An Economic Evaluation of Plastic Bag Regulation

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Master's Thesis for the Master of Philosophy Degree in Development and Environmental Economics

UNIVERSITY OF OSLO

August, 2010

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http://www.duo.uio.no/

Trykk: Reprosentralen, Universitetet i Oslo

To Dag:

A good friend

A great economist

The greatest father

Preface

I would like to thank my supervisor, Karine Nyborg. Her knowledge, dedication, and friendly demeanor were motivating and indispensible throughout this entire thesis writing process.

I would also like to thank the late Arne Næss for bestowing a life lesson on me that helped guide me throughout this academic trek.

Anders Nilsen

Oslo, October 2010

Abstract

In recent years, several jurisdictions worldwide have implemented plastic bag regulations to curb environmentally deleterious effects of plastic bag production and consumption. The problems that each jurisdiction experience vary from place-to-place; as do the policy mechanisms set forth to combat these problems. Documentation of explicit economic rationality regarding these plastic bag regulations is scarce. This thesis sets out to fill some of that void.

The thesis is organized as follows:

Chapter 1 briefly sets forth the goals of the thesis.

Chapter 2 researches current worldwide plastic bag regulation initiatives. Constituents ranging from small towns to large countries, in places ranging from Africa to America to Asia, have implemented regulation. The mechanisms chosen to date are either command and control instruments (such as prohibitions) or market based instruments (such as consumer taxes). This chapter discusses how various jurisdictions regulate plastic bags and why they do so.

Chapter 3 examines the economic fundamentals of potential negative externalities arising from plastic bag production and consumption. Empirical information is introduced that helps to discover why consumption externalities should be policy-makers' ultimate concern. The most important consumption externality, the littering problem, is then introduced. Models that utilize neoclassical economic actors of the *Homo Oeconomicus* variety show that littering problems can arise due to coordination failure arising from conflicts between social and private interests. The littering problem is shown to display payoff patterns that closely

parallel that of a Prisoner's Dilemma game. The potential externalities arising from the littering problem include aesthetics, biodiversity loss, and human catastrophe.

Chapter 4 evaluates in detail alternative regulation strategies to discover if they lead to more efficient outcomes. It is shown that policy justification depends on the behavior of the relevant jurisdiction's marginal benefit and marginal cost functions. Prohibitions are generally inefficient, but the two countries to date that have implemented prohibitions may still be justified in doing so. The concept of Pigouvian taxation is introduced and it is shown how a Pigou tax might correct an economy that finds itself at an inefficient equilibrium. The final part of Chapter 4 amends the *Homo Oeconomicus* model by introducing socially contingent moral motivation from the Behavioral Economics field. If consumers have moral preferences then moral norms might in certain cases be internalized so as to achieve the Pareto optimal result. One implication is that multiple equilibrium models exist in which societies can, at least in theory, move from a "bad" equilibrium to a "good" equilibrium where the littering problem disappears. Taxation and public education programs are policy instruments that can stimulate moral motivations.

Chapter 5 analyzes the plastic bag marketplace in Norway and seeks to apply findings from this thesis to the empirical findings regarding that nation. Norway is a high usage plastic bag nation, but the littering problem seems to be virtually non-existent. Finally, the thesis sets out to reconcile and provide possible explanations for why a jurisdiction such as Norway has virtually no littering problem whereas other jurisdictions have such extreme littering problems that they are compelled to implement regulation policies.

Chapter 6 concludes and summarizes the results of the thesis.

Contents

1 Introduction

In recent years the plastic bag has received its fair share of critical backlash. Several jurisdictions worldwide have implemented plastic bag regulations to curb environmentally deleterious effects of plastic bag production and consumption. The problems that each jurisdiction experience vary from place-to-place; as do the policy mechanisms set forth to combat these problems.

What are the relevant issues that need to be considered when contemplating the implementation of plastic bag policy? Which policy mechanisms have been chosen to date? Why, exactly, have these mechanisms been chosen? Are these mechanisms justified from an economic standpoint? Can economic theory teach us how to solve any of these problems?

At this point in time, Norway has chosen not to implement plastic bag regulations. But debate regarding plastic bag legislation continues. Environmental sympathizers, political champions, popular media, industry representatives, and as I have learned - everyday citizens - have their own personal opinions about the issues at hand. However, Norway has no discernable littering problem when compared to nations that have implemented plastic bag policy. Why does the problem seem so small here and so substantial in other places? Can these differences be reconciled using economic theory?

The general goals of this thesis are as follows. It seeks to research current worldwide regulation initiatives and evaluate the economic underpinnings behind them. Additionally, market failures associated with plastic bag production and consumption will be analyzed in order to understand the root of the plastic bag problem. This thesis seeks to discover which policy mechanisms are economically justified. Potential strategies for implementation are thereafter evaluated to show how they can lead to more efficient outcomes. Furthermore, an

analysis of the Norwegian marketplace will be undertaken and explanations for wide differences in worldwide littering problems will be suggested.

2 Current Worldwide Plastic Bag Regulation Initiatives

Since the mid 1990's, the world has witnessed a proliferation of plastic bag regulations. For the most part the mechanisms chosen for implementation in jurisdictions that decide to act can be categorized as either command and control (CAC) instruments or market-based instruments.

The predominant fraction of regulation is of the CAC type. The CAC strategy implies a 'command' aspect, which sets a standard, as well as a 'control' aspect, which monitors and enforces the standard. Essentially a CAC instrument can take the form of quantitative, technological, or behavioral restrictions at the firm or consumer level. The CAC instrument can be either performance based or technology based. If CAC regulation is performance based, consumers (producers) are required to consume (produce) at specified quantifiable levels so as to attain an environmental goal set forth by authorities. In practical terms, such stipulations take the form of outright plastic bag prohibition. If CAC regulation is technology based, the imposition of qualitative minimum technology requirements can be applied via production constraints as well as consumer suppression. In terms of plastic bag regulation, most such stipulations have taken the form of banning thin high density polyethylene (HDPE) plastic bags, which differ from low density polyethylene (LDPE) bags in terms of quality. On average, LDPE bags weigh 15 grams whereas HDPE bags weigh 6 grams[1]. HDPE bags lack robustness and therefore contribute to littering problems more than the LDPE alternative: the bags break easily, causing the reuse value to diminish instantaneously, conceivably provoking their immediate discarding into the litter stream. Also, in many countries, consumers

[1] Environment Australia (2002), p.27.

travelling longer distances or carrying heavier loads must use two or three HDPE bags at a time when one LDPE bag would suffice.

Market-based instruments operate by providing incentives for firms or consumers to alter their behavior on a voluntary basis. The instruments achieve this by reconfiguring the payoff structure that economic agents face. Economic literature heralds the theoretical effectiveness of numerous market-based instruments; taxes, subsidies, and transferable pollution permits alike. To the naked eye, taxes seem to be the only market-based instruments yet to be implemented specifically to plastic bags.

The following section updates the reader on the current plastic bag initiatives that have been implemented throughout the world. For most of these jurisdictions, documentation of explicit economic rationality is scarce. After learning which jurisdictions are doing what, I use Chapter 3 to exposit the theoretical economic underpinnings of currently implemented instruments to understand why some regulations might be relevant to plastic bag solutions in certain circumstances whereas others might not be (any potential regulations discovered to be irrelevant will cease to be studied further thereafter).

2.1 Performance Based Command and Control Instruments

2.1.1 Complete Plastic Bag Prohibitions

Bangladesh initiated a complete prohibition of polyethylene bag manufacture and distribution in the capital city Dhaka in 2002[2]. The perceived externality was of very serious nature: In 1998, Bangladesh experienced a flood that covered 60% of the nation, lasted more than two weeks, and caused major loss of life. It was detected after the storm that littered plastic bags

[2] SFT (2008), p.14.

had clogged sewage and drainage systems, thereby probably contributing to the causation of the catastrophic event[3]. In 2002, India implemented a similar ban for similar reasons[4]. India's plastic bag prohibition raised eyebrows because of its draconian forms of punishment[5]. Anyone caught using a plastic bag in that country can face imprisonment for up to seven years or a fine of 100,000 rupees (~13,500 Norwegian Kroners (NOK)[6])[7]. Plastic bag producers in India are still allowed to produce, so long as the end products are sold outside of the nation[8]. In a similar vein, Rwanda has effectively abolished the use of plastic bags by prohibiting the use of plastic bags under 100 microns thick[9]. Some Rwandans, however, have accused government militias of using the law to steal goods being carried in plastic bags[10].

In the USA, no all-encompassing federal law has been implemented to reduce plastic bag use. However, San Francisco was the first municipal jurisdiction in the USA to ban plastic bags[11]. The move prohibits the distribution of any plastic bag type and imposes a range of penalties for businesses that violate. Further, the legislation requires that substitutes such as compostable plastic bags, recyclable paper and/or reusable bags be offered at point-of-purchase. The city of Oakland attempted to enact a similar legislation in 2007, but met strong resistance from the *Coalition to Support Plastic Bag Recycling*, an organization that includes plastic bag producers[12]. The municipality eventually lost the decisive legal battle because

[3] Ibid.
[4] Ibid, p.15.
[5] BBC News, August 7, 2003. Note that this is an electronic source. A list of electronic resources used in this thesis can be found at the end of the literature list.
[6] All currency conversions in this paper measured in August, 2010.
[7] Ibid.
[8] Ibid.
[9] BBC News, January 17, 2006.
[10] Ibid.
[11] SFT (2008), p.18.
[12] Ibid.

they were unable to prove whether a) plastic bags are less environmentally friendly than paper bags and b) significant environmental externalities tangibly existed in that case.

In addition, there are many instances of small municipalities with relevant authority that have enacted their own prohibitions; Lord Howe Island in Australia[13], Leaf Rapids in Canada[14], Brighton in England[15]. For the most part, these are communities that thrive on tourism and seemingly enact such laws to solve perceived littering problems.

[13] Environment Australia (2002), p.49.
[14] CBC News, April 2, 2007.
[15] Mail Online, October 19, 2007.

2.2 Technology Based Command and Control Instruments

2.2.1 Partial Plastic Bag Prohibitions

In preparation towards the 2008 Summer Olympics in Beijing, China implemented a technology based CAC instrument, namely a partial prohibition[16]. For fifteen years prior, Chinese merchants handed out flimsy HDPE plastic bags for free. The ensuing litter problem became so bad that citizens took to calling the discarded remnants as "white pollution", in reference to the color of most bags found in that country. The Chinese Cabinet announced a two-pronged effort to combat the littering problem. First, all thin HDPE plastic bags less than 25 microns were from there on out prohibited. Second, all supermarkets, department stores, and shops were now forbidden from distributing plastic bags of any size free of charge. In 2007, Kenya, Uganda, and Tanzania implemented bans on the use and importation of HDPE bags[17]. Myanmar followed suit at the end of 2009 when they banned the manufacture and import of HDPE bags in the former capital city Yangon[18].

