

Managing Waste with a Waste Trading System

Work-in-Progress

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Motivation

- Landfill waste externalities: soil, air, water pollution, nuisances, etc.
- Growing importance of waste management, especially in large and dense urban areas
- Need for tailor-made regulation for waste sorting and reduction
- Application to the case of Hong Kong



Hong Kong Landfill
Credit: Bloomberg

Research Question

- 1 What is the potential of a Waste Trading System for Municipal Solid Waste Management?
- 2 How would it be characterized?

Cap and Trade approach for waste management: a barely explored policy

▶ Lit. Review

→ In Practice ▶ Contemporary approach

- Packaging Recovery Note in the UK (Hansjürgens, Antes, and Strunz 2011; Walls 2006; Vaudey and Glachant 2007; Mayers 2007)
- Waste-to-Energy in Australian carbon market Australian Waste Policy Action Plan
- New Zealand ETS includes Waste sector Waste sectors covered by the ETS, NZ Climate Response Act
- Incineration in EU-ETS for 2026 Euractiv, 2023

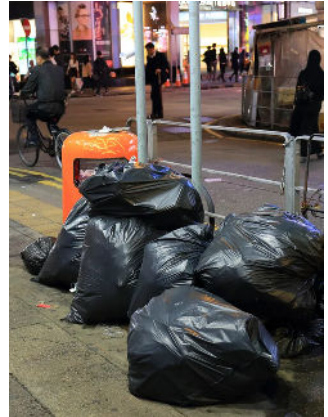
→ In Literature

- *New areas for the application of tradable permits: solid waste management*, Salmons 2002
- *Tradable Permits without Legislative Targets: A Review of the Potential for a Permit Scheme for Sterilized Clinical Waste in the UK*, Bailey, Haug, and O'Doherty 2004
- *If invisible carbon waste can be traded, why not visible construction waste? Establishing the construction waste trading 'missing market'*, Peng, Lu, and Webster 2022

Condition Favoring a Cap-and-Trade

- situation-related advantages
 - With uncertainty and urgency: give certainty on pollution level (Weitzman 1974)
 - Cost-benefit analysis
 - Variety of abatement costs: cost-effectiveness
 - Role of Property Management Companies

- Endogenous conditions: market power, transactions costs, etc.



Credits: Wilson Hui

Waste Trading System Design

▶ L.R. Design



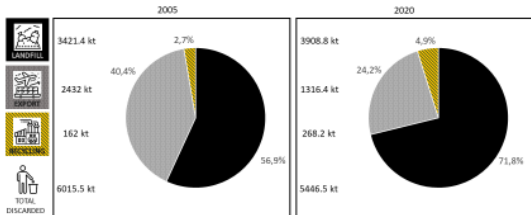
Waste issue in Hong Kong

▶ MSW Chain

▶ Landfill loc.

▶ Waste Volumes

▶ Waste policies



Hong Kong waste management strategies



A Hong Kong landfill in 2013.

Source: SCMP

- **High land costs from landfilling:** space scarcity, saturation of landfills, export difficulties (Operation Green Fence)
- **Lots of infrastructures but no sorting from citizens:** extra costs, psychological barrier, lack of education (Chung and Poon 1994; Lo and Liu 2018; Yau 2010)

Method and Data

▶ Price vs Quantity

▶ BAU Assumptions

▶ MDC Assumptions

▶ MACC Assumptions

→ Following Weitzman (1974), we compare the relative slope of the marginal damage and abatement costs curves:

- $D(L_\rho) = P_c(L_\rho) + SCC(L_\rho) + K_c(L_\rho)$
- $CE_i = \frac{NPC_i}{RP_i}$

- Fixed time period: 2020-2047,
- Data: government data from 2000 to 2021, and extrapolation.

