth noting that the recycling rate reported for the deposit return system is not equal to the collection rate via the system. The Norwegian Pollution Control Authority agreed energy recovery of returnable bottles and cans might be included as a part of the Infinitum's return percentage in 2009. The addition of the bottles and cans into the return percentage implies that it will be easier to reach the 95% threshold of full environmental tax exemption. In 2011, the recycling rate for plastic bottles reached above 95%. It means that the environmental tax

was completely waived for that year. In 2012, the recycling rate for cans also reached the 95% threshold (Infinitum, 2018). Table 11 shows that the PET bottles total returned rate was 88.6% in 2018. The total recycling rate is 95.1% by summing up total returned via RVMs, energy recovery and other ways of recycling.

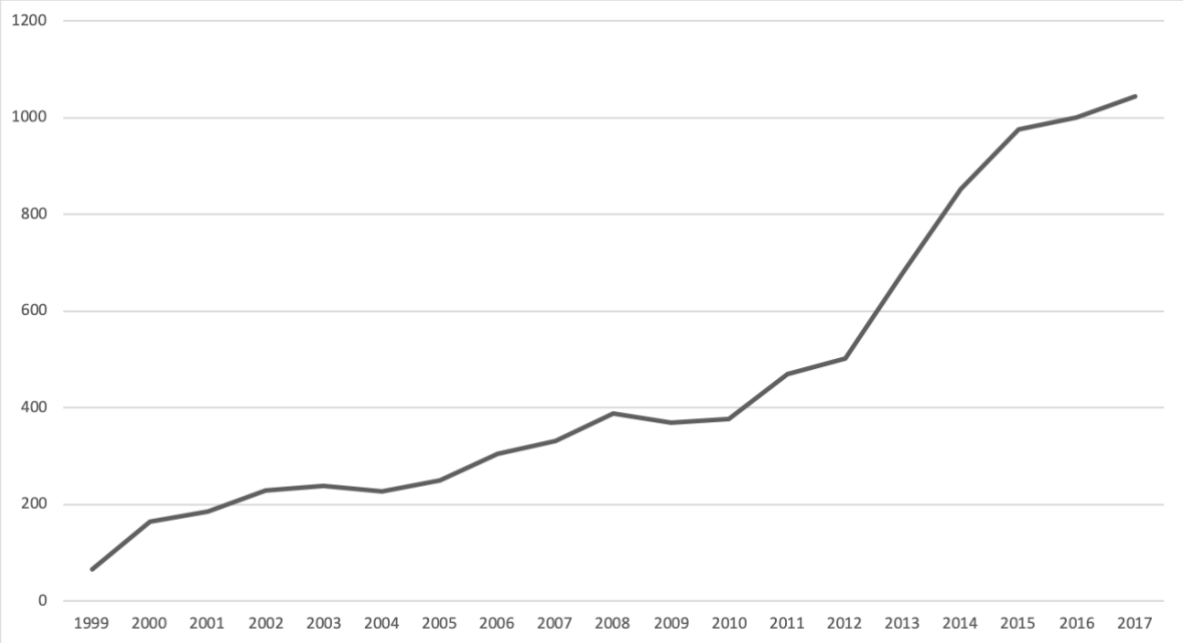

Figure 5 Numbers of items (cans and bottles) collected by Infinitum (millions of units) from 1999 to 2018

Table 11 Recycling quantities of PET bottles in Infinitum system, 2018

Supply chain	**PET bottles in unit**	**PET bottles in Tonnes (% added)**	
Total recycled	614,040,974	22,070 (95.1%)	
Total returned via RVMs	564,117,169		20,568 (88.6%)
Energy recovery	47,328,406		1,411 (6.1%)
Via other ways of recycling	2,595,399		91 (0.4%)
Non-recycled	31,963,546	1,133 (4.9%)	
Total sales + supply chain storage	646,004,520	23,203 (100%)	

How to join the Infinitum system

Companies join Infinitum on a voluntarily basis by paying an entrance fee of NOK 10,000. Thereafter, the company may register a new product by providing the necessary information launching it in the market place. The current registration fee for a new product is NOK 2,000. The Infinitum needs about six weeks to update bar code in all reverse vending machines and for Norwegian Customs and Excise processing (Infinitum, n.d.-b).

Producers and importers participating in the system also pay administration fees for their products. The administration will be adjusted according to the operational needs and the market situation. The basic fee for aluminium stands out among the administration fees, which is a negative value (as shown in Table 12, aluminium is NOK -0.06 currently). Infinitum is paying the producers for each unit of aluminium can because of the high value of aluminium (Maldam, 2019). For each unit of steel, PET, and HDPE beverage, the producers have to pay NOK 0.21, NOK 0.12 and NOK 0.12 respectively (Infinitum, 2019c).

Table 12 Current administration fees for producers or importers (figures in NOK)

12 October, 2019	**Aluminium**	**Steel**	**PET**	**HDPE**
Basic fee	-0.06	0.21	0.12	0.12
Standard barcode	0.06	0.06	0.06	0.06
Label or sleeve ≥ 75% of the packaging	0.03	0.03		
Light blue transparent packaging			0.08	0.08
Other colour, or Label/sleeve ≥ 75% of the packaging			0.15	0.15

The producers may choose between two types of barcodes, either a standard or a unique type. Standard barcodes mean universal codes that allow the beverages to be sold in both Norway and Sweden. Drinks with unique barcodes are restricted for use in Norway, only. Standard barcodes carry an additional price because it has to compensate the costs of the deposit-unpaid containers reimbursed in Norway. That is the consumers may buy products in Sweden. The deposits will go to the Swedish deposit return system. However, the containers of those products could be reimbursed in Norway. In this case, the Norwegian system will lose money for the foreign-deposited containers.

Infinitum imposes an additional fee for beverages with light blue transparent packaging. It is because coloured packaging has fewer possible applications in recycling. Thus, coloured packaging's market value is lower than transparent plastic bottles' market value. Infinitum will get less revenue for coloured packaging than transparent packaging. Setting additional fees also aims to encourage the producers to use better quality materials with lower costs, such as light and clear PET bottles or aluminium cans.

Tight requirements for PET bottles

Infinitum operates tight technical requirements for PET bottles (Infinitum, n.d.-c). The beverage producers or importers have to fill out a technical specifications form for PET bottles. They must submit four bottles to Infinium for shape acceptability testing six weeks before market launch. The technical specifications form requires the producer/importer to indicate the materials of bottles, cap, and labels. PET is the only acceptable material for plastic bottles. The rejecting materials are not allowed to be on any part of the bottle (Infinitum, n.d.-b).

Table 13 Materials of PET bottles accepted by Infinitum

	Accept	**Reject**
Cap	HDPE, PP	Thermoset PS, PVC, metal
Liner material and additional sealing	PE, EVA	PVC, metal, silicone
Bottle	PET	Other than PET
Barrier	Glaskin, bestPET	Coating, scavengers, additives
Label & glue	Paper, OPP, density lower than 1, water solvent glue (65°C), recyclable HotMelt	PVC, PET, OPS, Self-adhesives (under conditions), Hot-melt, heavy metal inks

Infinitum has to check the deposit symbol and barcode that appear on the packaging. The applicants could submit the sample either electronically or on paper. The beverage producers or importers then have to provide 15 cans/bottles of each EAN-code for to Infinitum for final technical testing before the product launches. The final technical tests take about a week to complete. Once the product design is approved, the product is ready to be launched in the

Norwegian market. The producers or importers must report the sales figures to Infinitum every month.

