# AN ECONOMIC ANALYSIS OF MANDATORY DEPOSIT SYSTEM OF BEVERAGE CONTAINERS

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## ABSTRACT

Attempts to prevent littering include legal sanctions, advertising campaigns, and the encouragement of altruistic behavior and intrinsic satisfaction, although self-interest is undeniably a prospect of human nature. The economic approach to the littering problem is to recycle the containers. This was done by introducing the legislation of bottle bills. The rationale behind a mandatory deposit system is economic in nature. The consumer would be reacting to the financial incentive and returning the containers. This paper attempts to examine the consumer's behavior under the mandatory deposit system, using the comparative static analysis within a consumer's optimization model. **JEL Classification:** C02, Q5, Q57

## INTRODUCTION

This paper estimated the cost of implementation of deposit-refund systems for the packaging of beverages in Latvia. The economic assessment is based on the projection of future consumption of beverages and the amount of deposit packing respectively. However, the authors could find no academic studies on this topic. Therefore, this paper presented the methodology for assessing the collection, maintenance, investment, and other costs, as well as the results of empirical studies of packing deposit-refunded systems (Dace et. al., 2013).

This study is to present an original model for the production-recycling-reuse of plastic beverage bottles. It was found that the amount of bottles collected has the largest influence on the outcome of the total system unit, time, and cost. The model incorporates several unique aspects such as the cost of land use, environmental damages, and changes to the manufacturer (Matar, Jaber, & Searcy, 2014). The authors found that activism increases stringency in regulating overall as well as media-specific pollution. The result of different approaches to activism matter to U.S. environmental policies and their varied impacts across pollution media (Basu & Davara, 2014).

The economic approach to the littering problem is to recycle the containers. This was done by introducing the legislation of bottle bills. For the most part, these bills are intended to encourage consumers not to litter their beverage containers by imposing a mandatory deposit on all beverage containers. The rationale behind a mandatory deposit system is economic in nature. The deposit is supposed to act as an inducement to compensate for the inconvenience of returning bottles. In this paper, a consumer's optimization model is built, and then the comparative static analysis is used to examine the consumer's behavior under the mandatory beverage container deposit system.

## LITERATURE REVIEW

A vast number of goods leave a residue or container after consumption. Litter is created by the selfish individuals who discard any piece of this solid waste. Litter poses a number of environmental, social, and aesthetic problems. The presence of litter in a residential community decreases property value, and litter in commercial areas reduces sales and attracts fewer customers (Schultz, Bator, Large, Bruni, & Tabanico, 2013). However, researchers such as Massell and Parish (1968) argued that a consumer of the product will return the bottle if the refund exceeds the marginal disutility of returning the bottle, otherwise he will discard the bottle. Levi, Cortesi, Vezzelo, & Salvia (2011, as cited by Cooper & Gutowski, 2017) studied the "crossover distance" variable as it relates to recycling and reusing products. When the distance to a recycling center is long, then the emissions from inefficiently constructed vehicles used to transport goods and products create an unfavorable condition, leading to increased levels of environmental pollution. The authors claim that reusable packaging is advantageous for all but sparsely populated areas.

There are many ways to prevent people from littering, such as legal sanctions or modifying people's attitudes through education and advertising campaigns. Some studies show that legal sanctions are not effective because they are difficult to monitor and enforce. The chance of being detected, arrested, and fined is simply too low and intermittent to control littering effectively (Burgess, Clark, & Hendee, 1971). At present, all states have legislation that imposes a fine for littering on highways. The ineffectiveness of such legislation is evidenced by the fact that people still litter on the highways. In Alabama, the state uses prisoners to pick up litters on the highways.

Behavior scientists have de-emphasized the use of punishment approaches for large-scale behavior change because the enforcement is cumbersome and difficult. As such, alternative approaches are needed to control the littering problem. Geller (1985) suggested using behavior change approach to the control of littering. He argued that if the expertise of behavior science is applied properly to real-world management of litter and reusable resources, the behavior change approach can be quite effective in decreasing littering.

De Young (1991) studied the relationship between lifestyle and environmentally responsible behavior and found that the frugal lifestyle is conducive to reusing and recycling the limited natural resources. This implies that the control of littering could be achieved through promotion of frugal lifestyle. Some studies, like Lee, De Young, & Marans, 1995) and De Young (1991), reported that people derive non-contingent enjoyment in carrying out many ordinary repetitive behaviors, including resource conservation. People are able to derive intrinsic satisfaction from recycling behavior.

