REFILLABLE VERSUS NON-REFILLABLE CONTAINERS: THE IMPACT OF REGULATORY MEASURES ON PACKAGING MIX AND QUALITY CHOICES

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Abstract: With the continually declining percentage of soft drink sales in refillable bottles in favour of cans and PET bottles, despite a growing soft drink market, governments have become increasingly concerned about the alleged more environmentally harmful impacts of throw-away convenience packaging and tried to enact policies to induce consumers to switch to refillable glass bottles. In many cases, fully or partially refundable deposits have been opted for to provide consumers with the incentive to properly dispose of packaging, but not to switch between different container types, and thus, they may not constitute the most desirable solution. The effects of various regulatory measures on producers' choices of packaging quality and mix in the presence of consumers with differing demand intensities are therefore analyzed to discern the least distortionary alternative.

1 Introduction

Product packaging has become an essential facet of daily market transactions, fulfilling numerous functions such as the protection, sanitization, and marketing of products, but has, at the same time, evolved into one of the major sources of litter and solid waste, accounting for "approximately 30 per cent by weight and by volume of all household waste."[1] Given that the private cost of using unappropriated environmental resources is zero, neither producers nor consumers have any market incentive to internalize the adverse impact of packaging upon the environment by eliminating over-packaging and investing in the development of less detrimental packaging, and by reusing or recycling. Government intervention is therefore reasonable through corrective measures such as product charges, litter taxes, energy taxes, mandatory deposits, and bans, if efficient use of environmental amenities is to be realized.

Although soft drink containers represent a very small proportion by weight of total solid waste (only 1 per cent in Canada),[2] they constitute one of the main targets of legislators, probably because of their growing variety and rapidly changing mix, both of which reflect changes in consumer tastes and the relative costs of packaging materials, and their increasing per capita consumption (from 72.3 litres in 1966 to 181.7 litres in 1992 in the United States, and from 68.6 litres in 1978 to 108.6 litres in 1995 in Canada).[3] At the present, there are three types of packaging in which consumers can buy soft drinks: glass bottles, which are further divided into reusable (or refillable) and non-reusable (or non-refillable), plastic bottles (usually made from polyethylene terephthalate, or PET), and aluminum or bi-metallic cans. As different container systems have different impacts upon the solid waste stream, governments have attempted to enact policies favouring the least waste-generating packaging, which has traditionally been identified as the refillable bottle. The hypothesis that reusable packaging is more environmentally sound has recently been subject of debate in view of the recent high recovery (or recycling) rates of the one-way container and the uncertainty over the trippage rate (i.e., the number of times the refillable bottle is reused).

The packaging dilemma is compounded by the continually declining percentage of soft drink sales in reusable bottles in favour of cans and PET bottles,[4] despite a growing soft drink market and, in some cases, the presence of refillable sales requirements (for example, in Ontario, regulations 340 and 357 of the provincial Environmental Protection Act require soft drink manufacturers to sell at least 30 per cent of their products in refillable containers). The reasons generally given to explain the strong positive trend towards non-reusable containers are not only demand-related, such as increases in consumer preference for throw-away convenience packages (which may reflect the more active labour market participation of households), but also supply-related, such as increases in the transportation distances due to bottling consolidation resulting, in turn, from economies of scale exploitation (from 3,000 plants in 1970 to just 780 in 1991[5]).[6] Hence, the question of whether governments should target the supply side or the demand side to encourage the use of the least environmentally harmful packaging further complicates the choice of the type of use-constraining policy.

The issue of consumer heterogeneity, which seems to be neglected by those advocating such measures as constraints on the minimum sales of more environmentally friendly containers or complete bans on “undesired” containers, therefore needs to be addressed before an evaluation of various policy proposals for the regulation of packaging is possible. In fact, producers may be unable to identify consumers (that is, to purely discriminate), but nonetheless, they may exploit the heterogeneous nature of preferences by supplying more than one type of container, even if they may find it more profitable to offer some consumers a less desirable packaging alternative. That consumers are heterogenous with respect to packaging is supported by the finding of a 1992 Angus Reid survey that almost a third of Ontarians would buy refillable bottles 75 per cent of the time, and 13 per cent would buy them 50 per cent of the time.[7]