4.3. Empirical data from Infinitum interview

An interview was conducted with the Director of Marketing and Communication at Infinitum, Randi Haavik Varberg, and the Director of logistics and operations, Sten Nerland in April 2019. The empirical data is presented in this section.

Refillable bottles retreated from the Norwegian market

Especially for the shops, the refillable bottles occupied a significant area in back storages. It is much more convenient for retailers to have non-refillable bottles. After 2014, there have been no refillable bottles in the Norwegian Markets. Refillable bottles are not preferred because of several factors. The material of the refillable bottles goes through the value chain is lower than its ideal returnable times. The Actual number of returns is about six or seven times. On the consumer side, the consumers do not know the difference between a non-refillable and a refillable.

Another problem to have refillable bottles is contamination. People might fill other stuff into the bottles before return, like gasoline. In addition, funguses might grow in the returned bottles after the summer season. These bottles could not be reused and have to be discarded. Besides, there is a 10% loss rate on every trip, which could be old or new bottles.

The above reasons make the actual average lifespan of the refillable bottles lower than the optimal reusable times. When the non-refillable and refillable bottles are displaying next to each other, consumers are likely to pick the non-refillable bottles, it is because they look new and fresh. When the refillable bottles went through the loops five or six times, they start getting greyish. The consumers prefer a bottle with fresh packaging than a greyish bottle.

Nerland emphasised that Infinitum is setting up the framework, but it is not filling it. The retailers have to decide on using which type of machines. Infinitum is paying for everything that put in with a fixed sum per unit. Infinitum pays for the labour cost, machines, the area

that spent in back rooms, and the equipment they need to send the empties. These expenditures would be covered by the handling fee that Infinitum was paying to the retailers.

Consumers' habits

About 80% to 85% of the population is engaging in returning the beverage containers. They see that it is a good thing to do or do it as a habit, irrespective to the monetary benefit habit. The last 15 per cent saying that 'I don't care about everything if I don't get paid for it.' Thus, if they get paid, then they will be encouraged to return the containers. There are two reasons behind the returning act of people in Norway. Firstly, it is a good thing to do. Secondly, there is a monetary incentive.

Varberg complemented that they observed that the consumers got 'angry' when they see some beverages do not have a deposit on their packaging. The dairy company, Tine, launched a milk product without a deposit mark. However, they decided to relaunch it with a deposit mark, because the company found that the consumers have unfavourable attitudes to the absence of deposit mark on their product. Verberg suggested that it is a good thing, and it shows that the consumers trust the system.

Another example is a beverage 'Fanta zero pink pomelo', which has a round and short bottle shape. RVMs could not recognize this design of bottle because the shape makes it rebound on the belt, and the RVMs could not read the label. Infinitum rejected this product joining the system. The producer thus launched it in the Green Dot System. However, the consumers said that this was ridiculous. They did not get used to a company putting a product into the market without deposit.

Nerland suggested that the other countries should not mix the deposit with the price. The deposit should always be put upon the product price. This could indicate that deposit and the price are two separate things. The consumer will know they are paying the deposit as a 'micro-loan'.

Exporting collected PET bottles

In the opinion of Nerland, plant-based plastic is less preferred when gas and oil is available. In Norway, today they can provide 80% of recycling material to all bottles. But because of the market price factor, the actual use is just ten per cent of recycling material. The oil companies subsidize the virgin materials. The local bottlers are looking for the cheapest sources.

Infinitum sells its sorted and baled bottles mainly to Western Europe. The countries which have a deposit return system like Denmark, Finland, Sweden and Norway, can provide good quality recycling materials to be used to produce new bottles in countries like England and France, which already are using recycled material in their production lines.

Figure 6 Infinitum sorts plastic bottles by colours and bales the plastic bottles.

Photo source: TOMRA (n.d.)

Effect of the increased deposit value

Starting from 1 September 2018, the deposit values for beverage cans and plastic bottles have increased from NOK 1 to 2 and from 2.5 to 3 for smaller (< 0.5 l) and larger (≥ 0.5 l) beverages, respectively. The deposit of smaller beverages was increased by 100%, while the larger beverages was increased by 20%. This differentiation in increase rate was due to the observation that the smaller beverages are more likely to be consumed outside home thereby being more likely to be discarded into the environment or thrown into garbage bins.

The systematic effects are too early to conclude. However, until April 2019, the return rate for PET Bottles and cans, increased by 1% and 3%, respectively. The return rate of cans for energy drinks, which are consumed mainly by young people, improved even more.

Balancing the deposit value and incentive for fraud

Increasing the value of deposit would provide a higher incentive for people to return. Infinitum has studied the elasticity. But the respondents reminded that it had to balance the value of the deposit and the temptation to cheat. If it is too easy to make money on fraud, thereby, it will start getting a very high return rate. Nerland elaborated that in hypothetic cases: if the collection rate is just 50%, then it is fairly reasonable to see how to increase the deposit. When the collection rate is next to 90%, then it is difficult to see a significant effect. If the collection rate is reaching 100%, a further increase of the deposit value will open a chance of fraud. Fraud activities include forging barcodes on foreign bottles and stealing returned bottles to cash out money by returning a second time.

Measures against potential frauds

The strategies to identify potential frauds include monitoring the return rate for each product to check any deviation from the normal. They will call the producer and ask for review reporting, thus seeing if the producer has reported correctly. For instance, it is unusual to have a return rate of 100%. The producer might be misreporting for some products. In the interview, Nerland revealed a fraud case that happened in November 2018. A product of canned beverage which registered with a quantity of 5000 units. However, 400% of return rate was recorded. Infinitum found that there was a regular return at seven o'clock every day in one shop. A man was caught with beverages with own-producing labels to get deposits.

The RVMs are not allowed to put the five items with the same barcodes in a row. Otherwise, an alarm will be activated. Moreover, there are shapes recognition on the bottles to monitor if the items are too long or too wide. If the features do not match with the barcodes, there will be an alarm.

Measures regarding direct imports

Infinitum charges NOK 0.06 extra fee for a standard barcode which could be traded outside Norway. This extra fee will compensate private imports of bottles. Infinitum accepts foreign cans in the RVMs, but the returners receive no deposits. Nerland explained that even though Infinitum gets free aluminium cans, it does not profit from those cans under the current aluminium market price in running the system. It is because foreign cans do not provide income from unredeemed deposits. Infinitum still accepts foreign cans because it will be easier for consumers. The consumers do not have to worry whether the cans could be return or not. However, Infinitum does not accept foreign PET bottles. The key reason is that they could not confirm the composition and quality of materials for foreign PET bottles. But aluminium cans are standard and stable.

Recommendation to Hong Kong

Nerland revealed that they had a dialogue with Hong Kong officials. One of the problems the officials mentioned was lacking areas to build factories. Nerland commented in the interview that Hong Kong spends a large area to run landfills. He suggested that the space for recycling should be much smaller than the area for landfilling. Nerland also realised that Hong Kong's authority was going to conduct a small-scale pilot test. According to him, "That does not test anything. "You either have to believe it, or not" (Nerland, 2019).