According to Haas, Krausmann, Wiedenhofer, & Heinz (2015), in some cases recycling can lead to ineffective reduction of material use, since energy requirements for recycling can be high. Graedel, Allwood, Birat, Buchert, Hageluken, Reck, Sibley, & Sonnemann (2011) and Mugdal, Tan, Carreno, Trigo, Dias, Pahal, & Fischer-Kowalski, (2011), as cited by Haas et. al. (2015), claim that the lower quality of secondary material can lead to increased virgin material demand, or secondary materials may not be used to substitute virgin materials, but may instead drive the production of new low-price products (Moriguchi, 2007). However, for some materials (such as metals), recycling is already very advanced.

Niero, Hauschild, Hoffmeyer, & Olsen (2017) devised a framework to combine eco-efficiency and eco-effectiveness which is based on a step-by-step procedure which aims to assess the effectiveness for establishing continuous loop beverage packaging systems. The result of the use of this procedure is a list of prioritized actions relating to elements necessary for efficient and effective implementation of upcycling, such as technology, logistics, waste management, and consumer and customer relationships. Niero et. al.'s strategy for the beverage packaging took into consideration an environmental and also an economic point of view.

Some researchers have found that increased rates of aluminum recycling can also affect overall aluminum demand (Zink, Geyer, & Startz, 2018). Increased recycling can lower the prices of both primary and secondary material, and thus increase demand for aluminum. Production and consumption data show that both aluminum recycling rates and a societal demand for aluminum have been growing swiftly over the last century. This increase in demand may be a result of a decrease in the price of aluminum.

There have been numerous studies on the use of economic incentives as tools of controlling littering. Burgess & Ratto (2003) reported that monetary incentive is the most effective way to reduce the littering. However, not all cities are provided with adequate funding for this approach. Fortunately, researchers such as Banguera, Sepulveda, Fuertes, Carrasco, & Vargas (2017) and Matar, Jaber, & Searcy (2014) have provided models that can be adapted to analyze and inform governmental policies or private initiatives in emerging economies in promoting the reduction, recycling, and re-use of waste, including models for understanding consumer behavior regarding the public's willingness to recycle.

The fear that human consumption is causing climate change, biodiversity loss, and mineral scarcity has recently caused an increase in rates of reuse and recycling, leading to a decrease in waste and new production. The environmental impacts of reuse have received attention. However, reusing old products does not guarantee an environmental benefit. Attention must be paid to the restoration and upgrading of old product efficiencies (Cooper & Gutowski, 2017).

## ASSUMPTIONS AND THE BASIC MODEL

In our analysis, we consider the problem of consumer choice in a world with only one commodity, and assume that this commodity has a returnable container on which a deposit is made. Let $I$ = consumer income, $x$ = commodity units purchased, $y$ = commodity container units returned, $P$ = gross price of $x$ including deposit, thus $P = P' + r$, where $P'$ = net price of $x$ and $r$ = deposit fee, $w = x - y$, the number of containers discarded.

Assume that all income I is spent on the commodity and discarded containers, the consumer's budget constraint is

$I = P'x + rw = Px - ry$

Let $U(x, \mathrm{y})$ be the utility function of the consumer. Since the consumer derives satisfaction by consuming the commodity x, the marginal utility of x is assumed to be positive, i.e, $\partial U/\partial x = U_1 > 0$ . However, it is inconvenient to return the containers, thus marginal utility of $y$ is negative, i.e., $\partial U/\partial y = U_2 > 0$.

Pursuant to these assumptions, the consumer's choice is to select a combination of $x$ and $y$ so as to maximize the utility function

(1) $U = U(x, y)$

Subject to the following constraints

(2) $I - Px + ry \geq 0$

(3) $x\text{-}y \geq 0$

The Lagrangean function is

(4) $L = U(x, y) + \lambda(I - Px + ry) + \mu(x - y)$

The first-order condition for utility maximization is

(5) $\partial L/\partial x = U_1 - \lambda P + \mu = 0$

(6) $\partial L/\partial y = U_2 + \lambda r - \mu = 0$

(7) $\partial L/\partial \lambda = I - Px + ry = 0$

(8) $\partial L/\partial \mu = x - y = 0$

## COMPARATIVE STATIC ANALYSIS

Here we will conduct a comparative static analysis to determine the impacts of the deposit fee on the number of the containers returned ($y$). Following the Jacobian implicit function theorem, we arrange the four partial derivatives of the first-order conditions into a square matrix in a prescribed order, called a Jacobian matrix and denoted by J, then take its determinant, the result is known as a Jacobian determinant, denoted by |J|.

