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Social Cost Accounting Method of Municipal Solid Waste Landfill Disposal and Application in Beijing

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Introduction

- **The production of municipal solid waste in China has experienced a steady increasing trend, amounting to a high level.**
  - **The total amount** of municipal solid waste **in China increases from 118 million tons in 2000 to 171 million tons in 2012**.
  - **In Beijing, the amount of waste generation reaches to 1.0 kg per day per capita in 2012**, whereas the figure in Taipei City has been declined to 0.37 kg.
- **The responsibility is much more evident to dispose these wastes for local governments, indicating more public fund should be used in this area.**
  - The steady increase of total amount of wastes, more tight discharge standard for disposal facilities, and soaring labor costs.

Introduction

- This present work first defines the entire physical processes and the management content and standard of each process. Based on market prices, it then calculates social cost of municipal solid waste disposal by taking Beijing city as a case study.

- The purpose of this study is to reveal the actual social resources used by waste disposal, provide enough cost information for society waste management, and correct the biased awareness of the public to facilitate waste classification.

Introduction

- **There are extensive studies regarding cost accounting of municipal solid waste. It's relatively mature in calculating the cost in other countries. Considering the differences in management system and discharge standard between China and other countries, cost accounting model including cost definition and classification in China is different from that used in other countries.**
  - For example, Lohri(2014), Debnath(2014), Kinnaman(2014), Fiorucci(2003), and Costi(2004).
- **Domestic studies on cost accounting of municipal solid waste are preliminary. These studies did not define entire cost from the social perspective and did not use market prices, making the results less credible. Besides, the data sources of existing studies are typically lack of explanation.**
  - Such as Chen(2002), He(2010), and Ge(2011,2012).

Introduction

- **Why does this work choose Beijing as the case?**
  - Beijing: large-scale urban size, massive amount of domestic wastes, severe challenges in waste disposal.
  - Domestic wastes management in Beijing can be a model for metropolis and satisfactory cost control in capital city will have a demonstration effect for other cities.

Theoretical background

Definitions

- municipal solid waste disposal
  - Delivering the solid waste from public garbage bin to closed storage station in residential community, then to transfer station, and finally to sanitary landfill or incineration to get them disposed without pollution.
- social cost of municipal solid waste disposal
  - The social costs refers to direct and indirect costs the society paid for municipal solid waste disposal. It includes public expenditures toward waste disposal and implicit costs that immune from market transaction (e.g., land cost).
  - Note: the whole country of China has the property right of urban land. Thus, urban land is controlled by local governments in China. Waste disposal belongs to public service and its land use is usually allocated by local governments for free.