- Biggest assumption: citizens' rationality

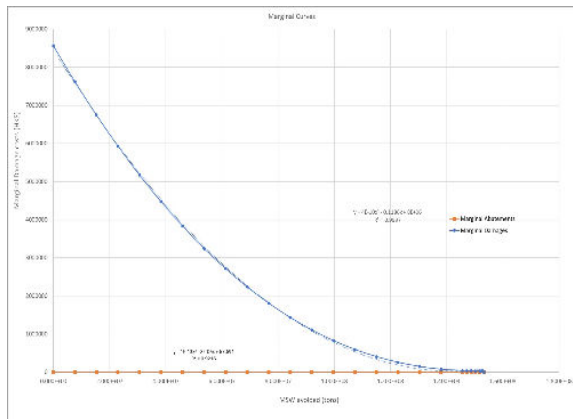
Results: A high potential for Cap and Trade in HK

▶ MDC

▶ MACC

▶ Empirical Results

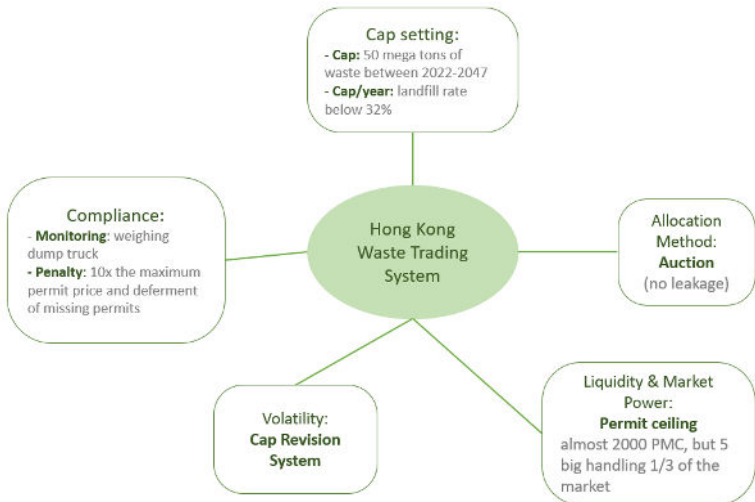
- Little need for additional infrastructure (1 OPark)
- $\rho^* = 0.68$
 $a' = 314$ HK\$/ton
- Current Tax
 - Gate fee: 365 HK\$/ton
 - Bags: 228.69 HK\$/ton
(Conversion rates, HK MSW Charging)



Discussion : Hong Kong WTS Design

▶ Monitoring

▶ Penelaty



Contribution and Conclusion

The Waste Trading System approach

- May be efficient for large and dense urban areas,
- Property Management Companies should bear the obligation,
- Need an efficient monitoring and non-compliance penalty,
- Could be suitable for Hong Kong situation.

Limitations and further researches

- Additional administration costs and possible volatility,
- Effects on households utility to be studied,
- Further research on the reduction of waste amount up-stream.

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Contemporary prevalence of CAC and Tax-based approach

▶ Cap and Trade approach

▶ L.R. Sorting rates

Existing MSW policies and recovery rate in 2015

Country	MSW recovered	Separation	Bans	Recyc. target	Restriction	PPP	EPR	DRS
Hong Kong	35%	0	0	1	0	0	1	0
Japan	89.90%	1	1	1	1	1	1	1
Germany	56.10%	1	1	1	0	0	1	1
Taiwan	55%	1	0	0	0	1	1	1
Korea	53.70%	0	1	1	0	1	1	1
Austria	53.60%	1	1	0	0	0	0	1
Switzerland	49.70%	1	1	1	0	1	1	1
Italy	49.70%	1	0	1	0	1	1	1
Belgium	49.40%	1	1	1	1	1	1	1
Netherlands	46.30%	1	1	1	1	1	1	1
Slovenia	45.60%	1	0	1	1	1	0	0
UK	44.50%	1	1	1	1	1	1	0
France	39.60%	1	1	1	0	0	1	0
Singapore	30%	1	0	1	0	0	0	0

Sources: OECD (2021); EEA (2016, 2017). PPP: Polluter pays principal; EPR: Extended Producer Responsibility; DRS: Deposit Return Scheme.



