

Master Thesis of Engineering and Public Policy

Analysis on Plastic Grocery Bag Policy in China

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Abstract

The main focus of the thesis is to obtain a comprehensive understanding of the impacts on environment of plastic bags through a life cycle assessment. Based on a literature review, the international experiences from Ireland, Bangladesh and Canada on plastic bags policies are addressed.

After 8 years implementation of plastic bags regulations, there are still existing some problems in China. The main purpose of the thesis is to present policy options on plastic bags policy in the context of China, including maintaining status quo, public education, substitutes developing, totally banning plastic bags, introducing plastic credits or a plastic bag tax. The recommendation is that public education is a persistent way to improve public awareness and to change consumer's behaviour. Additionally, for Chinese government, under the existing regulations, should extend the range of regulation implementation to farm markets and street vendor, which have been the main source of plastic bags consumption in China. Furthermore, research on reducing substitutes cost is essential, which could be accepted by more customers.

Keywords

Life cycle assessment, plastic bags banning, environmental impacts, public awareness

Introduction

As climate change is having significant impacts on our planet, human beings are encountering numerous environmental challenges and problems, such as global warming, glaciers melting, water pollution. In order to make our planet sustainable, everyone has responsibilities to find ways to solve or diminish these problems in our real life, not only because of our life dependency on conditions and quality of the environment, but also for moral reasons of responsibility for our next generations. The earth is over polluted and host of lands are covered by waste, even the oceans have been polluted by plastics and other harmful materials. ^[1]

Beyond that, scientists have compounded a large amount of artificial materials and chemical substances, which have no natural analogies. For this reason, it is difficult to make predictions about the degradation effects and the influence these substances would have on aquatic or ecosystem. ^[2] The influence of plastic on the ecosystems is the part topic of this thesis. Plastic is a material which is made from fossil fuels, natural gas. ^[3] Nowadays plastics have involved in our life everywhere and substituted many other materials for specific characteristics, such as being light-weighting, convenience, cost efficient, etc. Although plastics bring many advantages to our human-beings, they cause many potential problems for environment and eco-system, because plastic is very difficult to degrade in natural status. ^[3] For example, plastic bags are very dangerous to the wildlife and they are barriers for waterways and drainage system, which could destroy natural ecosystems. ^[4] In addition, plastic bags highly depend on oil, as it is the main raw material in plastic production. ^[3] Although all these disadvantages are known, plastic bags still have a large number of production and use.

Many studies have been conducted to evaluate the environmental effects of plastic grocery bags in many developed countries, such as Sweden, USA, UK, and some countries have taken actions to reduce usage of plastic bags, getting great effects eventually. Unfortunately, in many developing countries, problems from plastic bags are still not a public discussion. Chinese government has implemented the plastic bags policy since 2008, but the policy is not working as

expected. Street vendors and farm markets, which make up a significant portion of retail in China, do not abide by the policy in part due to difficulties of enforcing the policy. ^[5]

The main focus of the thesis is to obtain a comprehensive understanding of the impacts on environment of plastic bags through a life cycle assessment review. Based on a literature review, the international experiences on banning plastic bags are addressed. The main purpose of the thesis is to present recommendations on plastic bags policy in the context of China.

Literature Review

Life Cycle Assessment of Plastic Grocery Bags

Life cycle assessment(LCA) is a tool to evaluate environmental concerns of a product's whole life from cradle to grave, such as energy consumption, greenhouse gases emissions, water consumption and other resources from the manufacturing process, which is widely used around the world. ^[6]

Plastic bags have become the most popular shopping items around the world, as 1 million plastic bags are in use around the world per minute, while 80% of the marine litters are plastic. ^[7]

Plastic bags bring much convenience for consumers, but the environmental impact for our planet as well. Based on the life cycle assessment methodology, the following will be an overview of the raw materials, production and also outline the energy and emissions inputs and outputs during the cycle. (Fig. 1)