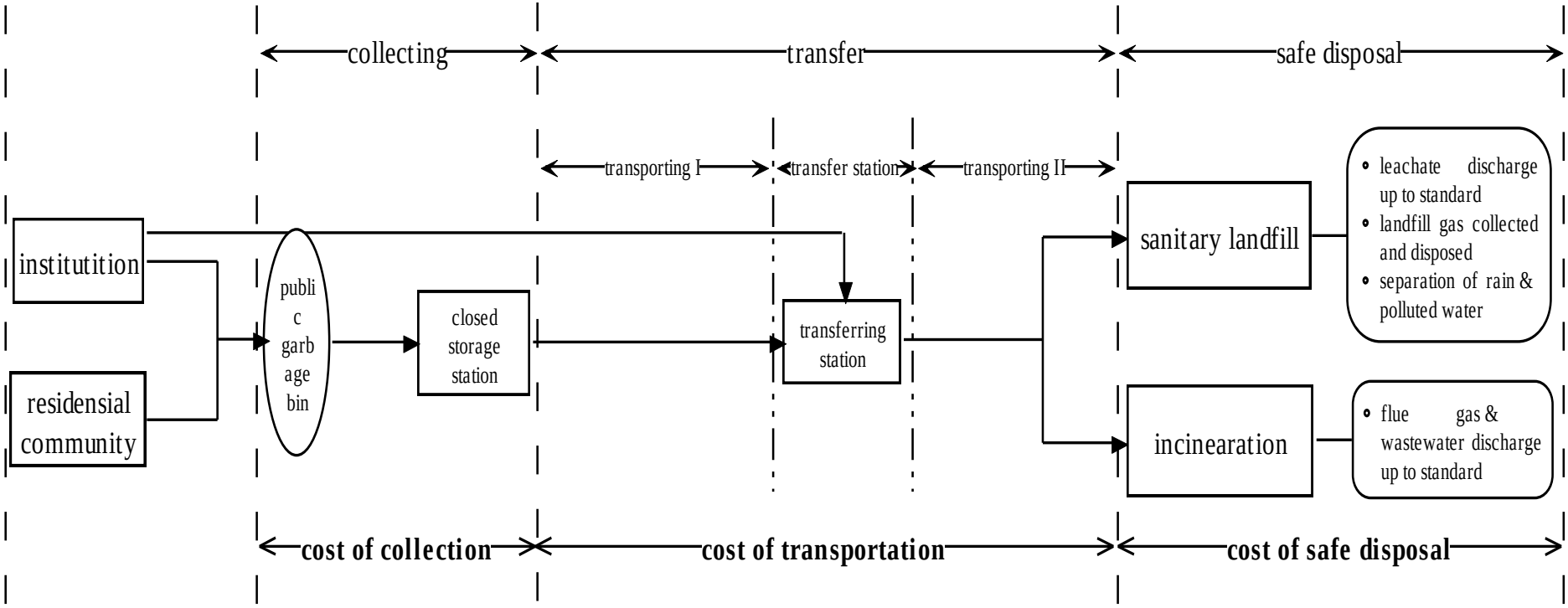
Theoretical background

- **Waste classification**
  - kitchen waste, recycling waste, non-recycling waste, we estimate the non-recycling waste disposal social cost
- **Considering the amount of sanitary landfill disposal in Beijing accounts for 70% of the total, we only calculate the social cost of waste flowing into landfills.**
- **According to household waste management processes, we classify the social cost into collecting cost, transferring cost, and sanitary landfill cost.**

Methodology

Cost classification

- Construction cost (fixed cost) and operation cost (variable cost)
- Explicit cost and implicit cost (construction land cost of landfill, transportation cost)



Methodology

- Reckon the depreciation cost of fixed asset by equally annual allocation method with the net salvage accounting for 4% of the original value.
- Estimate the land cost of solid waste disposal by opportunity cost method, and we use the commercial land price to reflect the opportunity cost of land.
- Evaluate the transportation cost using market price, getting the data by telephone interview of logistics companies.

Methodology

Table. 1 Municipal solid waste management costs of all processes

Management processes	classification	Cost detail		Calculation methods
collection	Collecting cost	Public garbage bin cost		Fixed assets depreciation method
		Trucking cost	Fixed cost (vehicle equipment depreciation)、variable cost (such as maintenance of insurance and labor cost)	Fixed assets depreciation method
		Closed storage station cost	Fixed cost (infrastructure construction depreciation, land cost), variable cost (such as labor cost, charges for water and electricity, insurances, cleaning and maintenance fees)	Fixed assets depreciation method, opportunity cost
transportation	Transferring cost	Transfer station cost	Fixed cost (infrastructure construction depreciation, land cost) , variable cost (such as labor cost, expenditure on power, material cost)	Fixed assets depreciation method, opportunity cost
		Trucking cost	Transportation cost I and II	Market price substitution
Sanitary landfill	Sanitary landfill cost	Fixed cost (infrastructure construction depreciation, land cost) , variable cost (such as labor cost, expenditure on power, material cost)		Fixed assets depreciation method, opportunity cost

Results

Collecting cost

- Case selection: Fuwaixili Community
  - Area: 1292 thousand m^2
  - Population: 6159
  - Amount of non-recycling municipal solid waste: 1168 ton per year
  - 38 public garbage bins for non-recycling municipal solid waste, one for 162 residents on average
  - Wastes are collected by closed electric trucks.
  - Closed storage station is together with a set of lifting equipment located in the residential community, whose area is 140 m^2.