2.3 Market-based Instruments

2.3.1 Consumer Tax

Ireland became the first country to invoke a plastic bag tax on consumers when the *Waste Management Regulations* were implemented in 2002. The levy was applicable to all plastic bags (including biodegradable bags) - with the exception of those used to contain fresh produce or freshly butchered meats. The tax was initially set at €0.15 (<2 NOK) and has

[16] BBC News, January 9, 2008.
[17] BBC News, June 14, 2007.
[18] Topnews, November 2, 2009.

since been adjusted to €0.44 (< 4 NOK). The main externality was the concern with litter[19]. It was feared that the problem was negatively impacting tourism, the second largest industry in Ireland. Plastic bag use has since diminished by 90% and the levy has proven so popular with the Irish public that "it would be politically damaging to remove it"[20]. The Irish plastic bags levy (PlasTax) will be alluded to in later chapters.

South Africa has a salient litter problem attributable to the proliferation of thin HDPE bags[21]. Initially, South African officials attempted to ban the production and use of bags smaller than 80 microns. Outcry among trade officials and industry commenced. Revamped attempts to ban the production and use of bags smaller than 30 microns ensued. But again, these efforts were ultimately stymied. As a final solution, involved parties eventually agreed on a plastic bag tax payable by the consumer to be denoted separately on sales receipts.

Many local municipalities have also implemented consumer taxes. For example, a tax on plastic bags was implemented in Washington, D.C., in January 2010[22]. At 5 cents (<1 NOK) per bag, the tax is relatively small compared to Ireland's. Under regulations created by the D.C. Department of the Environment, grocery stores, drugstores, convenience stores, department stores and any other "business that sells food items" must charge the tax on paper or plastic bags. The tax has heeded results. Annual monthly bag usage rates in that city shrank from 22.5M plastic bags per month in 2009 to 3.0M bags in the first month of the tax strategy. $150,000 US (~900,000 NOK) was raised in the first month – all of which will be used to clean up the local Anacostia River.

[19] Environment Australia (2002), p.21.
[20] Convery et al. (2007), p.2,
[21] All claims in this paragraph are attributable to Environment Australia (2002), p.14.
[22] All claims in this paragraph are attributable to Washington Post, March 30, 2010.

2.3.2 Producer Tax

Denmark also enacted a tax on plastic bags[23]. However, this tax differs from the Irish PlasTax as it is instead levied on producers. Denmark imposed a 22 DKK (24 NOK) tax per kg on plastic bag producers in 1994. It is difficult to determine the precise externality that Danish officials were attempting to internalize, but it seems that Denmark has set relatively ambitious objectives for environmental protection in general. In particular, it seems that Denmark at the time was intent on implementing green taxes, motivated by potential *double dividends*[24], a theoretical hypothesis that suggests emission taxes might be able to reduce tax distortions in the economy[25]. Intuitively this would mean that a tax on plastic bags might create, for example, higher employment as well as a better environment. Although plastic bags are still handed out free of any discernable charge to consumers in Denmark, the tax is passed along from producers to retailers and ultimately to consumers via increased prices on other retail goods. After introducing the tax, plastic bag consumption has been reduced by 66%. It is important to note that this tax is latent to the consumer, which may explain why the consumer behavioral effects of the Danish tax have been less dramatic than those of the Irish tax.

[23] All claims in this paragraph, unless otherwise stated, are attributable to Environment Australia (2002), p.12.
[24] For a detailed analysis of the Double Dividend hypothesis, see Bovenberg (1999).
[25] Mortensen and Hauch (1991), p.1

3 The Fundamentals of Plastic Bag Externalities

According to Meade (1973), "an external economy (diseconomy) is an event which confers an appreciable benefit (inflicts an appreciable damage) on some person or persons who were not fully consenting parties in reaching the decision or decisions which led directly or indirectly to the event in question". External economies and diseconomies arising out of such actions are often referred to as positive externalities and negative externalities, respectively.

Externalities can lead to market failure. Welfare economists often follow the maxim that externalities are best eliminated, if possible, by setting private property rights that would permit trade to take place (Coase, 1960). However, that strategy does not apply to the plastic bags case due to the practical difficulties in assigning private property rights to the environment. When people are not in a position to make voluntary agreements, most economists tend to agree that it is the government's role, if anybody's, to intervene in order to internalize the externality[26].

Several potential negative externalities appear when analyzing the economic and environmental activities associated with the production and consumption of grocery bags *in general*. However, plastic bags *in particular* have been a predominant recipient of recent negative attention and will therefore be the focal point of this thesis.

Externalities can also be classified as either *production externalities* or *consumption externalities*[27]. The research in this thesis has discovered, and will show in the following section, that production externalities in the plastic bag case are a problem of *general production emissions*. The consumption externality in the plastic bag case is predominantly

[26] Thaler & Sunstein (2009), p.195.
[27] Perman et al (2003), p.135.

a *littering problem* in terms of post-consumer plastic waste. The following section explores the general theoretical fundamentals of production and consumption externalities along with empirical analysis on each.

3.1 Production Externalities and Production

A production externality occurs when a firm's production process causes a decrease in utility to an impartial bystanding agent. If this externality remains unaccounted for then there remains cause for concern because inefficiencies in the marketplace exist[28].

Following and adapting Varian (1992, p.432-444), we can see how an incomplete market can lead to negative externalities. Consider a world comprised of two firms. Firm 1 produces an output level x at a cost $c(x)$ which it sells in a competitive marketplace at an exogenously fixed price *p*. However, the production of x negatively impacts Firm 2's profits at an increasing rate of Firm 1's output, $e(x)$. Here, Firm 2's profits are implicitly normalized to zero. The profits for Firm 1 and Firm 2 (disregarding other incomes and costs of Firm 2), respectively, are

$$\pi_1 = \max_x \ px - c(x)$$

$$\pi_2 = -e(x)$$

We assume that

$$c'(x) > 0, \ c''(x) > 0, \ e'(x) > 0, \ e''(x) > 0$$

Which implies that the profit maximizing amount of output for Firm 1, x_1, is

$$p = c'(x_1)$$

[28] Varian (1992), p.432.

This tells us that Firm 1 will produce until marginal private costs to the producer equals the given market price p. But such an output level is inefficient. We can see this by asking ourselves "What would the profit maximizing level of output be if the two entities merged in order to internalize any potential externality?" The profits of the newly merged conglomerate would then be

$$\pi = \max_{x} \; px - c(x) - e(x)$$

Which implies that the profit maximizing output of the merged firm, x_2, is

$$p = c'(x_2) + e'(x_2)$$

Thus the merged firm will choose x such that the sum of the combined costs for the two producers equals the given market price p. Inefficiency arises when no merger takes place because the firm pollutes too much. The firm in that case is only taking into account its marginal private costs, $c'(x)$, and ignoring completely the external marginal social costs, $e'(x)$, that arise out of the production process.

At first glance, production externalities seem to be of potential concern within the Norwegian plastic bag industry because, as the above analysis tells us, profit maximizing, polluting firms left to their own devices will not pollute at socially efficient levels. In the example above, the efficient level of output is x_2 as opposed to x_1 and therefore Firm 1 is producing, and thereby polluting, at an inefficiently high level.

Plastics are resins, or polymers, that have been synthesized from petroleum or natural gas derivatives. Additives are used in some plastics to modify physical characteristics and influence aesthetic properties. Plastic production exploits scarce, non-renewable resources. In particular, 4% of the world's oil and gas consumption is attributable to the production of

plastics[29]. Each plastic bag produced requires twice its weight in unrefined oil[30].

Two sectors of the economy are involved with the manufacture of plastic products: *manufacturers* of plastic resins as well as *processors* who incorporate additives and convert resins such that finished plastic products are tailored to ultimate end consumer needs[31]. Plastic production is a broad industry that encompasses a multitude of sources, actors, inputs, outputs, and processing techniques. Figure 3.1 describes an example of a specific plastic bag processing system. Figure 3.2 describes a generalized plastic processing system.

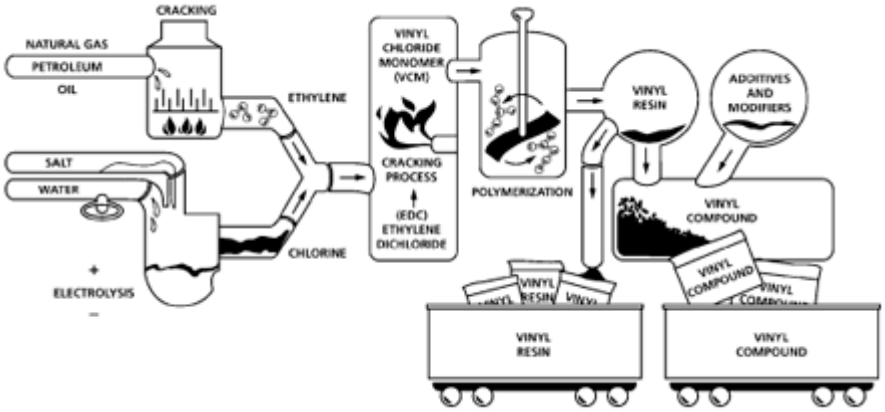

Figure 3.1 Specific structure of a plastic unit processing system (Source: plasticbageconomics.com)

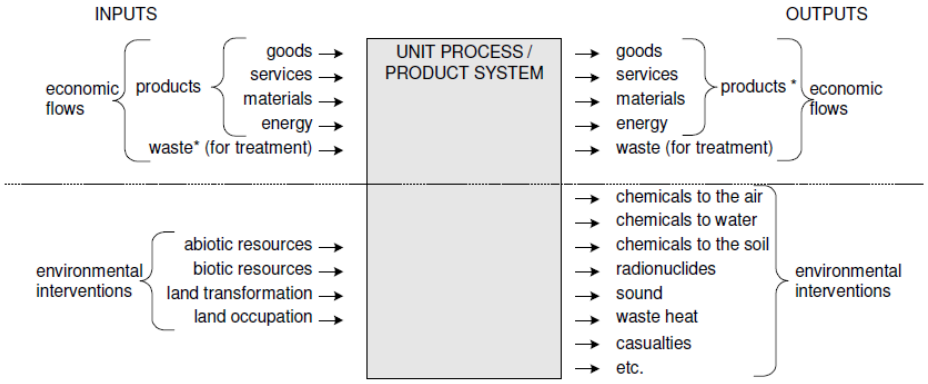

Figure 3.2 Basic structure of a plastic unit processing system (Source: Plastics Europe (2009, p.24))

[29] SFT (2008), p.6.
[30] Ibid, p.6.
[31] USEPA (1990).