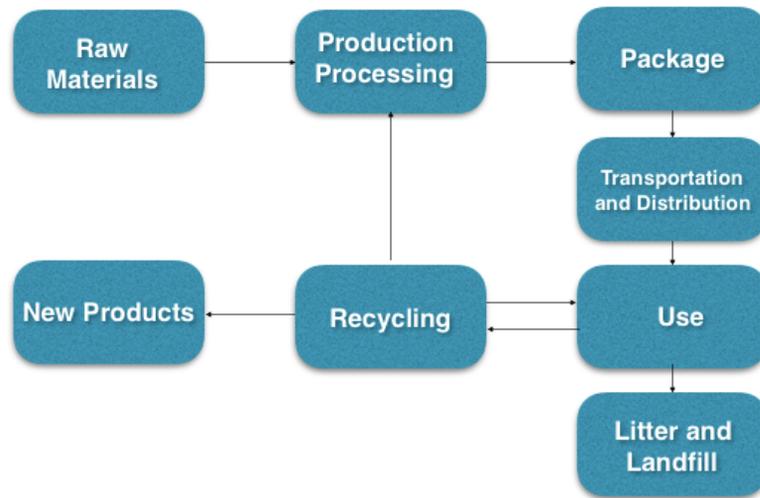


Fig. 1 Processing of life cycle of plastic bags ^[8]

Energy Usage

Energy is a very essential part in each phase of life cycle of plastic bags. Most of the energy is from non-renewable resources, such as fossil fuels. ^[3]

Feedstock energy is part of resource input that ends up in the polymer rather than being used as a fuel ^[10]. In other words, feedstock energy is the energy consumed to produce the High Density Polyethylene(HDPE). It is usually an accumulation of the energy used to extract, manufacture and transport the raw materials. While process energy is the energy used in the plastic bags production process.

From one research result, it uses about 95 KJ of natural gas, 120 KJ of petroleum, and 80 KJ of coal to make a single plastic bag ^[11]. Another research found that 1500 plastic bags use 159 MJ in fuel production, 171 MJ in fuel use, 16 MJ in transport, and 418 MJ in feedstock, for a total of 763 MJ. This equates to 508 KJ in total energy use for each bag ^[12].

Because of numerous assumptions, the research results are vulnerable to variability. These results include assumptions such as:

- Sources of oil, gas, and electricity
- Location of manufacturing
- Efficiency of manufacturing and process
- End use of product (how many time it is reused, etc.)
- Disposal method (landfill, incineration, etc.)

In one scenario, energy consumption varies by different location of manufacturing, mainly embodied in transportation distances from suppliers to manufacturing factory and factory to grocery stores. Taking harmful emissions into consideration, most of the locations of manufacturing are far away from residential district and downtown areas, which will increase the transportation distance of plastic bags, pushing up energy consumption significantly.

Raw Materials

Most of the traditional plastic grocery bags are made from polyethylene, and the main components of polyethylene are natural gas and petroleum. Extraction of both products is energy intensive. This is increasingly true as tapped wells become less productive, and supplementary methods are required to continue extraction. After extraction, the raw materials must be refined, adding to the energy consumed. These processes add to the embodied energy of the raw materials of plastic bags, before production have even begun ^[9].

Production

Once the raw materials are transported to the manufacturing factory, polyethylene are treated to created monomers. These monomers can be further processed to create the various types of plastic monomers. After further manipulation, these monomers will form long chains, which are essentially the backbone of the plastic polymer. The raw materials are usually shipped in granule form before production. The granules are mixed and worked in a heated chamber, and then thinned into a film. At the output of the extruder, the polyethylene is thin enough to form into

plastic bags ^[17]. Most of the polyethylene objects will skip the recycling stage and go straight to disposal. ^[18] The outputs of the product life cycle are emissions to the air, water, soil, and disposal of wastes. The research productive cycle is a significance, because harmful substances are only emitted to the air, including the following pollutants: abietic acid, butyl acetate, toluene, ethanol, carbon monoxide and dioxide, non-methane volatile organic compounds, methane, nitrogen dioxide and monoxide, soot, sulfur dioxide and so on. ^[19]

Transportation

The emission from transportation is a major contributor to environmental impact from plastic bags to get the bags from raw materials to the final customer. Firstly, the raw materials should be transported to the manufacturers, and then once created, the plastic bags are transported to the different levels of retailers. The GHGs emissions from transportation during the life cycle of the plastic bags have very harmful impacts on environment. The consumption of plastic bags is very huge, one organization suggests an estimated 500 billion to 1 trillion plastic bags are consumed each year. ^[13] For example, Canadians take home an estimated 55 million plastic bags each week, for a total of 2.86 billion each year. ^[14] Retailers cannot store too many bags which they need for the whole year because of consumption and storage space limited, so they need order plastic bags shipment very often. Therefore, the emissions generating from transportation is a constant process. After using, most of the plastic bags are transferred to landfills. According to a statistics from United Nations Environmental Programme, Americans discard about 33.6 million tons of plastic bags each year, but only 6.5 percent of it is recycled and 7.7 percent is combusted in waste-to-energy facilities, which create electricity or heat from garbage. The rest ends up in landfills where it may take up to 1, 000 years to decompose. ^[15] The frequency of GHSs emissions during transportation stages, brings one of the harming effects that plastic bags have on environment ^[16].