In the standard model of quality choice, the extent to which consumers' preferences affect producers' decisions depends on the market structure,[8] which, in the case of the soft drink industry, can be best described as a duopoly (Coca-Cola Company and PepsiCo Inc.) with a competitive fringe. However, the focus of this paper is not on the quality of soft drinks but on that of their packaging, and particularly, on the quality of refillable bottles versus that of non-refillable containers. Since the strategic variables of soft drink manufacturers are product quality and price and not packaging, the choice of packaging quality, along with that of packaging mix, can be viewed as a response to the differing preferences of the market segment each producer serves, and thus, in the context of a monopolistic structure.[9] Accordingly, a model of container choice with a single producer and a continuum of heterogenous consumers can provide useful insights into the trends of the soft drink packaging market, in addition to being an adequate conceptual framework for the analysis and evaluation of various regulatory measures on containers, as presented in section 3, on the basis of which policy recommendations are formulated in section 4.

2 The Model

This paper considers the decision-making process of a monopolist which produces some generic product (such as cola) but has to choose the quality levels of its two packaging options and their respective market shares. The demand side consists of a continuum of consumers who differ in their valuations of the environmental attributes of packaging, such as reusability and energy intensity; for simplicity, these attributes are embodied in a single index, q, from now on referred to as packaging quality. The utility function of each consumer, who is assumed to buy only one unit of the commodity, is quasilinear, as in Mussa and Rosen (1978) and Maskin and Riley (1984), and given by

$$U(\theta) = x + V(q_i, \theta), \qquad i = 1, 2, \tag{1}$$

where x is a composite commodity other than the good in question, θ is a positive, one-dimensional parameter which measures the intensity of the consumer's taste for container quality and is assumed to be distributed over an interval $[\underline{\theta}, \bar{\theta}]$ according to a continuously differentiable distribution function $F(\theta)$, and $V(q_i, \theta)$ is an increasing and strictly concave function of q_i and θ which satisfies the single-crossing property, or equivalently, the assumption that the consumer with the larger total willingness to pay has also the larger marginal willingness to pay. The surplus enjoyed by each consumer is then given by

$$CS(\theta) = V(q_i, \theta) - p_i, \qquad i = 1, 2, \tag{2}$$

where p_i is the price of the product of the i^{th} quality container.

Equation (2), when set equal to some constant k, defines an isovalue (or indifference) curve, which gives the various combinations of q and p yielding a surplus of value k. Illustrated in Figure 1, isovalue curves are positively sloped and concave, and the closer they are to the horizontal axis, the higher the level of satisfaction they represent.[10] Of special interest is the indifference curve defined by $CS(\theta) = 0$, which indicates the type-θ consumer's maximum willingness to pay for the various levels of q, and therefore, the maximum surplus the monopolist can potentially extract.

The producer has only two packaging options but faces a spectrum of heterogenous consumers, hence, it cannot engage in perfect price discrimination even if it is able to distinguish among different buyers prior to an actual sale or prevent resale in other markets. It must then "bunch" consumers with higher taste parameters onto the high-quality (or type-q_2) packaging, and accordingly, consumers with the lower taste parameters onto the low-quality (or type-q_1) packaging. For a fixed product market size given by the interval $[\underline{\theta}, \bar{\theta}]$, and by the single-crossing property assumption, the monopolist need consider solely the participation constraints of the marginal consumers, that is, the consumer indifferent between buying the low-quality container and nothing (or type-$\underline{\theta}$ consumer) and the consumer indifferent between buying the high-quality container and the low-quality container (or type-θ_{12} consumer). If the monopolist cannot separate buyers but knows their type distribution and utility functions, then it has to ensure not only that both marginal consumers are at least not better off withdrawing from the market, but also that the one type is at least not better off with the quality-price combination designed for the other type and vice versa (incentive compatibility or self-selection constraints).