In responding to how to make the logistic efficient and cost-effective, Nerland replied that it is quite easy by using the market. Since Infinitum is at the end of the value chain, utilising backhauling is one of the strategies to reduce logistics cost. Norway adopts a return-to-retail model that all retailers selling deposit bearing beverages are obliged to accept empty beverage containers. After cargoes delivered products to retailers, the load will be empty in the way of returning. Using these backhauling capacities could significantly reduce the cost of transportation. It is also environmentally friendly since the fuel is efficiently used.

Two recommendations were made by Nerland. He suggested that a large quantity of bottles rather would be an advantage. Firstly, the volume could be a possibility, because it could be efficient under a scale effect. Secondly, politicians should try to put up a framework and let

the participants in the value chain make decisions on how to achieve it. The participants will seek a way to make it efficient. Moreover, when the government set a framework to reward the participants and set a higher target, it could perform better and prevent to be satisfactory for a fair enough return rate. Nerland suggested that it is the reason why Norway perform better than Sweden in term of the return rate.

4.4. Empirical data from TOMRA interview

Tomra Systems (TOMRA) is a Norwegian multinational corporation, which provides collection solutions and sorting solutions. TOMRA, which was founded in 1972, began with the design, manufacturing and sale of reverse vending machines for automated collection of used beverage containers. Collection solutions and sorting solutions line are the two business areas of TOMRA. Reverse vending belongs to the collection solutions area, which includes material recovery as well. TOMRA currently owns 75% of the global market share for reverse vending (TOMRA, 2019a). TOMRA is a close partner with Infinitum, the company responsible for material recovery in Norway. TOMRA offers reverse vending solutions, such as development, production, sales and service of reverse vending machines.

An interview was conducted in the early of August with communication manager of TOMRA, Zara Lauder. The interview covered information about the return systems, machines and consumer's behaviour.

Several features of TOMRA' systems were highlighted:

- The RVMs' systems are going to employ more digital functions. Digital functions are equipped for consumers' convenience. For instance, deposits can be redeemed by scanning a barcode card, returning as a digital receipt. The money can be paid to a PayPal account or a digital receipt for shopping.

- More machines are going to be connected online. TOMRA owns about 82,000 machines worldwide, 55,000 of them are connected online. The older machines still work. When new machines are installed, those new machines will be connected online as well.

- The stores can use an App to monitor the RVMs' operation. The App can remind the store when the storage bags need to be replaced soon. Thereby, the services to end-users will not be disrupted because of a late replacement of cabinets.

- In addition, the machines can record the deposit time of the containers and how often it has been cleaned and cleared. The retailers can approve the arrangement in maintaining the RVMs with this operation data.

- TOMRA sells ownership of RVMs in two ways: 1) the retailing shops own the machines and 2) the shops lease it from TOMRA. For example, the shops in Norway are who own the machines which are bought from TOMRA. In cases of Australia and Lithuania, TOMRA owns the machines and receives payment by units processed by the shops.

The advantages of TOMRA's machines were presented by Zara Lauder:

- An RVM can have up to seven bins. The conveying belt can send the containers to a specific bin according to the sorting demand, for instance, one bin for cans and another for plastic bottles. Bins can be emptied individually without interrupting the machine's operation. As a result, consumers can keep returning when some of the bins are clearing.

- Different countries have different rules on what kind of containers to return. In Norway, the glass containers are not included anymore. If a market required to collected refillable glass bottles, a specific table set at the same level as the belt could be installed. Tables can prevent returned glass bottles from crushing.

- Along with the barcode, TOMRA also has registered the containers' attributes (length, width, shape, and material), so all four have to match up for the reverse vending machine to pay out the deposit. This can prevent a case that copying barcode and pasting on an ineligible bottle from redeeming deposits.

- Barcodes are preferred as a counting unit instead of by weight since the consumers may return unfinished bottles and bottles intentionally filled with water.

- Some models of TOMRA's RVMs, such as T-9, T-820, T705, are capable of recognizing crates and bottles in crates, facilitating a return of multiple containers. Nevertheless, demand for returning a whole crate of drinks is uncommon in Norway.

Two models of RVM work in limited space

Two models of TOMRA's machines, the *Engaging* (H-10/-11) and the *Compact* (T-70), were introduced by the respondent from TOMRA, Table 14.

T-70's recognition owns a feature of TOMRA Flow Technology™, which enable the RVMs to detect all barcodes and security marks instantly. TOMRA Flow Technology™ is a 360° instant recognition. According to TOMRA's description, "users can insert containers rapidly in a continuous flow, increasing convenience and peak-hour capacity" (TOMRA, 2019d). T-70 can detect up 45 containers per minute, which is three times more than H-10/H-11 can do.

H-10 and H-11 are designed for receiving low to medium volumes of containers. They are suitable for retailers who need an efficient and basic return solution for handling empty beverage containers. H-10 and H-11 take one-way containers. H-11 is equipped with a SoftDrop™ unit which can receive refillable containers.

H-10 and H-11 are models launched by INCOM TOMRA, which is a Chinese-Norwegian joint venture based in China, established by Tomra Systems and Beijing INCOM RECYCLE Co., Ltd. H-10 and H-11 are equipped with a larger than usual display. According to Zara, the enlarged display is designed to accommodate the Asian Market, which could provide more interactive experience.

Table 14 Two models of TOMRA's RVMs

	H-10/H-11		**T-70**	
Material types	Non-refillable PET, cans and glass (no compaction) Refillable bottles can be accepted with the SoftDrop™ bin		Non-refillable PET, cans and glass	
Container size	Diameter 50-115 mm, Height 80-380 mm		Diameter 50-115 mm, Height 80-380 mm	
Storage capacity	PET	760 bottles (0.5 L)	PET (based on mix)	Up to 1500 bottles
	PET	240 bottles (1.5 L)		
	Cans	900 cans (0.33 L)	Cans (based on mix)	Up to 3000 cans
Dimensions	1913 mm (Height) x 950 mm (Width) x 854 mm (depth)		1797 mm (Height) x 1293 mm (Width) x 1040 mm (depth)	
Electrical requirement	Power consumption H-10: Idle 55W, Max 500W H-11: Idle 70W, Max 500W Mains 110-260 V AC 1-phase w/ground 50/60 Hz, min 10A, Max 16A		Power consumption Idle 60W, Max 2000W, Mains 400 V 3-phase w/ground 50 Hz, Max 16A	
Speed capability	Shape & barcode reading Up to 15 containers per minute		Shape & barcode reading Up to 45 containers per minute	
Recognition	Shape recognition Barcode recognition		TOMRA Flow Technology™ Shape recognition Full container detection Barcode recognition Metal detection	
Environmental	**Humidity** Maximum 90% relative humidity, non-condensing **Temperature** 0°C to +40°C The machine has been designed for indoor use only.		**Humidity** Maximum 90% relative humidity, non-condensing **Temperature** +10°C to +40°C The machine has been designed for indoor use only.	
Connectivity	LAN (Ethernet TCP/IP) 3G/4G/5G WIFI		LAN (Ethernet TCP/IP) POS compatible	
User interaction	21.5" touch display		10.4" LCD colour touch-screen display	

Model of RVM takes a bulk of containers at once

TOMRA launched a new model of RVM, TOMRA R1, which can take multiple containers at once in November 2019. The machine allows customers to pour in entire bags of containers in one return. The machines can proceed over 100 containers in one go. TOMRA announces that the customers can return containers five times faster than single-feed RVMs. This model can process up to 140 containers per minute (TOMRA, 2019e).