Additional literature ▶ CAC & Tax approach

- Waste Trade - Leackages: Bernard 2015; Khan 2020; Copeland 2001; Barrie and Schröder 2022
- Arguments in favour of limited time frame to increase efficiency of cap and trade: Lange 2012; Kling and Rubin 1997; Montero 1998; Malueg and Yates 2009; Narassimhan et al. 2018; Kang and Létourneau 2016
- Reduce generation of waste is hard – it is easier to increase sorting for consumers: Chung and Poon 2001; Chung and Poon 1999; Roustta et al. 2017; Minelgaité and Liobikienė 2019
- Japan citizens and sorting rate: Kinnaman, Shinkuma, and Yamamoto 2014; Hotta and Aoki-Suzuki 2014; Tanaka 1999



Comparing Policy Tools: A Literature Review

▶ Market-Based Approach

Command and Control (CAC) versus Market-Based Instrument (MBI)

- CACs not suitable when **uncertain costs and damage** function (Hepburn 2006; Acuff and Kaffine 2013; Pearce and Turner 1993; Goddard 1995; Hettiarachchi et al. 2018);
- Social **acceptability** (Barragán-Beaud et al. 2018; Hong 1999; Wan, Shen, and Yu 2014; Tsai et al. 2020; Wan, Shen, and Yu 2015).

Price versus quantity

▶ Price vs Quantity

- Weitzman theorem (Weitzman 1974; Adar and Griffin 1976; Fishelson 1976);
- Extensions for error-correlation (Stavins 1996) and time-correlation (Newell and Pizer 2003).

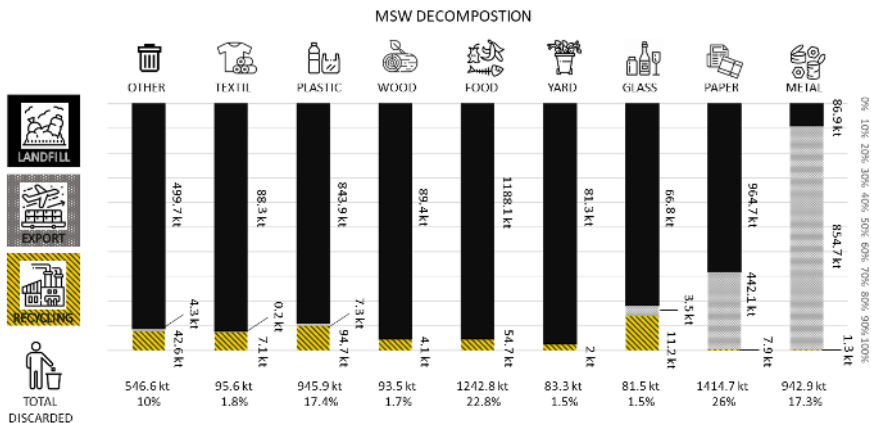
Literature about Waste Trading Design

▸ Waste Trading System Design

- **Definition of the cap:** on the targeted agent, see Montgomery 1972, Vaudey and Glachant 2007. On time flexibilities, see Weitzman 2020.
- **Allocation method for the permits:** On output-based, see Meunier, Montero, and Ponsard 2018.
- **Liquidity and Market Power:** On market power from State-owned companies on the CH-ETS, see Munnings et al. 2016.
- **Volatility:** On the necessity to adapt the cap, see Kollenberg and Taschini 2016. On the MSR, see Quemin and Trotignon 2019.
- **Compliance:** On the need for an efficient penalty, see Schaeffer and Sonnemans 2000 and Yan et al. 2020. On the penalty in case of linkage, see Haites et al. 2001.