Recycling

Polyethylene is the most consumed polymer around the world. ^[20] A large portion of polyethylene is turned into consumer products and packaging, such as bottles, plastic film, and

shopping bags. Many of the objects created out of polyethylene are designated as non-durables: their useful life is designed to be less than three years. Furthermore, most of these polyethylene objects will skip the recycling stage and go straight to disposal. ^[21]

It is estimated that only one percent of plastic bags are recycled worldwide ^[22]. After primary use however, polyethylene bags can be recycled in numerous ways. Even without reprocessing, plastic grocery bags can be re-used as garbage bags or shopping bags. Otherwise, the polyethylene can be reprocessed and create new plastic bags, or other goods such as clothing and containers.

Each type of plastic requires a different processing technique. As such, when sent to recycling facilities, they are sorted by polymer type. Plastic bags are sorted into a HDPE collection, where they are compressed and baled. Then they are shipped to a reclaimer. Here, the bags and other assorted HDPE are cut into small flakes, washed, and sold to container or bag manufacturers. When making bags out of recycled material, the strength and appearance significantly deteriorate. Also, due to the possibility of contamination, the recycled polyethylene may be unhygienic. Therefore, many “recycled” plastic bags are not made out of 100% recyclable materials. In some cases, the energy and costs of recycling plastic bags exceeds the energy usage and cost of creating new ones. ^[23]

Landfills and litters

Despite increased efforts to reduce plastic bag usage and increase recycling rates, the vast majority of plastic bags still end up in the landfill or as litter. Taking China’s plastic recycling as example, annual recycling rate in 2013 plunged to 22% from 29% in 2012, and 80% of the plastics transported to landfill or incineration in the end. ^[24] On average, a plastic bag is used for a mere twelve minutes, while they can take more than 25 years to break down. This means that they spend about 45360 times longer in a landfill than they spend being used. ^[23] The bags which end up at the landfill may not end up staying there. Many litter leaving the landfill by wind is plastic, most of which are plastic bags. ^[24] This litter may end up in the forests, rivers, and ocean.

There are approximately 46,000 pieces of plastic floating in each square mile of the world's oceans. And plastic bags are in the top 12 items of debris found in marine clean ups. ^[26] During the 2011 International Coastal Cleanup, volunteers collected 120,450 pounds of bags in the United States, and in Massachusetts alone, the volunteers collected 5, 712 pounds of plastic bags, one the most common forms of litter found. ^[25]

According to some researchers, polyethylene cannot actually bio-degrade. It can break down into synthetic granules if exposed to the ultraviolet radiation from the sun. However, it is not proven that these granules completely break down. Therefore, they may cause harm to wildlife and marine environments. Plastic bag litter has had a major effect on marine ecosystems. Animals such as turtles, seals, birds, and whales have been found to suffocate, become entangled, and starve due to blockages in their digestive systems. ^[27] In one situation, in 2002, a minke whale that was beached in Normandy was found to have 800g of plastic in its stomach. ^[27]

The Environmental Impacts of Plastic Bags

The effects of plastic bags on environment are really devastating, no matter on environment or for the health of human beings. The harming impacts are listed as follows.

Plastic bag litter. In most developed countries, the waste management processed very well. The majority of the residents are willing to classify the garbage, in order to make the plastic products recycled well. However, in many developing countries, the waste management is still inadequate. Even when residents try to manage their plastic bag disposal, sometimes wind plays a role in carrying them away as litter. This litter is not biodegradable and thus where it lands it tends to stay for long period of time. A bag that is eventually ripped to shreds from high winds or other factors doesn't disappear but instead is spread in smaller amounts throughout the area. This can cause more problems as these smaller pieces are carried away through storm drains and often end up in the waterways. With more than 500 billion and possibly as many as a trillion plastic bags in circulation annually this can lead to a catastrophic littering problem. ^[28] Not only is littering unattractive but it is also a very serious environmental hazard.