Damages inflicted upon non-consenting parties via plastic bag production can vary from very low levels of local noise pollution to high levels of global and uniformly spreading dangerous substances. They include, but are not limited, to the following: stratospheric ozone pollution, acid rain, the greenhouse effect, air quality, solid waste production, eutrophication of water bodies. Figure 2.2 reveals that plastic production consumes environmental inputs and emits environmentally damaging outputs. These byproducts of plastic production confer negative externalities by transmitting harmful emissions. For example, vinyl chloride is a key ingredient in the production of plastic bags, and it is a proven carcinogenic that may cause liver, kidney, or brain damage in people[32]. To illustrate the more general point, let's consider the example of CO_2 emissions.

CO_2 emissions are *not unique to plastic bag production*. Rather, these harmful emissions are a *general* production related problem emanating from multiple and diverse industrial sources all over the world. Typically one should target general externalities via general instruments and specific externalities via specific instruments. Otherwise policy instruments that single out plastic bag production in particular may result in inefficiency. The *Least Cost Theorem* of pollution control necessitates that emission taxes must be uniform across emitters for uniformly mixing pollutants (Perman et al., 2003, p.204). So, for example, if you introduce an emission tax unique to plastic bag producers and not to other emitters the result will be non-uniform taxes. Cost inefficiency ensues. Thus, the general nature of the market failures associated with plastic bag production, at least those associated with CO2 emissions, would best be addressed by a general instrument.

[32] Maltoni & Lefamine (2006), p.1-2.

Such a general instrument indeed exists, in Europe for example, in the form of a marketable emissions permit system[33]. Since 2005, when the European Union Emissions Trading System (EU ETS) was implemented, a quantitative limit on CO_2 emissions has been imposed. Tradable market permits are now allocated and traded by virtually all stationary, industrial, and electricity-generating installations within the EU[34]. Thus I conclude that negative externalities associated with plastic bag production in Norway *can* and at least partly *are* addressed by general emission instruments. With that in mind, we move onward in our analysis by evaluating consumption externalities.

3.2 Consumption Externalities and Consumption

CO_2 emissions from plastic bag production are an example of a production externality, defined as such because the pollution source is a producer. Externalities can come from other sources as well, and consumption externalities are similarly defined due to extraneous external costs arising from consumption activity. Consumption externalities are much more specific to plastic bags than the production externalities identified above. The following section uses economic theory to explain how a littering problem can occur.

3.2.1 Public Goods

A public good is different from an ordinary private good because of two inherent characteristics, non-excludability and non-rivalry[35]. A good is *non-excludable* if people cannot be excluded from consuming it. A good is *non-rival* if one person's consumption does not reduce the availability of that good for others. If a good possesses both of the

[33] See Perman et al. (2003), Chapter 7, for a detailed description of how marketable emission permits function.
[34] Ellerman and Buchner (2007), p.66.
[35] All claims in this paragraph are attributable to Perman et al. (2003), p.126-127.

aforementioned traits then it is a public good. If a good possesses none of the traits then it is a private good.

Littering of plastic bags can affect commodities that possess public good characteristics. One is the local environment in the sense of subjective aesthetic levels ("*aesthetics*"). Another is *biodiversity*. And yet another public good is the avoidance of *human catastrophe*. It might be difficult for non-economists to imagine aesthetics, biodiversity, and avoidance of human catastrophe as goods *per se* since they are not available for purchase on any market. However, consumers can use valuable time and effort to avoid littering plastic bags thereby attaining a better aesthetic environment, more biodiversity, and a lower probability of human catastrophe. *Full income* is a generalized income measure based on the idea that a consumers' total endowment consists of income (and/or wealth) as well as time available and effort capacity[36]. This full income can be allocated between private and public goods. In this sense, consumers are endowed with a requisite unit of account and medium of exchange needed to "purchase" the public good.

3.2.2 Prisoner's Dilemma

Non-cooperative game theory is a tool that allows us to predict behavior of economic agents that independently maximize their own utility, where the outcome of one agent's decision is dependent on the decision of another[37]. It will help us understand the economic motivations behind the littering problem.

Here I modify a simple two -player pollution abatement game found in Perman et al. (2003) to the case at hand. We assume a consumer retains the services of a plastic bag at the point-

[36] Whereas market analysis usually imagines agents endowed with monetary budgets that purchase commodities with monetary prices, congestion analysis often imagines agents endowed with time budgets who choose activities that consume time. See Becker (1965) for a description of the economics of time allocation.
[37] Game theory concepts and definitions can be found in, for example, Vega-Redondo (2003).

of-purchase for the primary purpose of immediately transporting purchased items. The consumer has two options upon completion of transport. She must choose one of the options and chooses only once. The options are to litter or not litter. She can choose *Not Litter* by reusing or recycling the bag immediately, for example. Alternatively, she can choose to *Litter* the bag by releasing it into the open environment. Allow the players in this game to be two different Consumers, X and Y. The two players are identical. The elements of this game are depicted in Figure 3.3 below.

The two horizontal rows correspond to X's binary choice options whereas the two vertical columns correspond to Y's binary choice options. The pair of numbers in each cell denotes the individual utilities, or net payoffs $(U_x(a,b), U_y(a,b))$ that accrue to each player given the corresponding choices in the figure[38] . Seen from the point of view of each individual player, *a* is her own action and *b* is the action of her opponent. This net payoff measurement takes into account the *private and social benefits* accruing to each as well as the *private costs* accruing to each.

Designating some hypothetical values for these cases, we can calculate the payoff for each situation. The costs, *C(a),* are private in nature and therefore accrue only to those who choose not to litter. The costs *C(a)* are identical for each player, a function only of her own choice.

Assume that

C (Not Litter) = 7, *C (Litter)* = 0

A benefit, *B(a,b),* on the other hand, is a function that depends on the choice pair resulting from both players' choices. Any player that chooses not to litter will confer a social benefit to

[38] Where U_x is defined as the amount of net benefits that accrue to player X and, similarly, U_y is the amount of net benefits that accrue to player Y.

both players. This is due to the non-excludability nature of public goods. The benefits function is symmetric, so the order of *a* and *b* does not matter.

Assume that

B (Not Litter, Not Litter) = 10, *B (Litter, Not Litter)* = 5, *B (Litter, Litter)* = 0

We can now define individual utility, or net payoffs by subtracting costs from benefits for each possible scenario:

Payoff for each when both choose Not Litter:

$$U_i = B(Not\ Litter, Not\ Litter) - C(Not\ Litter) = 10 - 7 = 3$$

Payoff for the Litterer when one chooses Litter and the other chooses Not Litter:

$$U_i = B(Litter, Not\ Litter) - C(Litter) = 5 - 0 = 5$$

Payoff for the Non-Litterer when one chooses Litter and the other chooses Not Litter:

$$U_i = B(Litter, Not\ Litter) - C(Not\ Litter) = 5 - 7 = -2$$

Payoff for each when both choose Litter:

$$U_i = B(Litter, Litter) - C(Litter) = 0 - 0 = 0$$

	Litter	No Litter
Litter	0, 0	5, -2
No Litter	-2, 5	3, 3

Figure 3.3 A two-player litter abatement game (Source: Perman et al. (2003), p.301)

Immediately we see that the payoff patterns in the environmental dilemma at hand closely parallel that of a Prisoner's Dilemma (PD) game[39]. PD games help demonstrate inefficiency problems that arise when provision of public goods are left to private individuals. Each player (in this case each plastic bag consumer) maximizes her own utility conditional on expectations of how others act.

Nash equilibrium can be defined as a case in which each player in the game has chosen her strategy and neither player can unilaterally benefit from altering that decision[40]. A dominant strategy is a strategy which is optimal for a player no matter how that player's opponent chooses to play[41]. Whether or not a dominant strategy exists is dependent on the payoff matrix associated with the game[42].

The above game illustrates important results for the issue at hand. Look at X's options. If Y chooses Not Litter, X will rationally choose Litter (5 > 0). If Y instead chooses Litter, X will still rationally choose Litter (0 > -2). Thus, no matter what Y chooses, X will always receive a higher net benefit by littering. Furthermore, the symmetry of the matrix implies the exact same outcome for Y given any choice by X. In this way littering is the dominant strategy for both players (a fundamental assumption in non-cooperative game theory is that players choose a dominant strategy should one exist). This game thus has a unique solution: everybody litters. Neither consumer wants to expend the time and energy required to reuse and recycle. Of course both players prefer a clean environment to a littered one, but choose to litter in hopes of piggybacking on the non-littering contributions of others. The economic term for such behavior is called *free riding*. The unique solution is a Nash Equilibrium.

[39] Prisoner's dilemma concepts and definitions can be found in, for example, Vega-Redondo (2003).
[40] Black, J. (2002), p.313.
[41] Black, J. (2002), p.129.
[42] Vega-Redondo (2003), p.136.

The implications are troublesome for two main reasons. First, the choices made ultimately lead to a non-Pareto efficient outcome - payoffs are lower for everyone than they would have been had everybody instead chosen not to litter. Second, it demonstrates the theoretical possibility that pure utility maximizing behavior can cause a littering problem, even if it would be in everybody's interest to avoid littering. This PD game is a relevant model to the extent that the structure of the payoff matrix corresponds to reality.

We can further analyze individual behavior in the case of consumption externalities within a public good framework by following Cornes and Sandler (1996). Their model has the advantage of extending the number of consumers in the economy to that of a large population. Consider a model where a profit maximizing consumer has preferences for two goods, y and q, denoting a normal private good and a pure public good, respectively. We can imagine the private good as being an aggregate of all private goods regularly purchased in that individual's goods basket. The utility function $U(y, Q)$ is strictly quasi-concave, increasing, continuous and differentiable in the second-degree for both arguments. A consumer can choose to spend her exogenously set income, I, on either the private good or the public good. Any amount of the public good purchased by the consumer is denoted as q, where the aggregate of the total public good expenditure within the economy is

$$Q = (\sum_{h=1}^{n} q^h) + q = \tilde{Q} + q$$

Where q^h denotes the quantity contributed by the other h individuals in the community . The rest of the community's public good spending is

$$\tilde{Q} \equiv Q - q.$$

Assume perfect substitutability between q and $\tilde{Q}$, which means individuals take into account only the *level* of the public good and not *who* it is that is contributing. Remember, the non-

rivalry and non-excludability traits of the public good ensures that each consumer, no matter what their personal contribution q is, cannot be denied access to the $\tilde{Q}$ contributed by other society members. Maximization of utility is subject to a budget constraint. The individuals' budget constraint becomes:

$$y + p_Q q = I$$

Where p_Q denotes the relative price of the public good compared to the numéraire price of the private good, y [43]. Notice that the budget constraint assumes equality, meaning consumers choose to spend their entire earnings. This allows us, as shown below, to solve for the consumer's utility via the budget constraint in terms of the two quantities, q and $\tilde{Q}$. The graphical depiction of the single public good model, found below in Figure 3.4, rests on the observation that since the budget constraint holds with equality, it can be used to eliminate the private good from the utility function. Thus we can invoke a two dimensional graphic representation that exploits the function $\vec{U}(q, \tilde{Q})$.

$$U(y, Q) = U\big(I - p_Q q, q + \tilde{Q}\big) \equiv \vec{U}(q, \tilde{Q}; \boldsymbol{p_Q}, \boldsymbol{I})$$

First we find that the consumers utility is a function of q, $\tilde{Q}$, $\boldsymbol{p_q}$ and $\boldsymbol{I}$. The latter two variables, which are bolded above, are influential to the consumer's utility but exogenously fixed and therefore outside of the consumer's control.