With the market size normalized to one (for ease of exposition and without loss of generality) and a per unit cost of production given by $C(q) = c_0 + c(q)$, where c_0 is the cost of the content of the container which is independent of container quality, and $c(q)$ is the packaging cost which is increasing in q at a non-decreasing rate and exhibits constant returns to scale for any level of q, the monopolist's objective is to

$$\max_{\{q_2, q_1, \theta_{12}\}} \Pi = [1 - F(\theta_{12})][p_2 - C(q_2)] + F(\theta_{12})[p_1 - C(q_1)] \tag{3}$$

subject to

$$V(q_1, \underline{\theta}) - p_1 \geq 0, \tag{4}$$

$$V(q_2, \theta_{12}) - p_2 \geq 0, \tag{5}$$

$$V(q_1, \underline{\theta}) - p_1 \geq V(q_2, \underline{\theta}) - p_2, \tag{6}$$

$$V(q_2, \theta_{12}) - p_2 \geq V(q_1, \theta_{12}) - p_1, \tag{7}$$

and

$$\underline{\theta} \leq \theta \leq \bar{\theta}. \tag{8}$$

Equations (4) and (5) are the participation constraints, and (6) and (7) the incentive compatibility constraints. Of these four constraints, only two are binding; specifically, if constraint (7) is binding, both marginal consumers participate in the market, and the single-crossing property holds, then neither (5) nor (6) is binding.[11] The interior solution to the problem is characterized by

$$V_1(q_2, \theta_{12}) = c'(q_2), \tag{9}$$

$$V_1(q_1, \underline{\theta}) = F(\theta_{12})c'(q_1) + [1 - F(\theta_{12})]V_1(q_1, \theta_{12}), \tag{10}$$

and

$$[V(q_2,\theta_{12}) - V(q_1,\theta_{12})] - [c(q_2) - c(q_1)] = \frac{[1-F(\theta_{12})]}{F'(\theta_{12})}[V_2(q_2,\theta_{12}) - V_2(q_1,\theta_{12})], \tag{11}$$

where $[1-F(\theta_{12})]/F'(\theta_{12})$ is the reciprocal of the hazard rate and is a non-increasing function for many well-known densities, including the uniform and the exponential,[12] and $V_i(q,\theta)$ denotes the partial derivative of $V(q,\theta)$ with respect to the i^{th} argument.

In terms of Figure 1, equation (9) corresponds to point A^{ID}, which is Pareto efficient in the sense that the marginal willingness to pay for packaging quality of the type-θ_{12} consumer is exactly equal to its marginal cost. However, from (10), the container quality provided to the type-$\underline{\theta}$ consumer, which is represented by point B^{ID}, is distorted by the sum of the marginal benefit of type-q_1 packaging to the type-θ_{12} consumer weighted by the market share of type-q_2 packaging and the additional cost of type-q_1 container weighted by its market share. By equation (11), which gives the steepness of the type-θ_{12} consumer's isovalue curves, with a higher θ_{12} corresponding to steeper curves, the monopolist equates the profit from inducing one consumer to switch from type-q_1 packaging to type-q_2 packaging through a lower θ_{12} to the decrease in the total consumer surplus it is able to extract from the consumers bunched onto the type-q_2 container, or high-demand consumers.

Graphically, points A^{PD} and B^{PD}, at which the slope of the zero-$CS(\underline{\theta})$ isovalue curve and that of the zero-$CS(\theta_{12})$ curve, respectively, are equal to the corresponding marginal costs (assumed increasing in q in Figure 1), constitute the separating equilibrium when the producer is able to successfully identify and separate consumers. In the alternative case discussed here, that is, when the monopolist is unable to distinguish among consumers, the quality-price combination represented by B^{PD} can no longer be offered, since it would attract the high-demand consumers and a pooling equilibrium would result. Furthermore, the quality-price pair at point B, where the two zero-$CS(\theta)$ indifference curves intersect, would not provide the type-θ_{12} consumer with a positive surplus, thus leaving him or her indifferent between switching and not switching. Any point on the zero-$CS(\underline{\theta})$ locus between B and B^{PD} is then a candidate for separating equilibrium: the closer to point B, the smaller the per unit profit on type-q_1 packaging, but the larger that on type-q_2 packaging.[13] The prevailing equilibrium is such that the marginal decrease in the profits collected from the low-demand consumers as a result of a reduction in q_1 (the difference between the vertical distance from the zero-$CS(\underline{\theta})$ locus to the cost function at q_1^G and the same distance but at q_1^F multiplied by the market share of type-q_1 packaging) just equals the marginal increase in the profits collected from the high-demand consumers (the vertical distance between $CS^F(\theta_{12})$ and $CS^G(\theta_{12})$ multiplied by the market share of type-q_2 packaging).