Figure 7 Multi-feed reverse vending machine newly launched, TOMRA R1

Photo source: TOMRA (2019b)

5. Discussion

The previous chapters indicated Hong Kong is managing its plastics waste poorly. The recovery rate of all plastics recyclables has been less than 15 % since 2014. Meanwhile, on about 130 to 140 tonnes of PET plastic bottles were landfilled each day from 2013 to 2017. The voluntary source separation measure, three-coloured bins, is not effective to prevent the PET from being landfilled. Hong Kong needs an innovative solution for the plastics waste problem. The Hong Kong government is reviewing the feasibility to introduce deposit return systems and RVMs for plastic beverage containers as a measure to promote plastics recycling. In addition to the government-commissioned study, at least four pilot RVMs schemes have been launched by non-governmental institutions since 2018. Despite some successful cases in some European and North American countries, the feasibility of operating a deposit return system for plastic bottles in Hong Kong is still hotly debated. The potential challenges are presented in Chapter 2.

Chapter 4 studied the Norwegian deposit return system by literature studies and interviews. It presented the empirical data from Infinitum and TOMRA. It shows that the Norwegian deposit return system is a voluntary scheme with an environmental tax exemption as an incentive. TOMRA provides innovative technological supports, like reserve vending machines. In addition to demonstrating the general capability of TOMRA's RVMs, the representative of TOMRA provide specific information of two models of RVMs which work in limited space.

This chapter will analyse what can be learnt from the case of Norway's deposit return system for Hong Kong. It will figure out in which aspects, and to what extent could the Norwegian be applied to Hong Kong. Firstly, it will discuss the geographical and socio-demographic comparison to justify referencing Norway's case for Hong Kong. Then it will study the finance of the Norwegian deposit return system to shed light on its financial sustainability. After that, it will discuss the feasibility of applying the Norwegian Model for Hong Kong.

5.1. Financial analysis of the Norwegian system

This section analyses the financial features of the Norwegian system to examine its financial sustainability and discuss the difference in sale and costs of cans and PET bottles.

Financial sustainability

This section analyses the financial features of the Norwegian system to examine its financial sustainability and discuss the difference in sale and costs of cans and PET bottles.

Net income from deposit return scheme, administration fees from producers and importers, sale of collected materials are the three major incomes for the deposit return system. Net income from deposit return scheme is derived from the difference between collected deposits and the returned deposit. In other words, the net income from deposit return scheme comes from the amount of deposits which have not redeemed by the consumers. Net income from deposit return scheme is negatively relative to the return rate of the containers. When a return system collected the containers more successfully, the net income from deposit return scheme will be lower. In 2018, the return rate of all cans sold was 87,3%, and the return rate of all PET bottles sold is 86.6%.

The “rate of deposit expenses” in the deposit income can be calculated by “income from deposit return” divided by “deposit return scheme expense”. The rate of deposit expenses was 92% in 2018. The return rate of cans was 87.3%, and the return rate of PET bottles was 86.6% in 2018. The price of deposit expenses is higher than the return rates. It is because Norway has two values of deposit for different sizes of containers. The people also have a high incentive to return higher value containers. Therefore, the return rate of containers is not identical to the rate of deposit expenses.

Norwegian deposit return system (which includes both cans and PET beverage containers) is financially self-sustainable in the current operating model. As shown in Table 15.3, Infinitum recorded net profits NOK 16,759,000 and NOK 422,000 in 2018 and 2017, respectively. Infinitum also recorded operating profits in 2016 and 2015 (Infinitum, 2017).

Table 15.1 Infinitum's deposits income and expenses in 2017 and 2018 (figures in NOK 1,000)

	2018	**2017**
Income from deposit return scheme (a)	2,206,991	1,705,685
Deposit return scheme expenses (b)	2,031,246	1,512,411
Net income from deposit return scheme (c)=(a)-(b)	175,745	193,274
Rate of deposit expenses = (b)/(a)	92%	89%

Table 15.2 Income and expenses of Infinitum in 2017 and 2018 (figures in NOK 1,000)

Income	**2018**		**2017**	
Net income from deposit return scheme (c)	175,745	34.6%	193,274	41.5%
Administration fees from producers and importers	113,075	22.3%	99,843	21.4%
Sale of collected materials	182,503	35.9%	140,943	30.3%
Other operating revenues	36,413	7.2%	31,686	6.8%
Total (d)	507,736	100%	465,746	100%
Expenses				
Handling charges to receiving locations	243,089	56.1%	224,593	55.2%
Transport costs	114,929	26.5%	105,813	26.0%
Other production costs	75,533	17.4%	76,409	18.8%
Total (e)	433,551	100%		100%

Table 15.3 Income and expenses of Infinitum in 2017 and 2018 (figures in NOK 1,000)

	2018		**2017**	
Net Operating profit (f)=(d)-(e)	79,185		61,931	
Administration, marketing and depreciation (g)	62,426		61,509	
Net profit (h)=(f)-(g)	16,759		422	

Despite that the return rate of containers is not linearly related to the rate of deposit expenses, I attempt to run a simple sensitivity analysis, by assuming a scenario in 2018 that the return rate of containers approximately has a linear relation to the rate of deposit expenses. That means an increase in the return rate of containers by 5% would lead to an increase in the deposit return scheme expense (the total deposits refunded) by 5%. In this scenario, the deposit return scheme expenses will be increased to NOK 2,132,808,000, and the net income from deposit return scheme will be NOK 74,183,000 (as shown in Table 16).

Table 16 shows the changed variables for the income and expense items in 2018. The administration fees from producers and importers and other operating revenues are assumed unchanged. The new total expenses are expected to be equal or higher if the return rate is increased by 5%. The new operating profit will become negative (NOK -18,252,000). The sensitivity analysis shows that if the return rate is increased by 5% and without generating higher income from other sources, it is more challenging to keep a positive operating profit.

It is worth pointing out that the deposit return scheme in Norway is a producer responsibility scheme. Producers and importers of the beverages have to pay administration fees when they are taking part in the system. In other words, the producers and importers partly pay for the operational costs of the deposit return system. The administration fees from producers and importers contributed about one-fifth of the total operating income in 2018 and 2017 (as shown in Table 15.2). Being a producer responsibility scheme implies that the administration fee might be raised to compensate for the decreased net income from deposit return scheme, which caused by a higher return rate of containers. As a result, incomes and expenses could be re-balanced.

Table 16 Sensitivity analysis of return rate (figures in NOK 1,000)

	2018	**Scenario 2018' (return rate of containers increased by 5%)**
Income from deposit return scheme	2,206,991	2,206,991
Deposit return scheme expenses	2,031,246	2,132,808
Net income from deposit return scheme	175,745	74,183
Sale of collected materials	182,503	191,628
Total income	507,736	415,299
Total expenses	433,551	≥ 433,551
Net operating profit	79,185	≤ -18,252

Scenario 2018' assumes that the return rate of containers increased by 5%. Table 16 listed the changed variables. The deposit return scheme expenses are assumed to be increased by 5% accordingly. The net income from deposit return scheme reduced significantly. When more containers returned to the retailing stores, the expense of handling fee and transport will increase. Since the accurate change in handling charges and transport cost is unable to estimate, it is not highlighted in Table 16. However, the total expenses are expected to be higher for Scenario 2018'.