(5′) $\partial L/\partial x = U_1 - \lambda P + \mu = F^1(x, y, \lambda, \mu) = 0$

(6′) $\partial L/\partial y = U_2 + \lambda r - \mu = F^2(x, y, \lambda, \mu) = 0$

(7′) $\partial L/\partial \lambda = I - Px + ry = F^3(x, y, \lambda, \mu) = 0$

(8′) $\partial L/\partial \mu = x - y = F^4(x, y, \lambda, \mu) = 0$

(9) $|J| = \partial(F^1,F^2,F^3,F^4)/\partial(x,y,\lambda,\mu)$

$$= \begin{vmatrix} \frac{\partial F^1}{\partial x} & \frac{\partial F^1}{\partial y} & \frac{\partial F^1}{\partial \lambda} & \frac{\partial F^1}{\partial \mu} \\ \frac{\partial F^2}{\partial x} & \frac{\partial F^2}{\partial y} & \frac{\partial F^2}{\partial \lambda} & \frac{\partial F^2}{\partial \mu} \\ \frac{\partial F^3}{\partial x} & \frac{\partial F^3}{\partial y} & \frac{\partial F^3}{\partial \lambda} & \frac{\partial F^3}{\partial \mu} \\ \frac{\partial F^4}{\partial x} & \frac{\partial F^4}{\partial y} & \frac{\partial F^4}{\partial \lambda} & \frac{\partial F^4}{\partial \mu} \end{vmatrix} = \begin{vmatrix} U_{11} & U_{12} & -P & 1 \\ U_{21} & U_{22} & r & -1 \\ -P & r & 0 & 0 \\ 1 & -1 & 0 & 0 \end{vmatrix}$$

$= (P-r)^2 > 0$

We are now able to determine the impact of the deposit fee on the number of containers returned (y). This impact can be determined by the sign of $\partial y/\partial r$.

(10) $$\frac{\partial y}{\partial r} = -\frac{1}{|J|}\frac{\partial(F^1,F^2,F^3,F^4)}{\partial(x,r,\lambda,\mu)}$$

$$= -\frac{1}{|J|}\begin{vmatrix} \frac{\partial F^1}{\partial x} & \frac{\partial F^1}{\partial r} & \frac{\partial F^1}{\partial \lambda} & \frac{\partial F^1}{\partial \mu} \\ \frac{\partial F^2}{\partial x} & \frac{\partial F^2}{\partial r} & \frac{\partial F^2}{\partial \lambda} & \frac{\partial F^2}{\partial \mu} \\ \frac{\partial F^3}{\partial x} & \frac{\partial F^3}{\partial r} & \frac{\partial F^3}{\partial \lambda} & \frac{\partial F^3}{\partial \mu} \\ \frac{\partial F^4}{\partial x} & \frac{\partial F^4}{\partial r} & \frac{\partial F^4}{\partial \lambda} & \frac{\partial F^4}{\partial \mu} \end{vmatrix} = -\frac{1}{|J|}\begin{vmatrix} U_{11} & 0 & -P & 1 \\ U_{21} & \lambda & r & -1 \\ -P & y & 0 & 0 \\ 1 & 0 & 0 & 0 \end{vmatrix}$$

$$= \frac{1}{|J|}\left[y\,(P-r)\right] > 0$$

Since $\partial y/\partial r$ is invariably positive, we can draw a qualitative conclusion that a small increase in the deposit fee will always result in an increase in the number of containers returned.

Similarly, we can use the same procedure to determine the impact of income on the number of containers returned.