3 Effects of Various Government Policy Measures

In view of the continually changing packaging mix in favour of non-reusable containers and at the expense of reusable bottles, which have traditionally been reputed to be less detrimental for the environment, governments have found their intervention necessary but have sometimes failed to formulate policies capable of achieving the desired outcome, as in Ontario, where a 1985 law stipulates 30 per cent of the volume of carbonated soft drinks be sold in refillable containers,[14] disregarding any potential reluctance of retailers to distribute them (for example, supermarkets tend to have a policy of low prices and fast turnover of goods, therefore preferring non-refillable containers) and consumer needs and demands. Of course, the possibility that the environmental performance of aluminum cans or PET bottles is better than that of reusable glass containers on account of their high recovery rates, as recently suggested, leaves room for an even more critical policy failure.

A comparative social evaluation of different packaging systems would require an accurate assessment of the life cycle impacts of each container type on solid waste or litter, air and water pollution, and energy usage,[15] which is beyond the scope of this paper. In the following subsections, the market share of total drink sales in refillable bottles is thus presumed suboptimal so that policy makers face the problem of defining the most effective strategy for the socially optimal packaging mix to be achieved, taking into account that the market is divided between consumers who prefer reusable (or the high-quality) containers and consumers who prefer non-reusable (or the low-quality) containers.[16]

3.1 Minimum Quantity Legislation

One of the regulatory measures available to jurisdictions to induce an increase in the market share of reusable packaging is the minimum quantity legislation, according to which the percentage of sales in refillable containers must not fall below a certain level or the producer is subject to a fine if caught. Under the assumption of risk neutrality, a minimum quota of h refillable bottles, with $0 \leq h \leq 1$, if binding (that is, if $(\bar{\theta} - \theta_{12}) < h$ under no regulation), translates into a decrease in the monopolist's profits by the expected cost of not meeting the target, so that its objective is now to

$$\max_{\{q_2, q_1, \theta_{12}\}} \Pi = [1 - F(\theta_{12})][p_2 - C(q_2)] + F(\theta_{12})[p_1 - C(q_1)] + \xi a[1 - F(\theta_{12}) - h] \qquad (12)$$

subject to (4), (7), and (8), where ξ is the probability of being caught selling below the quota and being convicted once caught, and a is the penalty for each per cent below the target. While the profit-maximizing conditions with respect to q_2 and q_1 remain unchanged, the first-order condition with respect to θ_{12} is altered to

$$[V(q_2, \theta_{12}) - V(q_1, \theta_{12})] - [c(q_2) - c(q_1)] + \xi a = \frac{[1 - F(\theta_{12})]}{F'(\theta_{12})}[V_2(q_2, \theta_{12}) - V_2(q_1, \theta_{12})], \qquad (13)$$

which gives a θ_{12} that is smaller than the one satisfying (11) from the second-order conditions. When choosing q_2, the monopolist then faces a flatter isovalue curve for the type-θ_{12} consumer and finds it in its best interest to lower the reusable packaging quality, as (9) is an increasing function of θ_{12}. The extent of the decrease in q_2 depends on ξ, a, and the skewedness of the taste parameter distribution. Clearly, the smaller ξ and/or the smaller a, the lower the impact of the legislation on the monopolist's choice of θ_{12}, and thus, the smaller the resulting distortion of the reusable container quality. Furthermore, the more concentrated towards the upper bound θ is, or the more skewed to the right the density function associated with $F(\theta)$ is,[17] the larger the reciprocal of the hazard rate is and the less responsive (13) is to a change in θ_{12}, and therefore, the greater the impact of the regulation on the producer's choice of θ_{12} and the larger the decrease in q_2.

If packaging mix and quality choices were considered to be made in a two-stage non-cooperative game and the analysis were to incorporate the first stage as well,[18] the overall effect of a minimum quantity legislation may also include a decrease in the market segment the monopolist serves; in fact, the larger the proportion of consumers with high taste parameters, the more profitable it is for the producer to distort the quality of non-reusable packaging upward and drive consumers with the least demand intensities out of the market, thus increasing the market share of reusable bottles only indirectly and offsetting the reduction in profits from the loss of some buyers of non-reusable packaging with the additional surplus it is able to extract from buyers of reusable packaging.