Difference in sale and costs of cans and PET bottles

The costs of cans and PET bottles impose differential burdens to the Norwegian deposit return system. The collected cans and PET bottles are recyclable materials with market values. The value per weight of cans usually is higher than PET bottles. Sale of collected materials contributed about one-third of the income in 2018 and 2017 (as shown in Table 15.2). Meanwhile, the costs of handling PET bottles are higher than those of cans. Table 17 and Table 18 further indicate the difference in sale and costs for cans and PET bottles[6].

Firstly, the market value of cans is higher than PET bottles. The annual report 2016 of Infinitum stated the income figures of cans and PET bottles separately (Infinitum, 2017). The sale of collected cans to recyclers was NOK 66,235,000 in 2016, which was higher than the sale of collected PET bottles to recyclers in the same year (NOK 51,070,000). However, the total deposited PET bottles in RVMs in tonnes are 2.74 times than the deposited cans.

Secondly, the costs of handling PET bottles for Infinitum are higher than those of cans. Table 18 shows the handling charges to receiving locations per deposited materials and the

[6] Infinitum's annual report has not separately presented the sale and costs for cans and PET bottles since the annual report 2018.

transports costs per collected materials in 2016. Both costs for cans are lower than that of PET bottles. Especially for the transport costs, the average transport cost of a PET bottle is 3.4 times than that of a can.

Table 17 Collected items of Infinitum, 2016

	Cans	**PET bottles**
Total collected via RVMs (numbers of containers)	466,793,339	545,397,194
Total collected via RVMs (tonnes)	7235	19798
Sale of collected material to recyclers (NOK)	66,235,000	51,070,000
Sale of collected material to recyclers per deposited materials (NOK per tonnes)	7634	2580

Table 18 Expenses per container of Infinitum, 2016

Expenses per containers	**Cans**	**PET bottles**
Handling charges to receiving locations per deposited materials (NOK per numbers of containers)	0.191	0.237
Transport costs per deposited materials (NOK per numbers of containers)	0.045	0.152

In summary, the Norwegian deposit return system (which includes both cans and PET beverage containers) is financially self-sustainable in the current operating model. Net income from deposit return scheme, administration fees from producers and importers, and sale of collected materials mainly contributed incomes for the deposit return system. A dilemma for the system is that a higher return rate will lead to less income for the system. When the return rate performs better, Infinitum may need to increase the administration fees from producers and importers in order to cover the reduce deposit income.

Besides, the Norwegian deposit return system collects both cans and PET bottles. Infinium currently does not profit from cans collection, even for receiving free foreign cans because of the currently low aluminium market price. However, cans are traditionally more profitable in the recycling market. Hong Kong's recyclers also are easier to maintain profits from cans' collection than plastics waste. If Hong Kong is going to run a deposit return system solely for PET bottles, it is foreseen that higher costs have to be borne by the producers or the government.

5.2. Feasibility of applying the Norwegian model

Two Implications of Deposit return systems to plastics waste recycling in Hong Kong

- *Alluring return rate*: The Norwegian case is promising for its high return rate. People return the containers out of environmental merit or an economic incentive. Hong Kong has endured a falling recycling rate of plastics waste since 2012. It was particularly walloped by the stricter waste import bans by China. Today, there are about 140 tonnes of PET bottles discarded to landfills every day. The recycling rate of PET bottles is estimated below 9%. The plastic bottles recycling industry in Hong Kong faces a series of difficulties, such as low market prices of plastics recyclables, insufficient quantities of plastics waste, high land costs. A well-functioning deposit return system is expected to be able to collect sufficient amounts of plastic bottles for high-quality recycling. The Norwegian case shows that the system can reach up to 88.6% of collection rate. A deposit return scheme is an attractive measure to encourage people to return the consumed beverages in exchange for rebates.

- *Supply of high quality and quantity*: Hong Kong suffers from low qualities and insufficient quantities of plastics waste. Infinitum requires strict standard control for the PET bottles registering to deposit return system. The composition of PET bottles can be unified through registration. Besides, the bottles have to be empty when they are returning via RVMs or manual collection. The collected bottles are less likely to be contaminated.

Industries have already bet on a high potential reliable supply of PET and HDPE plastics waste in the future. Swire Beverages is going to operate a recycling facility for plastics waste in Hong Kong, with ALBA Group Asia Limited and Baguio Waste Management & Recycling Limited in the third quarter of 2020. Swire Coca-Cola HK, a franchise to manufacture, market and distribute products of the Coca-Cola Company in Hong Kong, also launched the “Tap, Return & Earn” RVMs scheme. It also indicates the company’s ambition to create an infrastructure to collect plastic beverage bottles. Either a deposit return system or a reward-on-return is seen as essential to achieving such a high recovery rate of plastic bottles.

Setting up a framework – can Hong Kong place the carrot and stick?

The foundation of the Norwegian deposit return system is the environmental tax, which serves as a carrot and stick approach. The Infinitum system is voluntary to join. However, the environmental tax provides a strong incentive for the producers and importers to enter the system. The current environmental tax for PET bottles is NOK 3.55 per bottle. The lowest total administrative fee per PET bottle is NOK 0.12. If the PET recycling rate reaches the 95% threshold for environmental tax exemption, the producers or importers can save NOK 3.41 per bottle. It is a distinct and convincing advantage to be a member of Infinitum system. The tax framework works as a carrot and stick approach to encourage the producers and importers join voluntarily. If Hong Kong introduces an environmental tax framework with performance-based tax reduction reward, producers and importers will be encouraged to join the system.

Although the Infinitum system is voluntary, applying such a carrot and stick approach to Hong Kong will still face tremendous challenges because a new tax has to be introduced. Non-alcohol beverages are not dutiable commodities in Hong Kong currently. Hong Kong does not impose goods and services tax neither. Hong Kong long claims it has a "Low, Simple and Competitive Tax System"(HKSAR Government, 2019c). Introducing a new environmental tax on beverage commodities likely incur opposition from the business sectors and some of the citizens. The business sector would not like to bear an extra tax burden. Some citizens may be afraid that the tax will eventually shift to the consumers. The Hong Kong government must have a thoughtful approach to persuade the stakeholders that it is out of goodwill and will provide sufficient benefits.

Good news is the resistance from the business sector has been alleviated. The Single-Use Beverage Packaging Working Group, which consists of various stakeholders from different sectors, such as producers, distributors and retail, waste and recycling industry, NGOs, and other business institutions, the Working Group, in fact, supports the implementation of a cash-on-return scheme. It proposed that a levy should be collected from the producers and importers to subsidize the cost of the scheme. That opens an opportunity to establish a PRS on plastic bottles when the opposition from the industrial sector reduced.

However, the government has to consider the effect of migration to another packaging, if different packaging materials are not taxed at the same level. The government has to assess how to regulate other materials, for instance, imposing a similar rate of levy for all packaging.

A deposit return system or a return value system?