Effects on waterways. One of the greatest problems is that an estimated 300 million plastic bags end up in the Atlantic Ocean per year. ^[29] These bags are very dangerous for sea life, especially those of the mammal variety. Any hunting mammal can easily mistake the size, shape, and texture of the plastic bag for a meal and find its airway is cut off. Needless deaths from plastic bags are increasing every year. ^[27] It found that nearly 400 marine species are at risk as a result of tons of plastic bags. ^[30] Puffins, turtle, seals and whales are among the creatures that have swallowed or become entangled in plastic bags. ^[31]

Effect on land. The indefinite period of time that it takes for the average plastic bag to breakdown can be literally hundreds of years. Every bag that ends up in the woodlands of the country threatens the natural progression of wildlife. Because the break down rate is so slow the chances that the bag will harmlessly go away are extremely slim. Throughout the world plastic bags are responsible for suffocation deaths of woodland animals as well as inhibiting soil nutrients. ^[32, 33]

The land litter that is made up of plastic bags has the potential to kill over and over again. It has been estimated that one bag has the potential to unintentionally kill one animal per every three months due to unintentional digestion or inhalation. If you consider the number of littered plastic bags ranges from 1.5 million to 3 million depending on location, this equals a lot of ecosystem sustaining lives lost. ^[34]

Experiences from Different Countries

Many countries have already launched new policies for the shopping grocery bags. There has been a phase-out of plastic grocery bags in many nations of the world. Most of these countries have taken actions to ban the sale of grocery plastic bags, charge on some plastic bags, or tax the stores who sell plastic bags. (Fig. 2)

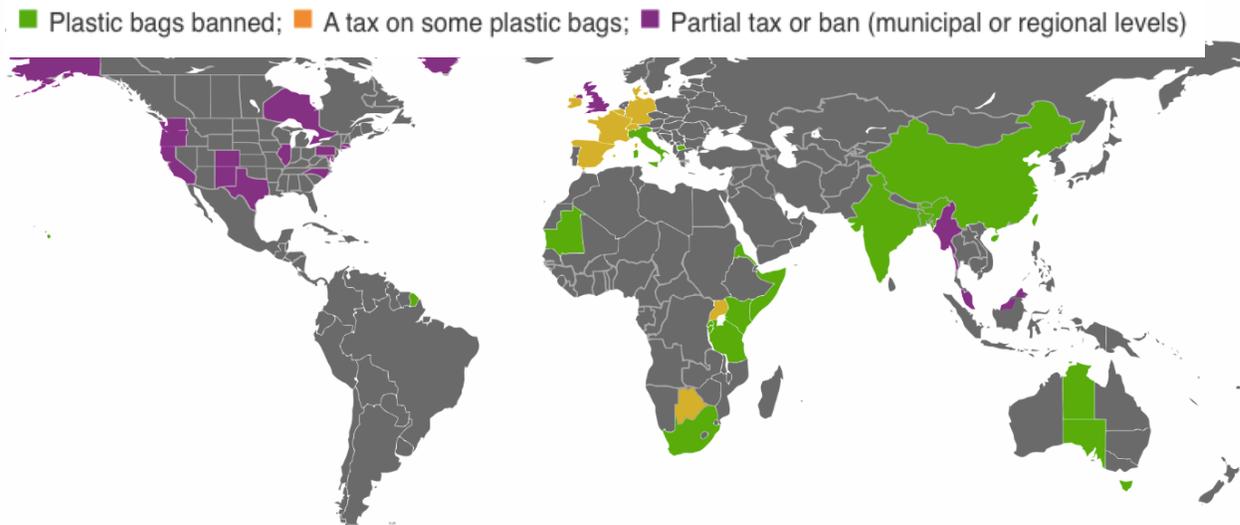


Fig. 2 Distribution of plastic bags policy in the world ^[35]

Ireland

In 2002, Ireland introduced a levy on the plastic shopping bags. The main purpose was to build a sustainable society by decreasing the consumption of plastic grocery bags. The government taxed 0.15 Euro for a plastic grocery bag. The effect from the levy was dramatic, with the usage of plastic bags falling by more than 90%. Besides, the annual revenues were about 12~14 million Euro. The collection and associated administration costs ate about 3% of the revenues. ^[36]