To create the graphical depiction in figure 3.4, we first create a family of indifference curves in $(q, \tilde{Q})$-space implied by the consumer's preferences. An indifference curve is a diagram that represents an individual's taste preference in the sense that any point along an indifference curve represents different combinations of the public and private good that

[43] Although this is a monetary constraint, the model can be generalized to include time and/or effort costs a lá Becker (1965).

provide constant welfare. Higher indifference curves imply higher welfare ($i \succ i' \succ i''$ in figure 3.4)[44]. The vertical line *BB* truncates this indifference map and can be interpreted as the level of q that exhausts the budget constraint. The individual in this model is a *quantity-taker* and thus chooses her contribution level q after the other society members have chosen their individual q^h , until their aggregated total supply $\tilde{Q}$ has been determined. For a given value of this exogenously determined $\tilde{Q}$ we draw horizontal dotted lines that represent the feasible set facing the consumer we are analyzing. A necessary condition for an individual optimum to exist is tangency between the indifference curve and the dotted line, which is where marginal costs and marginal benefits equate for the individual decision maker. When the level of $\tilde{Q}$ increases (the rest of the community collectively begins to spend more), a domain of individual best responses ensues, labeled *NN*, which delineates the individual's best response to each exogenously determined level of $\tilde{Q}$. In economics it is often assumed that this individual reaction curve is downwards sloping (Cornes and Sandler, 1996, p. 147). This means that there exists a specific level of $\tilde{Q}$ which, when attained, saturates the market for public contribution. At that specific $\tilde{Q}$ point of community public spending, an increment of q always provides the individual with a marginal benefit less than the marginal cost. Thus, at that exact point, the individual will maximize utility by spending her entire income on private goods instead of public goods. So we see that there exists a spectrum of environmental quality in which the individual will be willing to spend her income on improving the environment by not littering (to the left of NN). However, as a tangency point is reached (many within society are contributing), the individual will interpret the environment personally clean enough for her to litter more often. In other words, the economy's ability to collectively attain a completely litter-free environment is compromised.

[44] Here, " $\succ$ " means *strictly preferred.*

The result is discouraging because, in this model, a 100% litter-free environment would never occur given rational, classical economic actors.

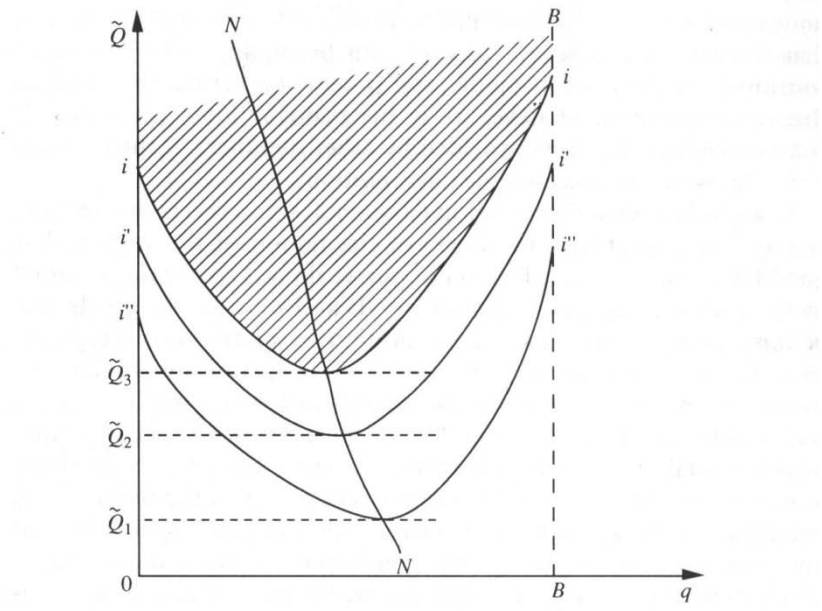

Figure 3.4 Indifference map in $(q, \tilde{Q})$-space (Source: Cornes & Sandler (1996, p.146))

3.3 The Littering Problem

3.3.1 Costs and Benefits of Plastic Bag Littering

This section outlines some of the costs and benefits of plastic bag littering. It might be difficult for a non-economist to acknowledge that benefits can arise from any littering whatsoever. Economists, on the other hand, might not agree so readily and instead seek to find levels of pollution that are *Pareto efficient*. An allocation of resources is Pareto efficient if it is impossible from a welfare standpoint to make any person better off without making at least one other worse off. Littering activities create both costs and benefits accruing to actors in the economic activity, residual flow, and environmental damage stages of the plastic bag lifecycle. Policymakers seeking to achieve a Pareto optimal situation must account for both benefits as well as damages when determining an optimal emission level. Nordhaus (2007,

p.9-10) states that "The essence of an economic analysis is to convert or translate all economic activities into a common unit of account, and then to compare different approaches by their impact on the total amount" and that "…economic welfare – properly measured – should include everything that is of value to people, even if those things are not included in the marketplace".

From a welfare point of view, plastic bag consumers derive utility throughout the plastic bag consumption experience. If we assume that at least some plastic bag litter is an inevitable, albeit unintentional result of plastic bag consumption, then utilization of these valuable consumption benefits will not be possible without generating at least some plastic bag litter. In this sense, plastic bag consumers gain utility via plastic bag littering. But benefits of littering can occur at least in two ways: *unintentional littering* (which brings benefits because it's an unavoidable by-product of beneficial plastic bag consumption), and *intentional littering* (as in the PD game), which provides benefits because one avoids the costs/ inconvenience of bringing the bag to a safe deposit place.

The *Prima facie* task of the plastic bag is to transport items from point-of-purchase to the ultimate destination. The plastic bag is a popular product, even ubiquitous, because it is well suited to its task – it is cheap, lightweight, resource efficient, functional, moisture resistant, allows for quick packing at the store, and is remarkably strong for its weight[45]. Additionally, the plastic bag has multi-use applicability. Because of its inherent carrying and containing capabilities, the plastic bag can of course be used beyond its intended, single-transaction life. Furthermore the benefits arising out of plastic bag littering do not accrue only to consumers. Plastic producers are indirect benefactors of plastic bag littering driven by consumption. For

[45] Environment Australia (2002), p.4.

example, in 2008 the plastics industry provided employment to 1.6 million people in the European Union, a number two-thirds that of the automobile industry[46].

Costs of littering are more straightforward. If we follow both the above models displaying the prisoner's dilemma nature of consumption externalities, then we understand that littering will invariably occur wherever plastic bags are part of the marketplace. This is a concern due to the negative externalities that arise from plastic bag consumption via litter. Plastic bags are especially salient components of the litter stream because they are lightweight (thereby easily airborne), moisture resistant (thereby float in waterways), and they degrade slowly (thereby persisting in the environment for longer periods than, say, paper bags)[47]. We saw in Chapter 2 that the littering problem is the most frequently stated reason for adoption provided by international jurisdictions that have chosen to adopt plastic bag regulations. Littering can negatively impact the utility of non-consenting parties via three types of commodities that all possess public good characteristics: *aesthetics*, *biodiversity*, and avoidance of *human catastrophe*.

3.3.2 Aesthetics

Littering is defined here according to the Norwegian pollution law (forurensningsloven §27) as discarding, leaving behind, storing, or transport of waste such that it can appear to mar or damage the environment[48]. In general, litter can be classified in a variety of ways. This is reflected in plastic bag research results, which are often reported in different measurement denominations (i.e. units per area, weight, surface area, material type, etc.). As such, measuring aesthetics is a difficult task because no universal measurement standard is in place

[46] Plastics Europe (2008), p.6.
[47] Environment Australia (2002), p.29.
[48] SFT (2000), p.5.

to help accurately convey the magnitude of littering problems. In addition, dependable littering studies unique to plastic bags are virtually non-existent[49].

3.3.3 Biodiversity Loss

"The library of life is burning and we do not even know the titles of the books"

-DR. GRO HARLEM BRUNDTLAND, former Director-General of the World Health Organization and former Prime Minister of Norway, on biological diversity[50]

The United Nations agreed to a global Convention on Biological Diversity in Rio de Janeiro in 1992, a clear display of the increasing concern over worldwide biodiversity loss and the recognition of a need to intervene via conservation and sustainable development. The objectives of the convention are the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources[51]. The United Nations (UN) has stated that "the adverse effects of human impacts on biodiversity are increasing dramatically and threatening the very foundation of sustainable development"[52]. Rising consumption is one of the primary causes of biodiversity loss[53]. Pearce and Moran (1994) define biological resources as simply those components of biodiversity which maintain current or potential human uses. Biodiversity in this case describes the number, variability, and variety of living organisms in a given domain,

[49] Green Dot Norway (2010).
[50] Chivian & Bernstein (2008), p.117.
[51] UNEP (2001), p.8.
[52] Ibid, p.8.
[53] Ministry of Environment (2001), p.8.

as well as the natural devices that keep such organism alive within that domain. As will be shown, plastic bag littering has a deleterious effect on many wildlife groups.

As the popularity of plastics increases worldwide[54], so has the amount of plastic pollution[55]. It is estimated that one million tons of plastic are dumped into oceans worldwide every year[56]. Studies of coastal debris demonstrate that 60-80% of wastes accumulating ashore are composed of plastic[57]. The UN Environment Program estimated in 2006 that every square mile of ocean contains 46,000 pieces of floating plastic[58].

It is difficult to know precisely what fraction of these are plastic bags. But plastic bags have proven deleterious effects on marine biota. Kofi Annan, former secretary of the UN, stated that marine litter is killing up to one million sea birds and 100,000 seas mammals each year[59]. At least 267 species are affected worldwide, including 86% of all sea turtles, 44% or all seabirds, and 43% of all marine mammal species[60]. Plastic bags are lethal to marine life mostly due to ingestion and entanglement. Some species are particularly susceptible to plastic bag litter. Sea turtles, for example, often mistake plastic bags for common prey such as jellyfish and squid[61]. In one survey, more than 97% of Laysan Albatrosses were found to contain plastics[62]. Among those that died, the average burden was 1% of their bodyweight. Another major issue concerns the food chain network effects attributable to toxic additives found in plastics. The organic compound PCB (polychlorinated biphenyl) found in plastic bags, for example, can cause reproductive disorders or even death, even at very low levels[63].