Deposit return systems are not the only form of return systems. Single-Use Beverage Packaging Working Group supports a return value system (or called cash-on-return scheme, a non-depositing scheme for containers. Returners receive monetary reward when they return empty containers.) as a new measure to cope with the plastic beverage waste. Despite that the working group also acknowledges that deposit return system is highly successful in driving up collection rates, they lean towards return value schemes rather than deposit return schemes. They suggest that it is because deposit return schemes are costly and complex to set up and administer. Solely monetary reward on return can save the costs on deposit administration. It is debatable if a deposit return system or a return value system is more suitable for Hong Kong.

Deposit return systems favour to achieve a higher return rate. It is because consumers will have a psychological sense to redeem what they have already paid for. Charging deposits also serve as a gesture to remind an environmental responsibility for consuming the products. Return value systems mainly encourage people to return the beverage bottles by economic incentives. Returning is to get an additional reward.

The drawbacks of deposit return systems are marked-up retailer prices for beverages and involvement of extra deposit administration. Consumers have to pay the deposits for beverages when they purchase them. The deposits either are displayed separately or included in the prices. The objective effect is that consumers have to pay more for those beverages carrying deposits. When the final payment is marked up, it might discourage the people from buying the beverages to some extent. Theoretically, if both depositing bottles and non-depositing bottles exist in the market, the depositing bottles are unfavourable to the customers. It is because the customers may have to pay more for the same original price. Norway has no such differentiation problem, although the deposit system is voluntary. In Norway, most beverages joined the Infinitum deposit system because of environmental tax

reduction. According to Infinitum, customers even favour beverages with deposit marks because they get used to the deposits and trust the system. The “marked up” effect depends on the participation rate of the deposit return system.

Deposit return system incurs extra administration costs, but it brings in income too. The Norwegian model shows that the deposit return system is financially sustainable. Sources of incomes include the income from net income from deposit return system, administration fees from producers and importers, sale of collected materials. The net income from deposit return contributed the largest share among different types of income (35%), as shown in figure 3. It is not claiming that the deposit system aims to generate revenue for the return system. The fundamental objective of deposit return system is to achieve a high collection rate over beverages consumption. However, it is still vital to point out that the role of net income from unredeemed containers is significant when the total number of deposited beverages is large. Norway’s bottles return rate is as high as 88.6%. Even though there are just about 11% of unredeemed bottles, the absolute amount of the unredeemed deposit is huge. It is because total beverages paid for deposit are plentiful (545,397,194 units). The income of unredeemed deposit may contribute to cover the administration costs even at a high return rate.

Meanwhile, administration costs occupy a limited role in the total costs. According to the Infinitum income statement, the administration, marketing and depreciation were NOK 62,426,000 in 2018. In the same year, the administration costs are far smaller than the net income from deposit return scheme (NOK 175,745,000), administration fees from producers and importers (NOK 113,075,000), and sale of collected materials (NOK 182,503,000).

Another financial advantage will ease the establishment of a deposit return system. A newly launched deposit return scheme will take two to three years to achieve a higher collection rate. One reason is that the consumers have to accommodate with the new scheme. It needs promotion to let them get used to the system. The objective effect is that the operating institution (in Norway’s case, Infinium) is receiving a microloan from consumers because the deposits they paid will become cash flow that needed to set up and develop the system. (Maldam, 2019).

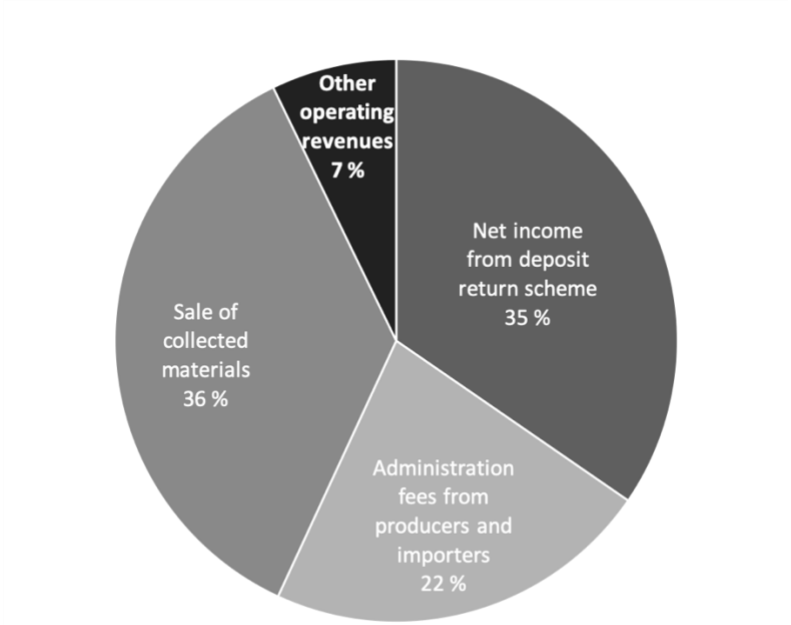

Figure 8 Composition of Infinitum's income, 2018

Is return-to-retail model applicable in Hong Kong?

The Norwegian deposit return system works as a return-to-retail model, which demands all retailers selling beverages bearing a deposit label to accept empty containers either via an RVM or a manual collection. Retailers receive handling fees in return. According to TOMRA, the world's eight best-performing container deposit schemes employ return-to-retail collection, with an average return rate of 93%. Regions without retail involvement achieve 77% of return rate averagely (TOMRA, 2019c).

The return-to-retail model could save costs for the whole establishment and operation of a deposit return system. Firstly, it avoids the need to construct new recycling stations because supermarkets and shops usually are located close to residential areas with good infrastructure. It reduces the time to launch the return schemes fully as well. Secondly, retailers' market network may be utilized to reduce logistic costs. Retailers have truck access to even remote areas. They could mobilize the trucks efficiently that suited them best or employ backhauling to transfer the returned containers to their central warehouse.

For retailers, a return-to-retail could bring them several benefits. Firstly, it increases footfall by the visit for returning containers. In Norway, people will get a receipt which could be cashed out from cashiers or use it to pay for the merchandise. The procedure of cashing out encourages the returners to go for an additional shopping trip. Secondly, retailers may receive reimbursement for capital investment and operational costs. When the initial investment is recovered, like RVMs installation, the reimbursement could be revenue for the shops. Lastly, retailers who join the deposit return schemes may build their brand images by presenting their corporate social responsibility, which supports an environmental-friendly initiative. Therefore, retailers can fulfil their environmental responsibility while gaining benefits for receiving deposited containers.

Whether Norway's return-to-retail could be fully copied in Hong Kong, a positive answer is unlikely. Hong Kong needs adjustments if it is going to implement a deposit return scheme. The respondents raised concerns, such as limited storage space, high business costs, and logistics issues. Flexibility will be needed for different types of retail stores. Tiny and small retailer shops can opt-out to be collection spots. Hong Kong's retail stores selling beverages consists of three main types, supermarkets, small grocery shops, and tiny roadside newsagent's shops:

- The roadside newsagent's shops usually sell bottled beverages along with paper publications. They would be too small to store the empties. These roadside newsagent's shops would be excluded from the collection sites due to the limited storage space and security issue.