3.2 Mandatory Deposit/Refund System

A deposit/refund system is probably the most common policy measure adopted by governments to encourage consumers to return packaging. In Canada, for example, all soft drink containers must carry a deposit, which is fully refundable in Quebec, Alberta, Prince Edward Island, Saskatchewan, and British Columbia, and partially refundable only in New Brunswick. In the United States, a legislation of the type introduced in Oregon in 1972, which requires that all beverage containers carry a refundable value and also prohibits the sale of cans with tabs, is in place in many other states including Vermont (since 1977), Michigan and Maine (1978), Connecticut (1980), Delaware

(1982), and New York and Massachusetts (1983). In most cases, the levels at which deposits and refunds are respectively set are independent of packaging type, therefore providing consumers only with an incentive to return containers but not to switch from non-refillable packaging to refillable packaging. In fact, as deposits impose an additional cost on consumers through higher prices and, if redeemed, through higher disposal time requirements (which are higher for refillable glass bottles because of their weight and breakable nature), they result in a vertically upward shift of the two zero-$CS(\theta)$ loci, with no effect on the monopolist's choices of q_1, q_2, and θ_{12}. Hence, in order for the monopolist to find it profitable to induce some consumers to switch to reusable packaging, the additional refund on refillable containers has to be greater than the additional cost of returning them, or the additional expected cost of not redeeming the deposit on non-refillable containers has to be larger than the expected cost of returning refillable bottles over and above that of returning non-refillable containers.[19] In other words, the expected cost of such a regulation has to be decreasing in container quality, either through a constant deposit on all containers but a higher refund on reusable bottles or through a constant refund but a higher deposit on non-reusable containers.

Mandatory deposit/return systems may also increase the bottling cost faced by beverage producers if reusing refillable packaging is more expensive than manufacturing new packaging and/or if recycling non-refillable packaging faces technical and economic barriers, as the recent German experience of the Duales System Deutschland (DSD) has found to be the case with plastics.[20] Given that reusing refillable bottles is likely to be more costly than recycling non-reusable containers and reusing recycled materials instead of virgin materials on account of the more demanding collection process and required washing and relabelling,[21] the additional cost imposed by such systems on producers is expected to be increasing in container quality.

Under a government-initiated differential deposit/return system, which levies higher deposits on the low quality packaging or allows higher refunds on the high quality packaging, the consumer surplus is given by

$$CS(\theta) = V(q_i, \theta) - p_i - b(q_i), \qquad i = 1, 2, \tag{14}$$

where $b(q)$ is the expected cost of the legislation, $b'(q) < 0$ and $b''(q) = 0$; the resulting two zero-$CS(\theta)$ loci are therefore steeper and shifted upward. Faced with a larger per unit cost of production, which is given by $C(q) = c_0 + c(q) + d(q)$, where $d(q)$ is the average cost imposed by the regulation, $d'(q) > 0$ and $d''(q) = 0$, the profit-maximizing monopolist chooses q_2 and q_1 such that

$$V_1(q_2, \theta_{12}) = c'(q_2) + b'(q_2) + d'(q_2), \tag{15}$$

and

$$V_1(q_1,\underline{\theta}) = F(\theta_{12})[c'(q_1) + b'(q_1) + d'(q_1)] + [1 - F(\theta_{12})]V_1(q_1,\theta_{12}), \tag{16}$$

respectively, and θ_{12} such that

$$\begin{aligned}[V(q_2,\theta_{12}) - V(q_1,\theta_{12})] - [c(q_2) - c(q_1)] - [b(q_2) - b(q_1)] - [d(q_2) - d(q_1)] \\ = \frac{[1 - F(\theta_{12})]}{F'(\theta_{12})}[V_2(q_2,\theta_{12}) - V_2(q_1,\theta_{12})].\end{aligned} \tag{17}$$

Unlike a minimum quantity legislation, a deposit/refund system can bring about an increase in θ_{12} if the monopolist's additional average cost of handling returned refillable containers exceeds consumers' additional expected benefit from buying them, or if $d'(q) > |b'(q)|$. However, given a good estimate of $d(q)$, governments always have the option of setting deposits and refunds at such levels that the opposite condition is satisfied, and that is, $|b'(q)| > d'(q)$, which implies that the θ_{12} solving (17) is smaller than that under no government intervention, and the q_2 solving (15) is smaller than that under fixed packaging mix.