Lessons from Ireland plastic bags levy are two folds: first, the introduction of a price signal through the use of a product tax can influence consumer behaviour significantly; Second, before implementation, comprehensive public education played a significant role in this policy, including introduction on the harms from plastic bags, the levy process, and even many advertisement transmitted daily. ^[36]

Bangladesh

Bangladesh is the first country to ban the plastic bags in the world in 2002. ^[37] In Bangladesh, the worst impact from the plastic bags is on the storm water drainage system. Because of the geography position, Bangladesh has an annual rainfall of up to 5 metres, and it is the world record for the highest rainfall in a single day. Thus, providing sufficient drainage infrastructure is

the main challenge for the Bangladesh Government. Huge amount of plastic bags were lying in the street, which severely blocked the drains and waterways, causing serious drainage problems. In 1998, the flood disaster happened in Bangladesh. It was estimated that about 80% of the city's waterlogging was caused by the polyethylene blocking the drains. In addition, the improper disposal of plastic bags brought a public health problem in Bangladesh as the increase the incidence of mosquito borne diseases such as dengue and malaria. ^[37] Therefore, the Bangladesh Government started to ban the plastic bags production and use of plastic shopping bags in Dhaka City from January 1, 2002. ^[38]

Canada

In March 2007, the town of Leaf Rapids , Manitoba, became the first community in North America to ban bags. ^[39] Toronto City Council voted on June 6, 2012, to ban plastic bags effective Jan. 1, 2013, and to scrap the city's five-cent bag fee starting July 1, 2012. ^[40] Industry groups have convinced city officials to include a grace period between January 1, 2013, and June 30, 2013, when no fines, only warnings, can be issues. ^[41] The bag ban and five cent fee have both overturned as of November 28, 2012 and it is up to individual retailers if they want to charge for plastic bags. ^[42] For example, Walmart Canada started to charge plastic bags since May 16, 2016, as part of its strategy for cutting the amount of plastic that ends up in landfill. ^[43]

Analysis on Plastic Grocery Bags Policy in China

On June 1, 2008, Chinese Government issued a new policy on plastic grocery bags. There are two regulations: the obligatory national standard of plastic grocery bags and the system of compensation for the use of plastic shopping bags in retailers. The first one stipulates that the thickness of plastic grocery bags should be no less than 0.025 millimetres, while the second one requires that the retailer cannot provide the plastic grocery bags for free. ^[44] Beyond that, Chinese Ministry of Commerce, National Committee of Development and Reform, and State Association of Industry and Commerce made a joint supplementary provision which expand the scope of implementation to restaurants and bookstores on July 10th , 2008. ^[45]

Product Charge under Polluter Pays Principle

In the environment law, the Polluter Pays Principle (PPP) is a principle where the polluting party pays for the damage due to the natural environment. The basic principle of PPP is that the price of a good or service should fully reflect its total cost of pollution control. The PPP is the chief economic principle for environmental policy including product charges. With respect to product charges, this generally refers to the charge for a product that generates emission or discharge in the course of production and consumption to raise the price level. ^[46] The purpose is to reduce product use and manufacture less pollution product and raise the capital for pollution prevention or treatment. Tax difference is a special case of product charges which means to make additional positive or negative charges on the product levied according to its different environmental impact.

If carried out effectively, the regulations will make a fundamental impact on all aspects of China economy and society: from the perspective of micro level, it will change the public awareness of environmental protection; from the perspective of macro level, namely from the perspective of the whole society in China, it will definitely help the construction of resources saving and environmental-friendly society and sustainable development. In other words, it can also improve the ecology system and save a lot of expenditure on pollution control, in the meantime, the public awareness of environmental protection and corporate social responsibility will be enhanced, which are the main intention of the policy.

Status Quo

China has implemented the regulations since 2008. From the statistics by the National Development and Reform Commission, the consumption of plastic bags has been cut down by at least 67 billion from 2008 to 2013, saving an equivalent of 6 million tonnes of fossil fuels, achieving significant results. ^[44] Although the consumption of plastic grocery bags is falling down, the regulations have not been carried out very effectively in many street vendors and farm food markets, and the ultra-thin produce bags are still in use in many grocery stores. It seems that

the implementation timeliness of the ban reached to a bottleneck period. The outstanding issues existing include as follows.