- Small grocery shops, including convenience stores (e.g. 7-eleven and Circle K), could be encouraged to join the scheme by reimbursement. Any they could decide if they will be a collection spot or opt-out from it. If they join, they can choose whether to install an RVM or to implement a manual collection. As the RVMs information provided by TOMRA, the two models of RVM's dimensions are 1913 mm (Height) x 950 mm (Width) x 854 mm (depth), and 1797 mm (Height) x 1293 mm (Width) x 1040 mm (depth). They are approximately equal to the size of the usual beverage vending machines. Most of the small retail shops' storefront shall be able to accommodate an RVM at these sizes. When these small grocery shops find that their storefront is not suitable to install an RVM, they

could choose to accept manual collection. A challenge for small grocery shops will be limited storage space. Frequent transport will be needed.

- Among the three main types of retail stores, supermarkets should have the highest potential to accommodate the deposit return scheme as the Norwegian chain supermarket. It is because chain supermarkets (e.g. Wellcome Supermarket and ParknShop) which operated by giant corporations, usually own relatively large areas of storefront and back warehouse.

Hong Kong can probably not implement a pure return-to-retail model. Involvement of non-retailers will be needed. In June 2019's number, Hong Kong has 2,189 supermarkets or convenience stores (HKSAR, 2019d). This number is less than the total number of collection spots in Norway. Besides, some convenience stores are unavailable to be collection spots due to limited space. Shopping malls, public facilities (such as sports centres, public libraries, schools and colleges), community green stations are sites which have high potential to install RVMs. Either private bodies or government departments manage these venues. They usually are close to the residential area. Vending machines selling beverages are commonly installed. If they could install at least one vending machine, they are likely to have space for one small RVMs. Non-retail collection spots in various private and public facilities will be needed to support a deposit return system.

The deficiency of these non-retail collection spots is that they are less convenient to clear and transfer the empties for temporary storage than retail stores. Therefore, frequent clearance and collection by the deposit return organisation will be needed instead. For instance, if the venue managing parties do not offer extra storage space, the deposit return organisation has to co-ordinate the pick-up in each several days according to the filling speed of the location.

The government may provide subsidies to the deposit return organisation. Norway's deposit return organisation does not receive subsidies from the government. However, subsidies can ease the challenges from spatial limitation and high business rent and the subsequent frequent transport. The subsidies can advance reimbursement to attract private management companies and private organisation to join the collection network. Since the deposit return system will redirect the PET bottles waste from the state's municipal waste treatment to the recycling

stream, theoretically it will save the government's expense in municipal waste treatment. The government subsidising the deposit return organisation will be justified.

The deposit return format could include immediate electronic payment, for instance, the popular local electronic payment platform Octopus. Octopus card system has been used in Hong Kong's mass transit system and shops for a long time. One of the beverage manufacturer-initiated schemes, Tap, Return & Earn, is featured with cash rebate via Octopus payment.

The drawback of immediate payment vis Octopus card is that the retailers may lose the opportunity to attract people cashing out at the cash desks. The chain supermarkets and convenience stores could provide more rebate options. For example, customers may choose to receive the returned deposit via their membership card or cash vouchers, as another option upon Octopus card.

Responses to the perceived challenges

As presented in Chapter 2, practical concerns exist among the Hong Kong industrial stakeholders. Chapter 4 introduced the practical experience from the key players in Norway's deposit return system. Table 19 summaries the response to the perceived challenges in Hong Kong according to the Norwegian experience.

Table 19 Response to the perceived challenges

Perceived challenges in Hong Kong[7]	**Response according to the Norwegian experience**
Returning Fraud	- Barcode registration with return rate monitor. Close to or more than 100% will be suspicious cases. - TOMRA's RVMs can read the containers' attributes (length, width, shape, and material)
Dilemma of deposit value	- Set up a non-profitable institution, which owned by producers and retailers
Return jam and Long processing time	RVMs are capable to process quickly: - TOMRA's RVM model T-70 can detect up to 45 containers per minute - Model TOMRA R1 can process up to 140 containers per minute. TOMRA R1 is a multi-feed RVM allowing returners to pour a bag of containers (at least 100) at once. It will be suitable for Community Green Stations, where waste pickers may return a bulk of collected bottles often.
Overwhelming number of foreign bottles	- Importers are encouraged to join the Infinitum system by the environmental tax - The membership fee should be set at an affordable rate
High business costs	- Retailers can receive reimbursement when being a collection point
High Transportation cost	- Volume is an advantage to be cost-effective - Utilise backhauling
High number of RVMs required	- Approximately 3,700 reverse vending machines are in Norway, and total 12,000 collection points over the country (Infinitum, n.d.-a) - In June 2019's number, Hong Kong has 2,189 supermarkets/Convenience stores, and 2,231 bread, pastry, confectionery and biscuits (HKSAR Government, 2019d). Hong Kong is a denser region with less storage spaces in the retailer stores. More transport is expected to be needed.
High administration costs for deposit return system	- Deposit system incurs extra administration costs, but it also brings in income - Administration costs occupy a limited role in the total costs of Infinitum - The initial accumulated unredeemed deposit serves as a micro-loan which could be used to develop the system

[7] See also Section 2.4.4. - Potential challenges for deposit return systems

6. Conclusion

Close to the end of the second decade, we are in a global battle against plastics waste. Local efforts in each region are crucial to fight in the waste war. This thesis studied plastics waste management in Hong Kong. It started by understanding the plastics recycling status in Hong Kong. The plastics recycling rate has fallen since 2012 because of the local recycling deficiency and stricter import requirement of China, which was the major importing region for Hong Kong's plastics recyclables. Therefore, we need brand-new solutions to improve the city's plastics recycling.

In this research, I recognize that PET bottles are one of the prominent categories of plastics waste sent to landfills every day and that foreign cases of deposit return systems sound promising to deal with the pile of PET bottles waste. Norway is one of the countries achieves a high collection rate with deposit return system. Therefore, I investigated the Norwegian deposit return system as a means to provide alternative solutions to Hong Kong's waste problem. The cornerstone of Norway's deposit return system is the environmental tax on beverages packaging. This tax could be alleviated according to the performance of the deposit return system. As a result, beverage producers and importers are eager to join the deposit system for their cans and plastic bottles.

I found that applying the Norwegian tax-based policy framework is justified by Norway's achievement: high collection rate, good quality supply of plastic bottles and its financial sustainability. The total return rate for PET bottles was 88.6% in 2018. The returned containers must be empty and in good shape. Manual collection and collection via reverse vending machines (RVMs) exclude contamination from other waste. Bottles with different colours can be sorted out in plants subsequently. Clean and well-sorted bottles provide higher revenue for the recyclables market. A stable supply of high-quality PET bottles can both boost and sustain the development of local plastic recycling industry. It can also give confidence for investment.

Norway's deposit return system is at a financially sustainable stage, which recorded operating profits in the last four years. The operating expenses are covered by three pillars - the contribution from producers and importers, materials sale and unredeemed deposit. The

producers and importers have to pay administration fees for their products which joined the deposit system. In return, they could enjoy a reduction of payable environmental tax.

Feasibility of applying the Norwegian model has several dimensions. I explored three dimensions in order to see if deposit return system can be a solution for Hong Kong: (1) Are the policymakers capable of introducing the set of policies within the economic, social and political constraints? (2) Does the model fit into the local conditions that it could obtain the policy goals? (3) Will the policy cause any unpleasant outcome or side effect?