Volumes per types of MSW and management

Waste in Hong Kong



MSW main streams and their types of management in 2020

Source: Environment Bureau 2021 - Data are provided by the HK government, which seems to be the main and only stakeholder that possesses data on current MSW situation.

A debatable current strategy ▶ MSW in HK

→ Infrastructure isn't everything

→ The Government strategy:

- Waste targets ▶ Targets
- Education campaign ▶ Poster
- Voluntary Program on Source Separation of Waste
- Tax garbage bags (0.013€/L)



Hong Kong MSW charge trial fees *Source: EPD (2021)*

HK and China Pollution targets

▶ HK waste management

▶ Hong Kong Strategy

China & Hong Kong pollution reduction targets

Area	Type of pollutant	Target	Ref. Year	Target Year	Pub. Year	Source
HK	MSW per capita reduction	-40%	2011	2022	2013	EPD 2020
HK	MSW absolute reduction	-40%	not mentioned	2035	2021	ENB 2030
HK	MSW recycling intensity increase	+55%	not mentioned	2035	2021	ENB 2030
China	MSW reuse intensity increase	+60%	2015	2025	2020	CIRCULARONLINE 2020
HK	CO2 intensity reduction	-65-70%	2005	2030	2016	ENB 2030
HK	CO2 absolute reduction	-26-36%	2005	2030	2016	ENB 2030
HK	CO2 per capita reduction	-3.3-3.8 tons	2005	2030	2016	ENB 2030
China	CO2 intensity reduction	-60-65%	2005	2030	2015	ORG 2020

Notes: Only targets which refer to MSW and CO2 are presented here. "Ref. Year" stands for the year taken as reference for the target. "Pub. Year" stands for the publication year when the target was publicly announced.

Education campaign

▶ HK waste management

▶ HK strategy

▶ L.R. policies comparison



Hong Kong education campaign
Source: EPD (2019)

Return vending machine for sorting plastic bottles

▶ HK waste management

▶ HK strategy

▶ L.R policies comparison



Return vending machine in Hong Kong

Source: EPD (2023)



Reusable container machine

▶ HK waste management

▶ HK strategy

▶ L.R policies comparison



Reusable container Machine in Hong Kong
Source: EPD (2023)

Conservative Assumptions for the BAU

[▶ C/B analysis](#)[▶ Results](#)

- Demographics: decreasing - expectations based from US gov. updated in 2022 (post covid)
- MSW Generated /Capita: constant = $0.89\text{ton}/\text{inhab.}$
- Total MSW Generated in 25 years = $1.53 * 10^8\text{ tons}$
- Current capacities of Recovery facilities = $9.78 * 10^7$
- Recovery facilities efficiency rate = 0.8%
- Fixed time-frame from 2022-2047
- Exportation: constant volume and prices
- Land cost: - 6%
- Discount rate: 3% (Gollier)
- All money flows from HK gov.

Assumptions MD

[▶ C/B analysis](#)[▶ MACassumption](#)[▶ Results](#)

The following assumptions are taken for the calculation of the MDC :

- Land cost: - 6% which is conservative according to current trend (According to Bloomberg¹, in 2022, housing market already dropped by 8% and was expected to drop by -20% next year)
- Social cost of CO2 emissions : trends from the US gov.
- Health cost: following trend for social cost of CO2 emissions
- Capital costs for new landfills: step function, real current price
- Discount rate: 3% Gollier 2016

¹bloomberg.com visited on October 15, 2022

Assumptions for the MACC

▶ C/B analysis

▶ Results

Tech.	Full capacity (10 ³ ton)	Total additional costs (10 ⁶ HK\$)	Marginal Cost of abatement (HK\$/ton)	Sources
Opark	4425.625	3350	757	LegCo website & Opark website
EcoPark	8103.157493	8819	1088	HK Gov website & Greening HK website
Ipark	26553.75	40223	1515	SCMP website & EPD notice
Ypark	531	2013	3790	EPD website & EPD notices
WEEEpark	728	3727	5123	WEEE park website