The decrease in q_2 resulting from the monopolist's choice of a lower θ_{12}-type consumer may then offset its upward distortion caused by the initial decrease in consumer surplus and increase in production cost; in fact, by the assumption that $|b'(q)| > d'(q)$, a deposit/return system of the type described above increases the marginal benefit of quality, as $[d(q)+b(q)]$, which represents the total negative impact of the regulation on the monopolist's profit (direct cost plus forgone consumer surplus), is decreasing in q. Hence, at the equilibrium levels of q_1 (q_1^{ID}), q_2 (q_2^{ID}), and θ_{12} (θ_{12}^{ID}) under no regulation,

$$F(\theta_{12}^{ID})[V_1(q_1,\underline{\theta}) - b'(q_1^{ID}) - c'(q_1^{ID}) - d(q_1^{ID})] > [1 - F(\theta_{12}^{ID})][V_1(q_1^{ID},\theta_{12}^{ID}) - V_1(q_1^{ID},\underline{\theta})], \tag{18}$$

that is, the marginal benefit of q_1 (the increase in the profits from non-reusable packaging sales) is greater than its marginal cost (the increase in the forgone surplus of the high-θ consumers buying non-reusable packaging over and above the surplus extracted from the low-θ consumers), and

$$V_1(q_2^{ID},\theta_{12}^{ID}) - b'(q_2^{ID}) > c'(q_2^{ID}) + d'(q_2^{ID}), \tag{19}$$

that is, the marginal benefit of q_2 (the increase in the surplus extracted from the high-θ consumers buying reusable packaging) is greater than its marginal cost. As both marginal benefits are diminishing in q, and both marginal costs increasing, the monopolist would definitively increase the quality levels of its two container types if it had no control over the market share of each of them. With packaging mix being endogenously determined and a mandatory deposit/return system which favours reusable packaging, the producer, however, finds it profitable to lower θ_{12}, thus increasing the market share of refillable bottles. The decrease in θ_{12} serves to also decrease the marginal benefits of q_1 and q_2 and contributes to bring them in line with the corresponding marginal costs, so that the overall impact of this policy measure on q_1 and q_2 may be negligible relative to that of a minimum quantity legislation.

3.3 Energy Use Constraint

Another policy measure of a less regulatory nature than that of a mandatory deposit/return system but capable of attaining the same results is a constraint on life cycle energy usage with a penalty per unit of energy used over and above an exogenously determined upper limit.[22] Given that different containers have differing energy requirements, the constraint can be expressed as a weighted average of the per unit energy requirements of the two packaging types under consideration, with the weights given by their respective market shares, and that is,

$$F(\theta_{12})E(q_1) + [1 - F(\theta_{12})]E(q_2) \leq \bar{E}, \tag{20}$$

where $E(q)$ is the per unit energy required in the production of quality q container, with $E'(q) < 0$ to reflect the claim that refillable bottles are less energy-consuming and $E''(q) = 0$ for simplicity, and where $\bar{E}$ is the maximum allowable average energy usage, net of trippage and recovery rates. Of course, the effectiveness of such a regulation is conditional upon the expected per unit punishment, or the probability of being caught consuming an average energy level above the target (δ) times the penalty per unit of average energy over and above the target (g).

With a positive expected punishment given by the product of δg and the difference between the right-hand-side and the left-hand-side of (20), the producer's two profit-maximizing quality choices are such that

$$V_1(q_2, \theta_{12}) = c'(q_2) + \delta g E'(q_2) \tag{21}$$

and

$$V_1(q_1, \underline{\theta}) = F(\theta_{12})[c'(q_1) + \delta g E'(q_1)] + [1 - F(\theta_{12})]V_1(q_1, \theta_{12}), \tag{22}$$

respectively, and the profit-maximizing θ_{12} satisfies

$$\begin{aligned} [V(q_2, \theta_{12}) - V(q_1, \theta_{12})] - [c(q_2) - c(q_1)] - \delta g[E(q_2) - E(q_1)] \\ = \frac{[1 - F(\theta_{12})]}{F'(\theta_{12})}[V_2(q_2, \theta_{12}) - V_2(q_1, \theta_{12})]. \end{aligned} \tag{23}$$

Hence, like under a deposit-refund system, by legislating an energy use constraint policy makers can induce an increase in the market share of refillable bottles with negligible distortionary effects on their quality level and that of non-refillable containers.