In answering question 1, I found that resistance may exist in imposing a new environmental tax, but the Hong Kong government has already faced less political challenges to introduce a beverage container return scheme than before. Multiple pilot RVMs schemes have been launched in recent years. As summarised in chapter 2, there are three RVMs schemes were launched by three leading beverages manufacturers. These manufacturers adapt to the recycling-concerned strategy. They see advantages to present a "greener" brand image because plastic bottles often are critiqued as environmentally unfriendly products. Before the Hong Kong government finish its assessment of introducing deposit return systems and RVMs, a commercial-manufacturer working group has already published its commissioned report. The working group is a proxy to represent industrial and commercial views and interests. They also advocate a reverse-on-return scheme for beverages in plastic containers. Therefore, the industrial and commercial sectors embrace more recycling and RVMs as solutions to plastic bottles waste.

Contrary to the argument by the working group, I argue that a deposit return system is more worthwhile to implement than a return value system. The industrial and commercial sectors incline towards a return value system instead of a deposit return system because they want to simplify the administration and save administration costs. In the analysis section, I revealed that the Norwegian deposit return system is financially sustainable, and the system's administration costs are not prominent. Firstly, a deposit return system will inevitably leave the unredeemed deposit as revenue. Secondly, the administration cost is not comparable to the total income of the deposit return organisation in the current. Lastly, a newly established deposit return organisation can take the unredeemed deposit as a cash flow to develop the system. Because of these reasons, costs are likely be covered by incomes. Considering that

depositing will encourage people to return their purchased beverages, a deposit return system is more worthwhile than a return value system if the government has to implement a return system for plastic beverage containers.

In answering question 2, I found that retail stores lack space to accommodate returned containers and RVMs, and therefore return-to-retail model is not feasible to replicate directly. The Hong Kong government needs higher engagement with the deposit return system. The Norwegian model belongs to a return-to-retail model, requiring all retailers selling beverages bearing a deposit label to accept back empties. It works well in Norway because it mutually benefits the retailers and the deposit return system. Retailers provide manpower and space to help collect the back empties in return of extra footfall and reimbursement. However, Hong Kong has spatial limitations. I suggest that tiny and small retailer shops can opt-out to be collection spots. Large retailer stores which sell beverages must receive back empties or accommodate RVMs for return. The rationale is that the chain supermarkets are selling a high number of beverages and can bear the responsibility of accommodating the collection spots. The exact threshold for defining "large" could be defined after surveying the range of chain supermarket sizes.

Based on the analysis, I suggest the following adaptation for implementing a deposit return system in Hong Kong:

- The small retailer stores can opt-out from joining the collection network, but the large retail stores and supermarkets selling beverages should be obligatory to join the network.
- Collection spots beyond retail stores shall be established, such as shopping malls, public facilities (sports centres, public libraries, schools and colleges), and community green stations.
- The government may provide subsidies to the deposit return organisation thus, the reimbursement can be reinforced. In Hong Kong, higher reimbursement will be needed for private collection spots to cover their rent and business costs.
- The rebate should include immediate electronic payment and retailers' vouchers for cashing out. Donation to charities can be included as an alternative.

In exploring the final dimension presented by question 3, I found that most of the challenges could be handled with reference to the Norwegian experience. The end of chapter 5 summarised the potential challenges and responses according to the Norwegian experience. TOMRA's RVMs models show that there has been a significant advancement in RVMs' technologies, for instance, the multi-feed RVM model TOMRA R1 developed by TOMRA. This is a milestone for application of RVMs because it reduces the time for return in bulk significantly. Having a machine also enables street-bottle collectors to recycle. Today, RVMs can process empties quickly and accurately. The processing time of a machine is up to 140 containers per minute. The machines also can read the containers' attributes such as length, width, shape, and material. RVMs technologies have been improved and will continue to improve, that supports for adaptation of deposit return system in Hong Kong.

A potential drawback of deposit return system is returning fraud, which has to be subjected to scrutiny. Fraud may happen when people intentionally copy labels for unregistered bottles. Only registered bottles should be accepted for return because it has to prevent unqualified plastics from mixing in and prevent money from leaking out from the deposit pool. Unregistered PET bottles may contain other material ingredients. For instance, Infinitum has a strict quality control for the PET bottles in registration. Unregistered PET bottles mixing with registered bottles is in the risk of contamination and downgrading the quality of the recyclables. Meanwhile, deposit pool leaking out, which happens when undeposited bottles are redeemed, will damage the financial sustainability of the deposit return system. The deposit return organisation may suffer from a deficit when the fraud is severe. Since Mainland China is near Hong Kong, a high amount of rebate may attract "grey goods" traders to return Chinese empty bottles with fake labels. This kind of fraud has to be monitor by the deposit return organisation to see if there is any abnormal return statistics. The amount of rebate per bottles also has to be decided thoughtfully with caution to the consequence of fraud.

In summary, the Norwegian model is a success story with two decades of experience. The largest challenge for Hong Kong to apply the Norwegian model will be placing "the stick" before the "the carrots" – introducing a new environmental tax. This depends on local political wills and resistance. However, because a pure return-to-retail model may not be feasible for Hong Kong, small retailers should be able to opt-out as collection spots. Instead, the Hong Kong government needs to support the deposit return institution with monetary

subsidies and provision of collection sites by public facilities. Besides, RVMs technologies have matured and brought convenience to the returners. Overall, introducing a deposit return system is a promising and feasible measure for plastic bottles waste management in Hong Kong.

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Appendices

Appendix 1: Interview guide for Community Green Stations

1 What are the considerations in determining the types of plastic to be collected? (If the Station acts according to the requirement from the Environmental Protection Department (EPD), what are their considerations?)

在訂立所決定收集的塑膠種類時，其考量是甚麼？（假如是按照環保署所提供的指引，他們的考量是甚麼？）

2 How effective is the reward scheme? How do you decide what kind of gifts as rewards? Do you think material rewards are more effective than monetary rewards?

獎勵計劃的成效如何？你們在選擇獎勵物品方面有甚麼考量？你認為獎品會比金錢獎勵更有效嗎？

3 What are the advantages and challenges for an NGO to operate a community green station?

你們認為以非政府組織（NGO）的身份營運社區回收站的優勢，及難處是甚麼？

4 If the Hong Kong Government were implementing a **central plastic collection system** and a **reverse vending machines system for plastic beverage bottles** in the future, what do you expect and suggest the roles and functions of Community Green Station to be?

如果未來香港政府推行中央收集塑膠和逆向膠樽回收機系統，你們預期和期望「綠在區區」的角色和功能是甚麼？

Appendix 2: Interview guide for operators in recycling sectors in Hong Kong

1 How are the plastics waste recycled in Hong Kong?
香港的塑膠垃圾是如何回收？

2 What are the difficulties in plastics waste recycling in Hong Kong?
在香港塑膠垃圾回收的困難是甚麼？

4 How does the stricter waste import requirement of China affect the plastic recycling in Hong Kong?
中國收緊廢物進口要求，其如何影響香港的塑膠回收？

3 Do you think if it is feasible to apply deposit return systems for plastic bottles in Hong Kong? What will be the challenges?
你認為在香港引入膠樽按金回收制度可行嗎？將會有甚麼挑戰？