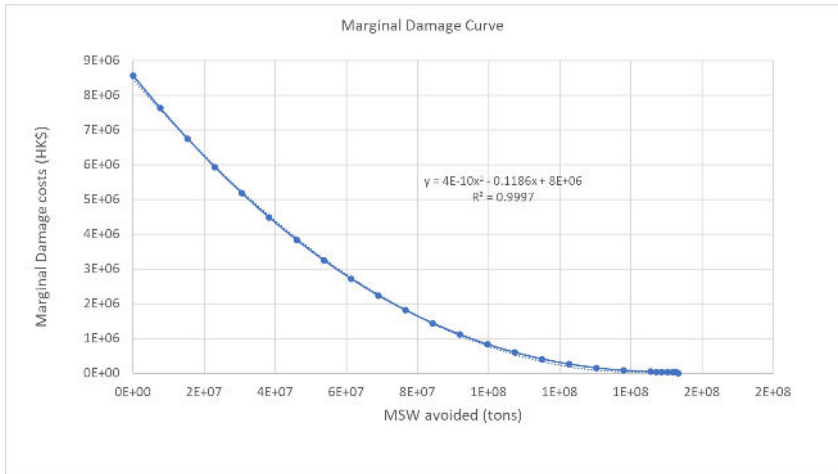
- Recovery facilities : 80% of max. efficiency
- Need for new facilities:

- OPark = 3
- EcoPark = 3
- IPark = 1

Marginal damage curve / Marginal benefit curve

▶ Results

▶ Assumptions



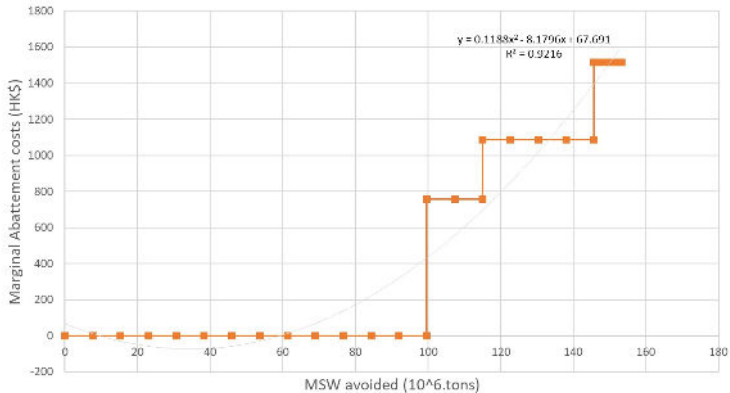
Marginal damage Curve of Hong Kong

MACC

▶ Results

▶ BAU assumptions

Marginal Abatement Curve



Marginal Abatement Costs Curve for Hong Kong

Empirical Results ▸ Results

Results from empirical analysis in Hong Kong for 2022-2047

Variable	Symbol	Optimal value
MSW Generated	W	1.53E+08 tons
MSW Landfilled	L*	4.95E+07 tons
MSW Recovered	R*	1.04E+08 tons
Recovery rate	ρ^*	0.68
Abatement cost*	a'*	314 HK\$
Additional Facilities needed	OPark	2

→ Target of the obligation: Property Management Companies = owners and/or managers of the building. They are already in charge of gathering waste, as a by-product of their activity.

Strong monitoring ▶ HK WTS Design



Hong Kong sorting containers being monitored.

Photo by J. Metta in 2019



Non-compliance penalty ▶ HK WTS Design

→ What the literature says:

- Key for the efficiency of an ETS: need to be high and symbolic (Yan et al. 2020);
- In case of linkage: penalty (M_i) \geq abatement cost (M_j) (Haites et al. 2001).

Potential penalty

To be efficient in Hong Kong, we can imagine a penalty of the form: fine + deduction of shortfall permits from next allocation period. The fine could be ten times the permit price.