Results

Table. 2 Calculation specification and accounting results of collecting cost

Cost types	Cost details	Calculation specifications	Total cost (yuan per year)	Unit cost (yuan per ton)	Percentage
Public garbage bin cost	Public garbage bin fees	280 yuan per one, 38; replacing once a year	10640	9.1	1.3%
	stainless steel protection cost	3500 yuan per set, 38; replacing every 5 years	25536	21.9	3.0%
	stainless steel protection cleaning fee	60 yuan per year every one, 38	2280	2.0	0.3%
Trucking cost	Electric truck cost	90 thousand yuan for one, 3 trucks; using for 10 years	25920	22.2	3.1%
	Maintenance cost and others	Battery cost (9000 yuan per year), maintenance fee 500 yuan per year, others 1500 yuan per year	11000	9.4	1.3%
	Labor cost	10 workers, 1380 yuan per month for one worker, welfare 7064 yuan per year for one worker	236240	202.3	27.8%
Closed storage station cost	infrastructure construction depreciation	lifting equipment's price 90 thousand yuan per set; using for 14 year	6171	5.3	0.7%
	Land cost	Commercial land price in Beijing in 2011 is 12787 yuan /m^2, use for 40 years	44755	38.3	5.3%
	Operation and maintenance fee	Wages, charges for water and electricity, insurance, cleaning and maintaining fees	486744	416.7	57.3%
total			**727.2**		

Results

Transferring cost

- Transfer station cost
  - Datun transfer station situation
    - Area: 9667 m^2, service for Dongcheng district, Xicheng district, Chaoyang district (including Fuwaixili community), its total investment is 104.170 million yuan, design transfer capacity is 1800 tons per day
    - If it services for 20 years, the infrastructure construction depreciation is 7.6 yuan per ton.
    - According to the closed storage station' s land cost calculation method, land cost of transfer station is 4.7 yuan per ton.
    - Operation cost：39.1 yuan per ton
    - Transfer station cost is **51.4** yuan per ton in total.

Items	Labor cost	Power cost	Material cost	Technical fee	Repair fee	depreciation	Asset tax	Management cost
Cost (yuan per ton)	19.3	1.8	1.4	4.8	4.3	1.7	1.4	4.4
Percentage(%)	49.3	4.7	3.5	12.4	11.1	4.3	3.5	11.2

Results

Trucking cost

- Considering that solid wastes from different communities are transported by various ways and distances, we use average distances to calculate transportation cost based on average distance to Datun transfer station (I) and Datun transfer station to Asuwei sanitary landfill (II).
- The centers of Xicheng district, Dongcheng district, Chaoyang district from Datun transfer station are 17.1 km, 10.9 km, 12.5 km, respectively, which means transportation I is equal to 13.5 km. Transportation phase II is 24.0 km, which is the distance between Datun transfer station and Asuwei landfill. So, the average distance of transporting municipal solid waste is 37.5 km.
- According to telephone interview of Debang Logistics company (large-scale), the trucking cost is 150.0 yuan per ton (price in 2012).

Results

Sanitary landfill disposal cost

- Asuwei is a large-scale landfill and accords to the discharge standard.
- Area: 604000 m^2, total investment 110 million yuan, designed life span for 17 years, disposal capacity of 2000 tons per day, undertaking the disposal responsibility of Dongcheng district, Xicheng district, and some commercial wastes in Chaoyang district, Shunyi district, Changping district (including Fuwaixili community)
- Infrastructure construction depreciation cost: 8.5 yuan per ton.
- Operation cost:110.0 yuan per ton
  - Material cost is the highest: 50.09%
- According to the closed storage station' s land cost calculation method, land cost of landfill is 264.5 yuan per ton.
- Social cost of sanitary landfill disposal is **383.0** yuan per ton.