[54] Plastics Europe (2008), p.6.
[55] Plastics Europe (2008), p.2.
[56] Chivian & Bernstein (2008), p.59.
[57] Derraik (2002), p.843.
[58] UNEP (2001), p.7.
[59] Chivian & Bernstein(2008), p.59.
[60] Ibid.
[61] Ibid.
[62] Ibid.
[63] Derraik (2002), p.846.

Ingestion of these additives by sea animals diffuses further up the food chain, and can ultimately affect humans that eat seafood. In general, biodiversity directly impacts human welfare - by providing medicines from nature; by ensuring adequate production and supply of food for the human population; by minimizing the implications for the spread of human infectious diseases[64].

One specific area of the globe has drawn attention to the littering problem that occurs in oceans. Although underdocumented, scientists have purported the existence of a waste "vortex" in the Pacific Ocean, 500 nautical miles in size that accumulates a disproportionately high fraction of the world's discarded plastics due to the centripetal direction of the sea current there[65]. Because of their buoyant nature, plastic debris can be transported over long distances and can persist in the environment for long periods of time[66]. The durability of plastics allows plastic bags to last anywhere from an estimated 3 to 10 years in water[67]. The additives can permeate into the ocean and last for an estimated 30-50 years[68]. Regardless of the disputed existence of the aforementioned vortex, the buoyancy of plastic bags, the persistence of their chemical makeup and the increasing amount of littering taking place points towards plastic bag litter as an increasingly serious externality.

3.3.4 Human Catastrophe

Some jurisdictions are susceptible to catastrophic externalities to the local human population as a result of plastic bag littering. Major flooding can be and has been the result of littered plastic bags in some places. For example, as mentioned in Chapter 2, India and Bangladesh are two countries that have experienced fatal floods as an outcome of plastic bag littering.

[64] See Chivian and Bernstein (2008) for a thorough analysis of the implications on humans of biodiversity loss.
[65] The Independent, February 5, 2008.
[66] Derraik (2002), p.844.
[67] Ibid.
[68] Ibid.

Furthermore, Malaria, a mosquito-borne infectious disease pervasive in subtropical regions, can be expedited by way of plastic bag litter. Plastic bags that fill with rainwater can offer ideal breeding grounds for mosquitoes. Wangari Mathaai, the assistant environment minister in Kenya and 2004 Nobel Peace Prize winner, has performed experiments that link plastic bag litter with malaria[69].

[69] UNEP, (2005).

4 Potential Strategies for Implementation

It was shown in Chapter 2 that, in general, unregulated market equilibria will be inefficient in the presence of externalities. Naturally the next step is to evaluate various alternative regulation strategies to see if they lead to more efficient outcomes. The previous chapter provides us an ad hoc list of potential strategies to evaluate for implementation, namely the regulations that have been used to date worldwide. The first strategy is *complete prohibition*. In that case, the government may, for example, enact a performance based CAC by completely banning consumption, production, and importation of plastic bags. The second strategy is *partial prohibition*. In that case the policymakers could, for example, enact a technology based CAC strategy in which producers and consumers are forbidden from utilizing thicker HDPE bags. These two strategies could also entail strict enforcement mechanisms designed to minimize black markets, hidden use, or any other sorts of actions that compromise the integrity of a prohibition instrument. Note that in the previous chapter we determined the most relevant externality in this case to be the littering problem. As such, this chapter sets out to evaluate the economic nature and welfare effects of the current worldwide regulation strategies.

4.1 Prohibition

As previously discussed in Chapter 3, economists seek to find levels of emissions that are *Pareto efficient*. Littering activities create both benefits and costs accruing to actors during the unit processing system. Policymakers seeking to achieve a Pareto optimal situation must account for both benefits as well as costs when determining an optimal littering level.

Here we will follow Perman et al. (2003, Chapter 5) in their partial equilibrium analysis of market efficiency to show that any Pareto efficient level of plastic bag littering will occur at the point of maximized total net benefits in society *(NB)*. It begins by identifying the benefits and costs to society of plastic bag littering. Then, defining net benefits as total benefits minus total costs, an efficient level of plastic bag littering would be one that maximizes net benefits[70].

Assume that

$$B'(L) > 0,\ B''(L) < 0,\ C'(L) > 0,\ C''(L) < 0$$

Where B means aggregate benefits of littering, C means aggregate costs of littering, L is the level of plastic bag littering, single primes denote first-order derivatives, and double primes denote second-order derivatives.

Consider the following maximization problem:

$$\max_L NB = B(L) - C(L)$$

Then, solving the above leaves us with the following first order condition

$$\frac{\partial B(L*)}{\partial L} = \frac{\partial C(L*)}{\partial L}$$

Figure 4.1 gives us an intuitive idea of these results. In that graph, the x-axis represents the quantity of littering whereas the y-axis represents economic value (NOK). In this case an efficient level of littering, L^*, occurs at the situation where the marginal benefits of littering and the marginal costs of littering intersect. If the actual level of emissions, L_a, is such that

[70] The hypothetical net payoff functions we used in the prisoner's dilemma game in Chapter 3 could apply here. Note, however, that the notation is now used in a slightly different way than in that chapter, since we now discuss aggregate rather than individual costs and benefits, as a function of aggregate rather than individual littering levels.

$L^* < L_a \leq \ddot{L}$, where $\ddot{L}$ denotes the unconstrained littering level, then the marginal costs of littering will be greater than the marginal benefits of littering. In that situation society can decrease littering and achieve a Pareto improvement. Similarly, if the actual level of emissions, L_a, is such that $0 \leq L_a < L^*$, then the marginal benefits of littering will be greater than the marginal costs of littering. In that situation society can increase littering and achieve a Pareto improvement. Given that the marginal benefits and marginal costs functions are as drawn in Figure 4.1, we immediately see that a prohibition strategy would be inefficient in such an economy.

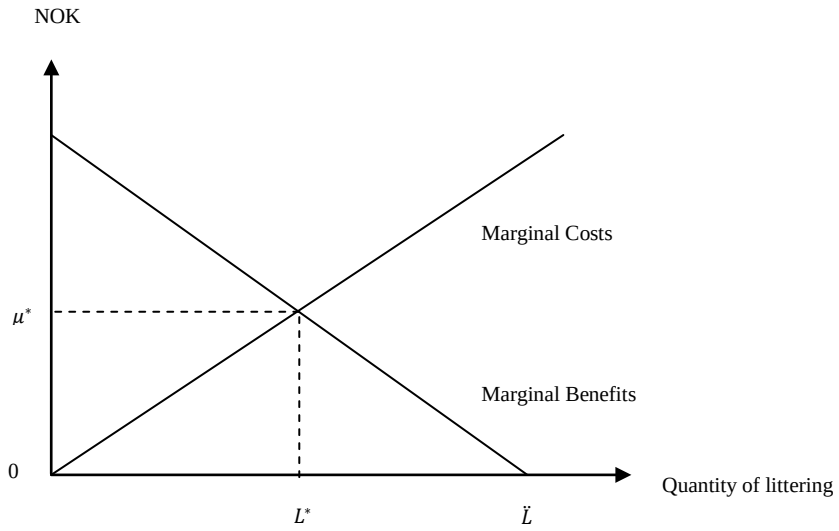

Figure 4.1. An economy in which the economically efficient littering level is greater than zero (Source: Perman et al. (2003), p.173)

A prohibition strategy however need not always be inefficient. Given some adjustments in the marginal benefits and marginal costs functions, we can classify economies in which a plastic bag prohibition would indeed be justified. Figure 4.2 gives us an idea of how such an economy might look. This figure is similar to Figure 4.1 with the exception that due to the positions of the curves, they never cross. These curves may in practice be unique to each

jurisdiction. Given that the marginal benefits and marginal costs functions are as drawn in Figure 4.2, then the maximization of net benefits would only occur with zero littering, at L^* . In such an economy a prohibition strategy would be an effective method to attain efficiency.

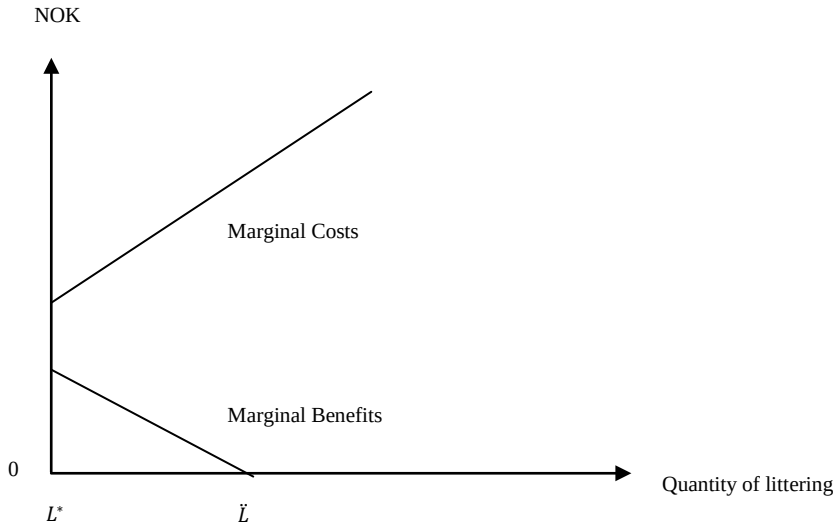

Figure 4.2. An economy in which the economically efficient littering level is zero (Source: thesis author)

Whether an economy resembles Figure 4.1 or Figure 4.2 depends on the externalities particular to that jurisdiction. Remember the three potential externalities listed in Chapter 3; aesthetics, biodiversity, and human catastrophe. Figure 4.1 might describe a jurisdiction that is experiencing an aesthetics problem. Figure 4.2 might describe a jurisdiction that is experiencing a potential human catastrophe problem. The difference is in the behavior of the benefits and costs functions. If a jurisdiction is merely experiencing a relatively less harmful aesthetics problem, then it is likely that the marginal benefits function begins at a higher point than the marginal costs function. In that case more plastic bag littering is justified because of the increased welfare benefits society would garner from the associated plastic bag consumption. However, if a jurisdiction is prone to human catastrophe, then it is likely that the marginal costs function begins at a higher point than the marginal benefits function. In

that case more plastic bag littering is not justified because of the serious repercussions that can occur with littering.