- **Farm food markets and street vendors are the most difficult places to carry out the policy.** In China, most people like to purchase the produce products and fresh food in the farm food markets and street vendors, which make up a significant portion of retail in China. However, in these places, the traders often have 2 kinds of plastic bags, one of which meets the national standard and is only used to deal with the inspection, while the other is thinner than 0.025 millimetres which should have been banned from providing to consumers. They often provide the free ultra-thin plastic bags to customers which have become the main source of the plastic bags pollution. The policy cannot be carried out well in these markets in China. ^[47]
- **The consumption of free produce bags is increasing.** Since the regulations issued, grocery stores start to charge plastic grocery bags. The consumption of free produce bags which are provided for carrying fruits or vegetables is increasing sharply. Many consumers choose to use more produce bags to avoid buying the charged plastic bags. According to statistics, the consumption of free produce bags is double since the plastic bags regulations issued. ^[48]
- **Plastic bags substitutes are not widely in use.** Many grocery stores started to sale non-woven bags in China since the regulations issued in 2008. However, the non-woven bags are not popular in use because of the price, which is 20 times prices than a plastic bag. Additional, the non-woven bags need to clean frequently after reusing, they are not acceptable widely in China. Actually non-woven cloth is plastic which is not degradable and will result in huge consumption on fossil fuels such as oil. It can be used as transitional goods but should avoid excessive use so to prevent it from being another source of pollution after plastic bag. ^[49] Paper bags have replaced plastic bags in some grocery stores and clothing stores in China. Due to its non-durability, paper bags cannot be used widely.

Policy Options

The purpose of the regulations on plastic grocery bags is to improve the awareness of the public on environmental protection, eliminate plastic bags pollution, and build up the resources-saving and environmental-friendly society. To fulfill the aim, several policy options could be taken to better carry out the regulations.

Public Education

The most publicly acceptable solution would be an information campaign aimed at explaining the harms from plastic bags consumption and encouraging the use of reusable grocery bags, in order to motivate a more dramatic behavioural change. The public education in China started late and the public is not active to participate in many developing countries. From a survey conducted in the beginning of 2016 by China Environmental Culture Promotion Association, the result showed that 43% of people thought human beings play an important role in environmental protection, but 79% argued that the government should provide more funds into environmental protection, and 60% people recognized that the government should put more efforts on publicity, especially in the rural areas. ^[50] The survey shows that the awareness of environmental protection is still lacking among Chinese people. To better carry out the ban on plastic grocery bags, the government should step up the publicity efforts to enhance public awareness. For example, encouraging people to participate voluntary or compulsory activities in communities or schools.

Substitutes Developing

Substitutes must be used widely as soon as possible. At present, paying for the plastic bag by general public is the only way to practice the plastic bag regulations in China, while other substitutes such as to manufacture biodegradable plastic bag and cotton bags are not used widely.

Bag type	Example	Material consumption (kg)	Global warming (kg CO ₂ eq)	Energy consumption (MJ)	Water use (kL H ₂ O)	Litter marine biodiversity (kg.y)	Litter aesthetics (m ² .y)	Disposal options
Reusable kraft paper bag (2 trips)		♣♣♣♣♣	♣♣♣♣♣	♣♣♣♣	♣	♣	♣	Recycle in household recycling bin
Single use compostable starch-polyester blend bag (e.g. Mater-Bi)	Photo unavailable	♣♣♣♣♣	♣	♣	♣♣♣♣♣♣	♣	♣♣	Compost (degrades within six months) Reuse as a garbage bin liner
Single use plastic (HDPE) bag		♣♣♣♣	♣♣	♣♣♣♣♣♣	♣	♣♣♣♣♣♣	♣♣♣♣♣♣	Recycle at major supermarkets Reuse as a garbage bin liner
Single use kraft paper bag with 100% recycled content	Photo unavailable	♣♣♣♣♣♣	♣♣♣♣♣♣	♣♣♣♣♣♣	♣	♣	♣♣	Recycle in household recycling bin
Single use kraft paper bag		♣♣♣♣♣♣	♣♣♣♣♣♣	♣♣♣♣♣♣	♣♣	♣	♣♣	Recycle in household recycling bin
Single use 'boutique' plastic (LDPE) bag		♣♣♣♣♣♣	♣♣♣♣♣♣	♣♣♣♣♣♣	♣	♣♣♣♣♣♣	♣♣♣♣♣♣	No recycling, reuse as a garbage bin liner
Bag type	Example	Material consumption (kg)	Global warming (kg CO ₂ eq)	Energy consumption (MJ)	Water use (kL H ₂ O)	Litter marine biodiversity (kg.y)	Litter aesthetics (m ² .y)	Disposal options
Reusable non-woven plastic (polypropylene) "Green Bag"		♣	♣	♣	♣	♣	♣	Recycle at major supermarkets
Reusable calico bag		♣	♣	♣	♣♣♣♣♣♣	♣	♣	No recycling, dispose to landfill
Reusable kraft paper bag with 100% recycled content (2 trips)	Photo unavailable	♣♣♣♣♣♣	♣♣♣♣	♣♣♣♣	♣	♣	♣	Recycle in household recycling bin
Single use oxo-biodegradable bag (e.g. TDPA-EPI)		♣♣♣♣	♣♣	♣♣♣♣	♣	♣♣♣♣	♣♣	Reuse as a garbage bin liner (disintegrates over several years)
Single use plastic (HDPE) bag with 100% recycled content		♣♣♣♣	♣	♣	♣♣	♣♣♣♣♣♣	♣♣♣♣♣♣	Recycle at major supermarkets Reuse as a garbage bin liner