Iitems	Labor cost	Power cost	Fuel and oil	Material cost	Technical fee	Repair fee	depreciation	Asset tax	Management cost
Cost (yuan per ton)	12.6	1.5	3.2	55.1	23.9	2.7	2.9	1.1	7.1
Percentage (%)	11.4	1.3	2.9	50.1	21.8	2.4	2.7	1.0	6.4

Results

Real price adjustments

- We adjust prices in different years to the comparable price in 2012.
- Considering discount rate is important in inter-temporal cost analysis, we choose 4% as the basic discount rate according to some studies such as Ma (2014).
- Meanwhile, we use Consumer Price Index to adjust the prices in different years due to inflation.
- The adjusted total social cost of municipal solid waste disposal is 1530.7 yuan per ton in total.

Cost types	Cost details		Unit cost (yuan per ton, current prices)	Original years	Unit cost (yuan per ton, prices in 2012)	Percent age %
Collection cost	Public garbage bin fees		33.0	2009	41.5	
	Electric truck cost		233.9	2009	293.9	
	Closed storage station cost	Infrastructure construction depreciation	5.3	2012	5.3	
		Land cost	38.3	2011	40.9	
		Operation and maintenance cost	416.7	2009	523.6	
	Sub total		727.2		905.1	59.1
Transfer cost	Transfer station cost	Infrastructure construction depreciation	7.6	2008	9.9	
		Land cost	4.7	2011	5.0	
		Operation and maintenance cost	39.1	2012	39.1	
	Transportation cost		150.0	2012	150.0	
	Sub total		201.4		204.0	13.3
Safe disposal cost	Infrastructure construction depreciation		8.5	1994	29.4	
	Land cost		264.5	2011	282.2	
	Operation and maintenance cost		110.0	2012	110.0	
	Sub total		383.0		421.7	27.6
Total			1311.6	2012	1530.7	

Discussion

- **Collection cost accounts for 59.1% of the total social cost; transfer cost takes up of 13.3%; and sanitary landfill disposal cost occupies 27.6%.**Collection and landfill costs are the primary part of the total.
- Collection process is labor-intensive. Its labor cost accounts for 36.5% of collection cost.
- **Land cost reaches to 328.1 yuan per ton, taking up 21.4% out of the total social cost. Thus, the cost of land resource can not be ignored.**
- **Based on statistical yearbooks, municipal solid waste disposal cost in Beijing is estimated only to 151.2 yuan per ton, which shares only 9.9% of the social cost, suffering from downward biases.**

Discussion

- **According to the total amount of municipal solid waste clean-up of Beijing and unit social cost in 2012, Beijing should pay for 9923 million yuan in municipal solid waste disposal, which occupies 2.1% of fiscal expenditure, and the average person affords 556.4 yuan per year.**
- **The social cost is so high that solid waste reduction is pressing in Beijing.**