4.2 Pigouvian Taxation

The idea of environmental taxation was first introduced by A.C. Pigou in his 1920 book *The Economics of Welfare*. A Pigou tax is a tax levied on a market activity that generates negative externalities (such as plastic bag consumption generating a littering problem) in order to fully internalize the externality[71]. Thus a market that finds itself at an inefficient equilibrium can theoretically be corrected by implementing a tax set at a rate equal to the difference between the social marginal costs and the private marginal costs, evaluated at the optimum, or a Pigou tax.

Figure 4.1 shows how to find the tax level that will lead to efficiency. First, locate the efficiency equilibrium where the marginal benefits of littering intersect marginal costs of littering. Next, trace a horizontal line towards the x-axis from that point. Ultimately we end up at μ^*, the equilibrium price of littering. So if an economy indeed displays benefit and cost functions as described in Figure 4.1, the attachment of a market price μ^* to plastic bag littering will lead to an efficient economy.

The Pigou tax works because it makes private and social choices compatible by ensuring that incentives coincide as such. As Hoel mentions (1998, p.1), littering taxes might be preferable to CAC instruments because they are cost effective. They are cost effective because it is in each actor's own interest to equate her marginal abatement cost with the littering tax rate. As long as each actor faces the exact same tax rate, marginal abatement will be equalized across

[71] Black, J. (2002), p.354.

sources, which is a necessary condition for cost effectiveness. Thus the environmental goal will be achieved as cheaply as possible. Tietenberg (1990, p.17) states that the cost savings from using emission taxes instead of CAC instruments are very often substantial.

It is important to note, however, that a broad-based, community wide consumer tax on the purchases of plastic bags would not be a first-best solution for the littering problem. That is because littering is ultimately caused by the consumer, not the plastic bag itself. Ideally the tax burden should be placed on the *activity* that generates the pollution, rather than the *good* itself (Sandmo, 2009, p.8-9). A perfectly corrective Pigou tax would actually be charged solely to litterers each and every time a plastic bag was littered. But administrative feasibility makes this difficult in practice due to the non-observability of the littering action. Practically speaking this means that both litterers and non-litterers alike will be taxed upon purchase of the plastic bag commodity - whether their individual use of those bags convey adverse environmental effects or not. However, as Sandmo (2009, p.9) states, even an imperfect regulation may be worthwhile:

> It might perhaps be tempting to draw pessimistic policy conclusions from this analysis: If corrective Pigouvian taxes are likely to introduce new distortions, is it not to be expected that the net welfare gain from their use might easily become negative? In my view, this pessimism is unfounded. It is important to distinguish between achieving on the one hand a social optimum and on the other hand a welfare improvement. Imperfect taxes, if used with good judgement and empirical knowledge, can clearly result in substantial welfare improvement in spite of falling short of the first best welfare ideal.

4.3 Behavioral Economics

Previously, when discussing consumption externalities, we saw that market failure might arise when consumers are faced with public versus private good spending decisions. Specifically, we saw that consumers can maximize personal utility by spending their income on private

goods while free riding on others' contributions to the public good. The implication in the plastic bag case is that a littering problem will arise. This result is based on the classical economic assumption that society is comprised of traditional, self-interested, and "rational" utility maximizers that are assumed to be able to make judgments towards their subjectively defined end. The name of this economic actor is *Homo Oeconomicus*.

In recent years economists have incorporated elements of psychology into economic decision making to predict market outcomes with more precision. A new economic field, Behavioural Economics, has been spawned in light of this. The field emphasizes that consumer behaviour is not motivated purely by material payoffs and it seeks to discover the true motives behind consumer decision making. Behavioural Economics amends assumptions behind *Homo Oeconomicus* in order to account for emotional and other factors in the consumer decision-making process that conventional economics does not account for. Behavioural economists refine the *Homo Oeconomicus* model by integrating social and/or moral preferences into the consumers' utility function. According to Pollak (1976), there is nothing in the logic of economic thought that mandates the narrow view of preferences found in most neoclassical consumer theories. Behavioural economic tools allow economists to reconcile distortions in the *Homo Oeconomicus* model to help explain, for example, why some people refuse to litter even when traditional models insinuate that it is rational for them to do so[72].

4.3.1 Social Aspects of Perceived Responsibility

Behavioural Economists incorporate psychological aspects of social and moral norms into classical economic methodologies to help analyze modern economic consumer behaviour. Andreoni (1990), for example, attempts to explain seemingly irrational public good contributions by advocating a utility function that includes an emotional private benefit,

[72] Donating blood to the blood bank would be another example.

namely an impurely altruistic "warm glow" feeling that accrues to consumers when they contribute to the public good. This would explain, for example, why some people are willing to spend more money on environmentally friendly green goods that are otherwise identical in function and form to less environmentally friendly brown good substitutes. Some other notable writings in the behavioural economic and related fields include Akerlof (1980, 1997), Becker and Murphy (2000), Durlauf and Young (2001), Elster (1989), Frey (1997), Holländer (1990), and Manski (2000)[73]. Part of the literature on voluntary contributions is based on social norms, where the modelled behaviour is influenced by preferences for social approval (e.g. Rege (2004)). I make the assumption that plastic bag littering occurs when consumers are alone and thus devoid of the requisite social incentives required to alter behaviour from a social standpoint[74]. This means that social norms enforced by social sanctions do not apply to the plastic bag littering problem. However, literature also exists where the modelled behaviour is derived predominantly by preferences for a self-image as a morally responsible person. These moral norms might be internalized so as to achieve the collectively best result. One implication from these studies is that multiple equilibrium models exist in which societies can move from a "bad" equilibrium to a "good" equilibrium. In turn, government policy initiatives might be able to "nudge"[75] consumers to behave towards their perceived morally ideal way. If progression from the status quo towards the moral ideal is a Pareto improvement (or environmentally better alternative), then economic credo at least justifies exploring the issue further.

[73] As per Nyborg (2003), p.260.

[74] Social norms could apply to the plastic bag littering problem in the sense that it prevents littering when one is not alone. But that structure would still not provide internalization of social norms when one is alone and the incentive to litter plastic bags is at its highest.

[75] The term "nudge" is attributable to Thaler & Sunstein (2008). Their book of the same name draws on behavioural economic research to defend libertarian paternalism and active engineering of choice architecture.

4.3.2 Moral Norms

Private benefits can accrue to a non-litterer when an internal reward arising from that contribution exists that is based on morally responsible behaviour. As described by Nyborg et al. (2006, p.353), such internal rewards depend on the interplay between (a) the contributors' belief that the action in question would benefit others, and, (b) the perception that the action is governed by a norm that is observed and recognized by the community at large. If the individual has preferences for developing and maintaining a self-image as a morally responsible person, then that person's self-image will improve when her behaviour approaches the perceived morally ideal behaviour. If this internal reward is positively related to others' contributions, then it can be shown that progression might be made from an inefficient equilibrium with a free riding problem to an efficient equilibrium with little or no litter. The following sections adapts Nyborg et al (2006, p.355-358) in order to analyze moral motives and determine their relevance to the plastic bag market.

4.3.3 A Moral Motivation Model

Assume that a large, finite number of n identical individuals live in a society, and that each has purchased and is in possession of a plastic bag. Each individual, i, has two alternatives, *Litter* or *Not Litter*. Not littering confers a personal cost of C to each person. However, not littering also confers two benefits. The first is S, which is the subjective benefit of attaining a favourable self-image when not littering. The second is the environmental benefit, b, which accrues to every person in society (due to the non-excludability aspect of the environment). It seems natural to assume that $b < C$ whereas $nb > C$. This means that individuals who do not care about their self-image will rationally choose to litter. A non-littered environment is Pareto superior to a littered environment. We assume that not littering is perceived as the morally correct choice.

The payoff for an individual opting not to litter is as follows:

$p_i = (S + b - C)x_i = (S - c)x_i$

Where $x_i \in (0,1)$ where $x_i = 0$ means that *i* litters and $x_i = 1$ means that *i* does not litter.

The value c is defined as the net private cost of not littering:

$c = C - b > 0$

Noting that not littering yields an external environmental benefit to all individuals, and that the external benefit is increasing in n:

$B = b(n - 1)$

Such that the net environmental benefit when nobody litters is:

$n^2 b$

The marginal rate of improvement in self-image is an increasing function of the external effect, B, as well as the extent to which the individual perceives not littering to be her responsibility, which in turn is an increasing function of the share, a, of individuals choosing Not Litter, where

$$a = \frac{(\sum x_i)}{n}$$

The self image benefit function is thus

$S = s(B, a)$,

$s'(B) > 0,\ s''(B) < 0,\ s'(a) > 0,\ s''(a) < 0$

Given the above equations, the decision rule is that an individual chooses Not Litter $(x_i = 1)$ whenever the perceived benefit of a positive self-image exceeds the marginal private cost of not littering:

$$s(B, a) > c$$

It is important at this point to set forth some further assumptions. Note that a moral preference is dependent on the perception that the action is governed by a norm that is observed and recognized by the community at large. In experimental economics humans show a strong tendency to conform[76], or cooperate conditionally[77]. Moral norms can be triggered by signalizing that other people are behaving in the morally appropriate way. This requires at least some degree of observability. In this model I make the following assumptions regarding observability:

1) The act of littering *cannot* be observed
2) The resulting litter *can* be observed

Norm adherence is observable in the sense that it can be recognized when resulting litter levels stagnate or decrease. This means that if a member of society chooses not to litter, all other members of society will notice and register that particular choice in their morally impacted payoff function, even though they may not observe the littering action and subsequently the identity of the litterer [78]. This observability will affect the self image benefit function through the a variable. This happens when individuals have preference interactions for internalized moral approval. Preference interactions happen when one consumer's

[76] This conformity, also known as "imitation", "contagion", "bandwagon effect", or "herd behavior", was displayed in, for example, Solomon Asch's groundbreaking conformity experiment of the 1950's in which experiment participants taking a vision test produced startlingly incorrect answers when they witnessed enlisted "confederates" before them make their (incorrect) answer first. See Larsen (1974) for more.
[77] See Fischbacher et al. (2001) for evidence from public good experiments that humans are conditionally cooperative.
[78] Social sanctions are not relevant in this model due to the indirect, not direct, observability assumption.

preference ordering over the alternatives in a choice set depends on the actions (or even preferences) chosen by other consumers (Manski, 2000, p.120-121). Thus, the choice that any society member makes is importantly dependent on what others do. In this way the model differs from neoclassical models in which people act independently of one another. This provides us with an infrastructure for moral motivation to stimulate demand for the environmentally friendly alternative based on socially contingent moral motivation: conditional cooperation can take place.