(11) $$\frac{\partial y}{\partial I} = -\frac{1}{|J|}\frac{\partial(F^1,F^2,F^3,F^4)}{\partial(x,I,\lambda,\mu)}$$

$$= -\frac{1}{|J|}\begin{vmatrix} \frac{\partial F^1}{\partial x} & \frac{\partial F^1}{\partial I} & \frac{\partial F^1}{\partial \lambda} & \frac{\partial F^1}{\partial \mu} \\ \frac{\partial F^2}{\partial x} & \frac{\partial F^2}{\partial I} & \frac{\partial F^2}{\partial \lambda} & \frac{\partial F^2}{\partial \mu} \\ \frac{\partial F^3}{\partial x} & \frac{\partial F^3}{\partial I} & \frac{\partial F^3}{\partial \lambda} & \frac{\partial F^3}{\partial \mu} \\ \frac{\partial F^4}{\partial x} & \frac{\partial F^4}{\partial I} & \frac{\partial F^4}{\partial \lambda} & \frac{\partial F^4}{\partial \mu} \end{vmatrix} = -\frac{1}{|J|}\begin{vmatrix} U_{11} & 0 & -P & 1 \\ U_{21} & 0 & r & -1 \\ -P & 1 & 0 & 0 \\ 1 & 0 & 0 & 0 \end{vmatrix}$$

$$= \frac{1}{|J|}\,(P-r) > 0$$

Based on the fact that ∂2y/∂I is positive, our qualitative conclusion is that an increase in income will invariably increase the number of containers returned. It is reasonable to assume that people will purchase more commodity when their incomes are increased, thus they have more containers to be returned. To prove this assumption mathematically we have to determine the sign of ∂x/∂I.

(12)

$$\frac{\partial x}{\partial I} = -\frac{1}{|J|}\frac{\partial(F^1,F^2,F^3,F^4)}{\partial(I,y,\lambda,\mu)}$$

$$= -\frac{1}{|J|}\begin{vmatrix} \frac{\partial F^1}{\partial I} & \frac{\partial F^1}{\partial y} & \frac{\partial F^1}{\partial \lambda} & \frac{\partial F^1}{\partial \mu} \\ \frac{\partial F^2}{\partial I} & \frac{\partial F^2}{\partial y} & \frac{\partial F^2}{\partial \lambda} & \frac{\partial F^2}{\partial \mu} \\ \frac{\partial F^3}{\partial I} & \frac{\partial F^3}{\partial y} & \frac{\partial F^3}{\partial \lambda} & \frac{\partial F^3}{\partial \mu} \\ \frac{\partial F^4}{\partial I} & \frac{\partial F^4}{\partial y} & \frac{\partial F^4}{\partial \lambda} & \frac{\partial F^4}{\partial \mu} \end{vmatrix} = -\frac{1}{|J|}\begin{vmatrix} 0 & U_{12} & -P & 1 \\ 0 & U_{22} & r & -1 \\ 1 & r & 0 & 0 \\ 0 & -1 & 0 & 0 \end{vmatrix}$$

$$= \frac{1}{|J|}(P - r) > 0$$

Based on (12), we conclude that people will purchase more commodity as their incomes increase. Some empirical studies, like Vining and Ebreo (1990), found that recyclers are older, better educated and of higher socioeconomic status than non-recyclers. They believe that people in higher socioeconomic strata have better access to information about recycling, improving their willingness to recycle.

## CONCLUSION

Litter causes a number of environmental, social, and aesthetic problems. The economic approach to the littering problem is to recycle the containers. This was done by introducing a mandatory deposit system by legislation. The first bottle bill was enacted in Oregon in 1971. Today ten states have mandatory deposit systems requiring refundable deposits on certain beverage containers. The purpose of these systems is to encourage the reuse and recycling of beverage containers, and to discontinue the wasteful "no deposit, no return" throwaway attitude such attitude has created a littering problem.

This paper has examined the consumer's behavior under the mandatory deposit system, using the comparative static analysis within a consumer's optimization model. The result of our analysis indicated that an increase in the deposit fee will always result in an increase in the number of containers returned. It was also found that an increase in income will invariably increase the number of containers returned. Our analysis indicated that people will purchase more beverage as their incomes increase, thus they have more containers to be returned.

This article demonstrates the operation utility, and challenges the methodology, in the context of the U.S. aluminum industry. Sensitivity analyses reveal that displacement estimates are sensitive to uncertainty in price elasticities. Findings suggest that 100 per cent displacement is unlikely following a sustained supply-driven increase in aluminum recycling and even less likely in the long term (Zink et. al, 2018). Our conclusions are supported by the data collected by the container recycling institute. The institute reported that states with mandatory deposit systems have a beverage container recycling rate of around 60 per cent, while no-deposit states only reach about 24 per cent.

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