Table 1. Environmental impacts of single use plastic grocery bags and their potential substitutes over the full life cycle of the bag ^[51]

According to a result of life cycle assessment of plastic bags alternatives ^[51], we could find that reusable bags have lower environmental impacts than all of the single use bags. A substantial shift to more durable bags would deliver environmental gains through reductions in GHGs, energy, resource depletion and litter. The reusable, non-woven plastic bag was found to achieve the greatest environmental benefits. Recycled content in bags generally led to lowering the

overall environmental impact of bags.^[51] The following table summarizes the findings of environmental assessment of grocery shopping bags substitutes. A rating of one to five was used to show the delivery of impacts of each criteria, with one being the lowest impact. For China, research on life cycle assessment of these substitutes are very important to cut down the cost of the substitutes.

Plastic Bag Credits

Cap and trade is a policy tool designed to reduce emissions of a pollutant by placing a limit (or cap) on the total amount of emissions that can be released by sources covered by the program during a fixed time period.^[52] The overall cap on emissions is implemented through a system of allowances.^[52] Similar to cap and trade, China could consider a marketable permit solution to the plastic bags problem. Rather than totally banning plastic bags consumption, Chinese government could assign each grocery store and retailer a specific number of plastic bag credits. The total number of the bag credits could be set to the amount that the country estimates to be the socially optimal level. Although this system would ideally lead to a socially efficient allocation of plastic bags, it would involve extensive government oversight. In China, there are many street vendors which can not be managed easily. In addition, it is far more difficult to determine the number of the plastic bags that could be used annually. Therefore, although a creative application of tradable permits, this is probably not the best feasible approach to solve the problem.

Plastic Bags Tax

The final option for China is to introduce a plastic bags tax. The tax is imposed either on the retailer or the customer. A tax could be set equal to the value of the external cost of a plastic bag. The government could use the revenue generating from plastic bags to deal with the litter problem and other environmental problems. From the experience of the similar plastic bags tax policy in Ireland, the tax dramatically incentives for consumers to reuse the plastic bags. In the contrary, Denmark taxes retailers a similar amount as part of a general waste tax. While this tax has reduced plastic bags consumption 66% since its implementation. The results are less

dramatic than Ireland's because consumers are often unaware of the increased cost of the bags they are purchasing as many grocery stores simply incorporate the cost of the tax into the price of their products. However the tax does provide incentives for retailers to find innovative ways to reduce bag consumption. Overall, a plastic bag tax is much more effective if placed on the consumers because the goal of the tax is to effect consumer behaviour, not cause retailers to incorporate the tax into their product pricing.

Recommendations

In summary, public education is a persistent way to improve public awareness and to change consumer's behaviour. In the first step, for Chinese government, under the existing regulations, the range of regulation implementation should extend to farm markets and street vendors, which have been the main source of plastic bags consumption in China. In the second step, research on substitutes is essential. If the cost of substitutes is reduced, people would be accepted by more customers.

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