4.3.4 Multiple Equilibria

Nyborg et al (2006, p.365) states that "the existence of multiple Nash Equilibria leaves open the possibility that two otherwise identical economies might display highly different [propensities for littering]". Multiple Nash equilibria can exist in the plastic bag case, as follows.

Assume that:

$s(B,0) < C, \qquad s(B,1) > C$

So that the subjective benefit obtained when choosing to litter exceeds the net private cost in the event that *everybody* litters, whereas the subjective benefit when choosing not to litter exceeds the net private cost in the event that *nobody* litters. This means that moral motivation is stronger when supported by the observable actions of others. Given these assumptions, two pure strategy Nash Equilibria exist:

NE (0): *Everybody litters*$(a = 0)$, and the sense of personal moral obligation is weak

NE (1): *Nobody litters*$(a = 1)$, and the sense of personal moral obligation is strong

4.3.5 Dynamics

Nyborg et al (2006) use replicator dynamics from evolutionary biology to show how the existence of multiple Nash equilibria and dynamics of moral motivation might influence consumer behaviour. The theoretical nature behind replicator dynamics are outside of the scope of this thesis, but the conclusions drawn there help us analyze how a society might move from a Pareto dominated position where everybody litters, NE (0), to a Pareto optimal position where nobody litters, NE (1).

The evolutionary game dynamics of that paper discern that the growth of a strategy is proportional to the success of that strategy, where success is measured by the strategy's payoff relative to the other strategy[79]. For the model at hand, this would imply the following dynamics of a:

$\dot{a} = \frac{\partial a}{\partial t} = a(1-a)(s(B,a) - c)$, where t = time

This tells us that the popularity of a strategy with a higher payoff will increase at a higher rate over time than the strategy with the lower payoff. It allows us to create a dynamic path illustration as depicted in figure 4.1. In the figure, the two pure Nash equilibria, NE (0) and NE (1), are asymptotically stable. The third Nash equilibrium, NE (a'), is an unstable, mixed-strategy Nash equilibrium that operates as a tipping point. Here, each individual litters with a probability a'. This a' is defined implicitly such that:

$s(B, a') = c$

[79] See Nyborg et al. (2006, p.357) for a more comprehensive look at how these replicator dynamics are determined.

The tipping point is vulnerable to small changes in the share of individuals adopting one of the policies. Incremental changes towards $a = 0$ ($a = 1$) will initiate movements towards a completely littered (non-littered) equilibrium[80].

$a > a'$ ⇒ Moves the economy permanently to $NE(1)$, or a "virtuous circle"

$a < a'$ ⇒ Moves the economy permanently to $NE(0)$, or a "vicious circle"

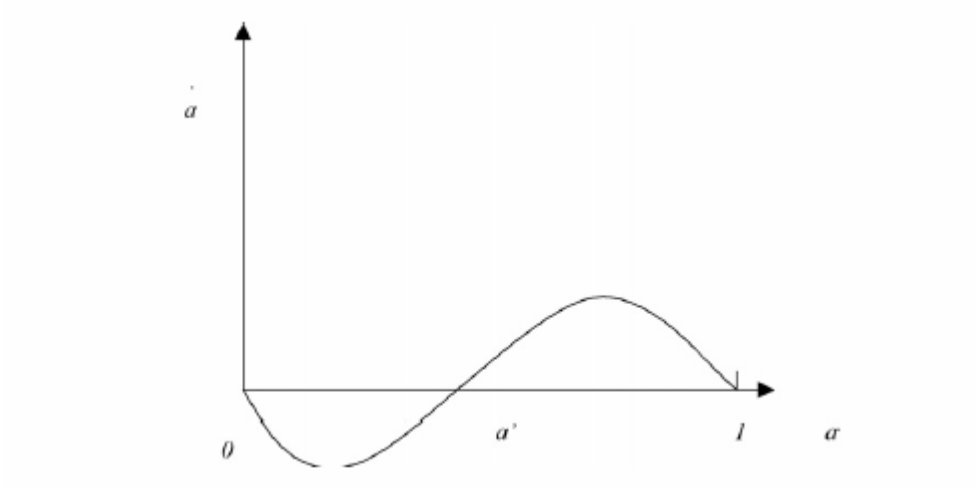

Figure 4.3 Dynamic development of the share of non-litterers (Source: Nyborg et al., 2006)

4.3.6 Taxation as a Moral Incentive to Eliminate Littering

Nyborg et al (2006, p.358-359) analyze policy mechanisms (such as taxes) and their relevance to socially contingent moral motivation. The following section discusses how a consumer tax on plastic bags might persuade consumers to choose the preferred behaviour in this model, thereby creating the virtuous circle that ultimately propels society to the preferred, no-litter equilibrium.

Assume that a society is positioned at NE (0) where everybody litters their plastic bag. Now suppose that government enacts a tax on all plastic bags at point-of-purchase locations

[80] Note: In this model, individuals are identical. If they were not identical we might see some economic actors that do not have preferences for internalized moral approval (i.e. *Homo Oeconomicus*). If this is the case then the environment will not be perfectly litter free in practice.

throughout the country. A tax implementation will be reflected in a price increase, and the higher price will reduce demand for plastic bags. Individuals will only purchase plastic bags if their use value exceeds the price of the tax. Low use valuers will drop out of the plastic bag market[81]. We assume that plastic bag littering levels are a monotonically increasing function of plastic bag purchases such that littering levels will drop as plastic bags are purchased with decreasing frequency. Individuals will then observe and recognize the stagnating or diminishing levels of visible litter, which may lead them to conclude that the share of non-litterers now exceeds a'. This could potentially make the economy move to the non-littering equilibrium. Also, it is conceivable that consumers may interpret a tax as a signal that the environmental effects of littering are more important than they previously thought, i.e. that the external benefits of not littering, B, are larger than previously believed. Since S depends on B, this could also potentially move the economy to the other equilibrium.

There are two mechanisms that pressure individuals to stop littering in this model. First, a tax can potentially stimulate a moral incentive for individuals to stop littering. If the tax changes the self-image effect of littering, either through consumer beliefs about the fraction of non-litterers or about the external benefits of non-littering, then the tax can sometimes be sufficient to move the economy to the other equilibrium.

The second mechanism behind the behavioural change is caused by the altered monetary incentives induced by the plastic bag tax. A tax implementation will make the cost of littering increase. If the littering option becomes more expensive than the non-littering option, the original position NE (0) would no longer be a Nash Equilibrium. In fact,

[81] Given a multi-period setting, it seems reasonable that some consumers will rationally purchase fewer bags over time and instead reuse previously purchased bags as often as possible to avoid repeatedly incurring the tax. That situation is outside of this mode. Here, each consumer is assumed to own only one plastic bag and make her littering/non-littering choice only once.

according to Rege (2004)[82], the model can be interpreted to suggest that even a *temporary* tax would be sufficient enough to create such a permanent shift. In that situation the removal of the tax after full compliance has been attained would not alter the consumer's impression that littering is the morally incorrect decision to make. Such a result would presume that there is no signalling effect of removing the tax such that *B* (or rather, consumers' perception of B) becomes smaller.

Such a process invokes policy measures that influence consumer perceptions of the littering problem, with an ultimate eye towards altering consumer behaviour. If the tax can stimulate widespread disapproval of the littering problem, moral norms can be internalized into consumer utility functions such that the ultimate decisions – despite being based on self-interest – are associated with less negative externalities. The end result would be a more efficient system and a less littered environment.

4.3.7 Public Awareness as a Moral Incentive to Eliminate Littering

Moral norms can be triggered by signalizing that either *many* people or a select *few influential* people are behaving in the morally appropriate way[83]. When considering the plastic bag littering problem it is vital to study the determinants of consumer choice, including public policy's capability to influence those choices. Public authorities often use advertising campaigns where the purpose is solely to remind consumers of their moral responsibilities (Nyborg, 2003, p.259).

Advertising campaigns are a way of creating *stimulus response compatibility*. The idea of stimulus response compatibility is that the stimulus causing moral norm change is consistent

[82] This was presented in a different context. It was presented within a social norm motivation model.
[83] Thaler & Sunstein (2009, p.64).

with the ultimately desired action without forbidding any options[84]. Creators of such campaigns are called *choice architects* (Thaler & Sunstein, 2009). Choice architects have the responsibility of organizing the context in which people make decisions[85]. A nudge is any aspect of the choice architecture that alters people's behaviour in predictable ways. As shown above, a consumer tax on plastic bags could function as the stimulus required to nudge a society towards a non-littering environment. However, a properly designed advertising campaign or public awareness effort coinciding with the tax might be needed to strengthen - or at least would not negatively influence - the effects of the tax in the model. This is one interpretation of what the Department of the Environment, Heritage and Local Government did in Ireland when they introduced that country's plastic bag tax. In that case, the advertising campaign that accompanied the consumer tax was originally intended as a mechanism to protect retailers from appearing to "profiteer" from the tax[86]. But the ultimate effect of the public awareness campaign was to create a link between price and good environmental behaviour in the public mind[87]. Thus the internalization of the moral norm was achieved by manipulating - or framing[88] -product attributes such that the schema of interpretation the consumers relied on to understand the choice option was altered. The tax on plastic bags functioned as a salient signal to consumers of the littering problem that accompanies plastic bag consumption.

A public awareness campaign (alone) might be able to stimulate the correct moral behaviour. One example of a successful advertising campaign that used conformity to combat a littering problem occurred in the USA in the 1980's when Texas successfully reduced their highway

[84] Ibid. (2009, p.90).
[85] Ibid. (2009, p.3).
[86] Convery et al, (2007, p.6).
[87] Ibid.
[88] See Tversky & Kahneman (1981) for information on framing effects and their role in the psychology of choice.

litter problem[89]. Initially the Texas government grew frustrated when numerous expensive and highly publicized advertising campaigns did not achieve their ultimate goal of curbing their considerable highway littering problem. However, in 1986, the Texas Department of Transportation implemented a state-wide advertising campaign aimed at altering moral behaviour towards littering by stimulating allegiance towards the local public good. The slogan of the campaign, "Don't Mess with Texas", was supplemented by advertisements that included famous Texans[90] imploring citizens to address their civic duty by not littering[91]. In this way the campaigns stimulated an association between the consumer action of not littering and morally correct behaviour. The results were substantial; visible litter was reduced 29% after the first year of the campaign inception and 72% after six years.

One example of a tax successfully *combining* with an informational campaign is the Irish PlastTax. Convery et al (2007, p.9-10) states that that the primary lesson in the PlastTax case was two-fold. "Firstly, the introduction of a price signal through the use of a product tax can influence consumer behaviour significantly; secondly, ensuring stakeholder and consumer acceptance of the tax is central to the successful implementation of such a tax. Informational campaigns highlighting the environmental impacts… are central in ensuring such acceptance".