Conclusion and implication

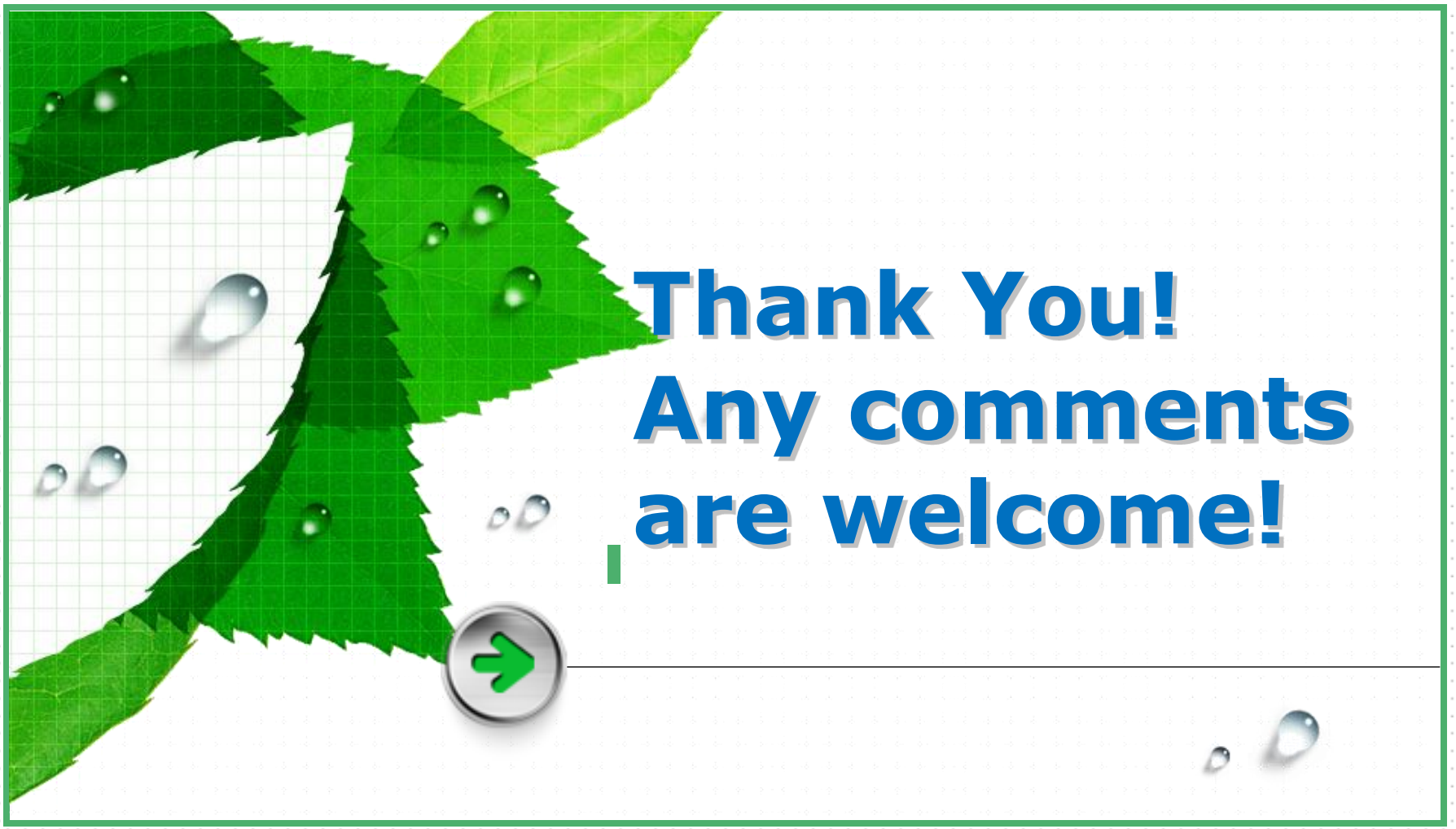
Conclusions

- **Social cost of waste landfill disposal in Beijing reaches to 1530.7 yuan per ton**
  - collection cost 905.1 yuan per ton, transfer cost 204.0 yuan per ton, and sanitary landfill disposal cost 421.7 yuan per ton.
- **Collecting cost is much larger than the middle transfer process and the end disposal costs.**
  - Collection cost, transfer cost, and sanitary landfill cost account for 59.1%, 13.3%, 27.5% , respectively.
- **Land cost takes 21.4% out of the total social cost, and the land resource** that used for solid waste disposal **can not be ignored.**
- **Beijing spends substantial expenditure on waste disposal with an average person affording 556.4 yuan per year.**

Conclusion and implication

Implications

- Cost estimated by statistics yearbook can not reflect the real social cost, misleading the public's understanding of waste disposal cost. The severely downward biased costs can not facilitate the development a sense of reduction and incomplete information blocks the reduction implementation.
- We put forward the following suggestions:
  - **Optimizing the social cost structure and cutting the total cost;**
  - **Paying more attention to source reduction and exploring reduction methods;**
  - **Establishing cost accounting system, and disclosing cost information to the public regularly.**


Thank You!
Any comments
are welcome!