[89] All information regarding the Texas highway case attributable to Thaler & Sunstein (2008, p.64-65).
[90] For example musician Willie Nelson, actor Chuck Norris, and athlete Lance Armstong are some of the people since 1986 that have lent their names to the ongoing campaign.
[91] Thaler & Sunstein (2009, p.64).

5 The Norwegian Marketplace

Norway is a high usage plastic bag nation. In general, Norway, along with Denmark and Ireland, produce the highest levels of per-capita waste in Europe[92]. Norwegians consumed approximately 1 billion plastic bags in 2008[93]. The total weight of this refuse was 15,000 tons, or approximately 3% of the 500,000 tons total plastic waste amount in Norway[94]. Yearly consumption of plastic bags rounds to approximately five hundred units per family, or about 7kg of plastic bag consumption per capita each year[95]. Plastic bags comprise 20% of all general plastic packaging in the Norwegian marketplace[96].

In chapter 3 it was shown that two sectors of the economy are involved with the manufacture of plastic products: *manufacturers* of plastic resins as well as *processors*. An analysis of the Norwegian marketplace shows that plastic bags in Norway are predominantly imported. Most of the imports come from China and Sweden[97]. There are currently zero Norwegian manufacturing firms in Norway, one major Norwegian processing firm (*Norfolier Norge AS*), and four minor processing firms (*Beca Plastindusri AS, Petroplast Industrier AS, Serviteur AS, Tommen Gram Folie AS*) [98].

It was also shown in Chapter 3 that major production externalities, such as CO_2 emissions, are not unique to plastic bag production. Thus, the general nature of the market failures associated with plastic bag production, at least those associated with CO_2 emissions, would best be addressed by a general instrument such as the EU ETS. Norway joined the European

[92] SFT (2008), p.19.
[93] Ibid, p.10.
[94] Ibid, p.10.
[95] Ibid, p.12.
[96] Ibid, p.10.
[97] Personal communication with Eirik Oland, Green Dot, 09.09.10.
[98] Ibid.

Union Emission Trading Scheme in 2007[99] and the aforementioned firms are required to comply with this agreement.

Norway does not seem to have a littering problem. *Keep Norway Clean (Hold Norge Rent)* is a Norwegian organization that sends out voluntary *dugnad*[100] groups into Norwegian public and nature areas to pick up litter. Via analyses from these experiences, *Keep Norway Clean* is of the opinion that the plastic bag littering problem in Norway is minimal[101]. On the contrary, there is more evidence that suggests Norwegians are very effective reusers of plastic bags[102].

In Norway 80% of plastic bags are reused for various functions[103]. We can deduce some of the indirect benefits of plastic bag use in Norway by analyzing, for example, the sources of plastic bags that ultimately end up in Norwegian landfill sites, as described in Table 5.1[104]. The table shows that a fraction of Norwegian plastic bags are well utilized. Plastic bags can even be interpreted to be environmentally friendly; it is insightful to see, for example, that *plastic bags* are used to transport and recycle *plastic bottles*. Bottle recycling stations are standard in Norwegian grocery stores, with garbage bins and hand washing mechanisms placed within near vicinity. Evidence of bottle recycling popularity can be witnessed when one stops to notice that these garbage bins in Norway are often filled with plastic bags that bottle recyclers have used to transport their bottles in (these plastic bags tend to leave olfactory remnants of beer or soda pop spillage) . Thus we see that plastic bags act as an important transport technology that the plastic bottle recycling industry depends at least partly on.

[99] European Union (2007).
[100] Dugnad is a custom in Norway in which local neighborhoods, schools, clubs, and organizations rely on joint voluntary work as a way of providing services required by the group. For example: painting playgrounds, refereeing sports events, cleaning curbsides.
[101] SFT (2008), p.13.
[102] Ibid.
[103] SFT (2008), p.2.
[104] SFT (2008), p.10.

Industrial and household waste bins: as garbage liners	60 %
Industrial and household waste bins: as waste	3 %
Waste bins placed beside bottle deposit-refund machines	18 %
Plastic recycling locations	15 %
Near glass and metal recycling locations	3 %
Near clothes collection and recycling locations	1 %
Total landfill plastic bags	100 %

Table 5.1. Sources of plastic bags that ultimately end up in Norwegian landfills. Source (SFT (2008), p.10)

In addition, we can see that Norwegians use plastic bags to recycle a host of other materials: glass, metal, and clothes. It should be noted that the effectiveness of these reuse and recycling programs could plausibly be compromised if Norwegian authorities were to follow other countries in implementing prohibitive plastic bag policies.

Plastic bag prohibitions, both performance based as well as technology based CAC strategies, would probably be inefficient if implemented in Norway. In Chapter 4 it was shown that implementation of prohibition strategies are less justified in societies that are not prone to human catastrophe via plastic bag littering. Norway is a country with an economy that more resembles the economy exposited in Figure 4.1, as opposed to the economy in Figure 4.2, because it does not seem to be prone to major floods, malaria infestation, or any other human catastrophe via plastic bag littering. This means that a full prohibition on plastic bags would probably be too stringent if applied in Norway. This result is exacerbated when we take into account the high benefit levels that Norwegians seem to extract from plastic bag consumption. In addition, it would seem that a partial prohibition on the thinner HDPE plastic bags would be less effective in Norway than many other jurisdictions due to the low fraction of HDPE

plastic bags in the Norwegian marketplace - the more robust LDPE plastic bags capture a dominant 90% of the Norwegian market[105].

It should be noted that information regarding the effects of plastic bag use in Norway on biodiversity loss are undocumented. Norway signaled its interest in preserving biodiversity when they ratified the Convention on Biodiversity in 1993[106]. In Norway, it is estimated that at least 130 plant and animal species have gone extinct in the last 150 years[107]. Whether or not any of these were a result of plastic bags littering is questionable due to the aforementioned underdocumentation. In Chapter 3 biodiversity loss as a potential externality was discussed. If evidence were to point towards plastic bag littering as being a cause of biodiversity loss in Norway, then Norwegian policy-makers must take that information into account when determining the optimal welfare level of plastic bag littering.

Chapter 2 was used to analyze worldwide plastic bag policy implementations. We saw there that the littering problem is so high in other countries so as to warrant plastic bag regulations. Norway, on the other hand, does not have any discernable plastic bag littering problem. This is a puzzle that can be reconciled by the economic theory exposited in this thesis, as follows.

One explanation might be that strong moral motives already exist within the Norwegian marketplace, moral motives that effectively function to restrain the littering level. If we go back to figure 4.1, we can imagine the moral norm being strong enough such that the economy's location on the dynamic development curve initially fell to the right of the unstable tipping point, a', which would have made the economy move to the stable equilibrium at $a = 1$. If this is the case then a consumer tax would be redundant because Norwegians already find themselves in a low litter or litter free environment. The plausibility of this explanation is strengthened when we consider a survey conducted by Bruvoll et al

[105] Ministry of the Environment (2001), p.8.
[106] Ibid.
[107] Ibid.

(2002) that points towards a high level of moral internalization in Norway. That particular survey found that up to 73% of Norwegians that recycled their household waste agreed that one of the reasons they recycled was because "I wish to think of myself as a responsible individual" and that 88% of Norwegians that recycled their household waste agreed that one of the reasons they recycled was because "I should do myself what I want others to do".

Another explanation might be because monetary incentives have already been altered by relative price increases set forth via commercial retailer charges on plastic bags in Norway. Commercial grocers such as *ICA, Rema 1000, Rimi,* and *Bunnpris* all charge a token payment, typically approximately 1 NOK per bag. As we saw in Chapter 4, if this commercial charge alters consumer beliefs about the *fraction of non-litterers* such that the interpretation goes from the left to the right of a' in Figure 4.1, then that charge can in fact cause the non-littering option to become the perceived morally correct action. On the face of it, it would seem that a commercial charge would be less effective when compared to a government charge. It could be argued that a government tax would appear less profit-oriented and thus have stronger signalling power than a commercial charge and therefore more effectively change consumers' idea of the morally ideal contribution. This would certainly be the case if we make the assumption that government taxes are backed by educational campaigns enlightening consumers about the morally ideal contribution whereas commercial charges are not. But nonetheless, commercial charges could still explain why moral norms became internalized in Norway – because the commercial plastic bag charge altered the consumer payoff structure by making it individually less profitable for individuals to litter plastic bags.

6 Conclusion

The world has witnessed a recent proliferation of plastic bag regulation policies. Most of these policies are implemented to curb perceived littering problems. The littering problem in the plastic bag case is a negative consumption externality that can have deleterious impacts on public good commodities such as aesthetics, biodiversity, and protection from human catastrophe. The environmental dilemma associated with the littering problem closely parallels that of a Prisoner's Dilemma game. This is a concern because, given economic actors of the *Homo Oeconomicus* type, a free riding problem can ensue and ultimately lead to inefficiency. In a model depicting a large population, a 100% litter free society would never exist.

The policies implemented to date are either command and control instruments such as complete or partial prohibitions or market based instruments such as consumer or producer taxes. Whether or not any of these instruments are economically justified depends on the nature of the jurisdiction's marginal benefits and marginal cost functions. Typically plastic bag prohibitions are inefficient. But economies do exist in which prohibitions may be justified.

A market that finds itself at an inefficient equilibrium can theoretically be corrected by implementing a first-best Pigou tax. However, only a second-best tax is possible in the plastic bag case because a consumer tax on the product itself is feasible whereas a tax on the littering activity is infeasible. The justification for a second-best tax implemented in the form of a plastic bag consumption tax is strengthened if consumers have moral preferences. If we amend the *Homo Oeconomicus* model to account for moral preferences, norms might be internalized so as to achieve a collectively better result. Government policy initiatives might be able to incentivize consumers to behave towards their perceived morally ideal way based

on socially contingent moral motivation. The consumer tax could best propagate a non-littering environment if aided by an educational campaign that creates stimulus response compatibility.

At this point in time, Norway has chosen not to implement plastic bag regulations. Norway does not seem to have a littering problem. This means that the potential negative externalities arising via plastic bag littering are of little relevance to Norway. A full prohibition in Norway would probably be inefficient because Norwegians seem to derive relatively high benefit levels from the plastic bag consumption process and they don't seem predisposed to human catastrophe via plastic bag littering. Effects of a partial prohibition on thin HDPE bags would presumably be marginal because the thicker LDPE bags dominate the Norwegian marketplace. Economic theory can help suggest why discrepancies exist between jurisdictions with significant littering problems and jurisdictions, like Norway, with insignificant littering problems. One such explanation, supported by empirical evidence, suggests that Norway is a country with strong moral motives already in place, moral motives that effectively function to restrain the littering level. Another explanation might be that monetary incentives to not litter have already been provided by relative price increases set forth via commercial retailer charges on plastic bags in Norway.

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