3.4 User Charges for Refuse Disposal

The contribution of packaging to solid waste generation is of a much lesser concern whenever individuals are made directly responsible for the disposal of the waste they generate, and that is, they are charged the marginal cost of the services they consume. In most cases, however, refuse collection is financed through property taxes, which do no vary with the amount of refuse collected, the type of service (i.e., the pickup location), and the frequency of collection, and are thus unable to provide individuals with incentives to reduce waste generation and to recycle or, if applicable, return the waste generated. In contrast, user charges can enhance economic efficiency by inducing individuals to change their consumption patterns in ways which economize on scarce resources.[23]

While pay-as-you-throw programmes can bring about quite substantial reductions in the quantity of consumption wastes, they are not necessarily capable of inducing consumers to switch from non-refillable to refillable packaging. If user charges are imposed on waste per unit of volume or weight, it is quite possible that the use of refillable glass bottles be discouraged in favour of cans and plastic containers. Hence, in order for programmes of this type to be effective not only at diverting both types of packaging from landfill sites through recycling and return practises but also at encouraging the use of refillable packaging, containers must be separated from other waste prior to curbside collection and the charges on users of cans and/or plastic bottles must be greater than those on users of refillable glass bottles. In terms of the model of section 2, disposal charges must be decreasing in quality, therefore affecting the producer's choice variables in the same manner as, but more effectively than (in the absence of the partially offsetting effect of $d(q)$ on θ_{12}), a deposit/refund system.

Under a curbside fee programme, the interior solution to the monopolist's maximization problem is given by

$$V_1(q_2, \theta_{12}) = c'(q_2) + r'(q_2), \tag{24}$$

$$V_1(q_1, \underline{\theta}) = F(\theta_{12})[c'(q_1) + r'(q_1)] + [1 - F(\theta_{12})]V_1(q_1, \theta_{12}), \tag{25}$$

and

$$[V(q_2, \theta_{12}) - V(q_1, \theta_{12})] - [c(q_2) - c(q_1)] - [r(q_2) - r(q_1)]$$

$$= \frac{[1 - F(\theta_{12})]}{F'(\theta_{12})}[V_2(q_2, \theta_{12}) - V_2(q_1, \theta_{12})], \tag{26}$$

where $r(q)$ is the expected cost of the regulation on consumers, $r'(q) < 0$, and $r''(q) = 0$. Diagrammatically, for any given θ, the zero-$CS(\theta)$ locus is to the left of and steeper than that under no regulation; however, as the consumer indifferent between buying type-q_2 packaging and buying type-q_1 packaging is chosen with a lower θ_{12}, the $CS(\theta_{12})$ indifference curve is flatter than that under fixed packaging mix.

4 Policy Evaluations and Recommendations

If the objective of governments is to affect packaging mix in favour of reusable bottles and not at the expense of container quality distortions, especially if downward, a minimum quantity legislation is doubtlessly the most ineffective of the four policies considered in the previous section. Furthermore, a refillable bottle sales constraint which targets only producers, therefore overlooking the economic significance of retailers' and consumers' preferences on producers' decisions, is very difficult to enforce, as experienced in Ontario, where the percentage of sales in refillable glass bottles has been below the legally required minimum of 30 per cent since 1988.

Because of the distortionary effects of a minimum refillable quota on the quality levels of the two packaging options available, governments should turn their attention to either a deposit/return system, an energy use constraint, or a curbside fee programme. Of these three interventionary directions, however, the energy use constraint can be shown to be the most welfare-enhancing; in fact, under the assumption that $\delta E'(q) \equiv r'(q) \equiv b'(q) + d'(q)$, or that the impacts on packaging mix and quality of the three policies are the same, an energy use constraint represents a Pareto-improvement to a curbside fee programme which, in turn, is socially superior to a mandatory deposit/return system under the assumption that the recycling and disposal incentives of the two regulations are the same.[24] The welfare gain (WG) of an energy use constraint over a disposal charge programme is given by

$$WG^E = r(q_2) + \delta g[\bar{E} - E(q_2)] > 0, \tag{27}$$

and that of a disposal charge programme over a deposit/return system is given by

$$WG^r = b(q_2) + d(q_2) - r(q_2) > 0, \tag{28}$$

which is strictly positive if $r(q_2) = b(q_2)$, implying that the two policies have exactly the same economic efficiency effects on the reduction of waste disposal. Hence, a constraint on energy usage is the best regulatory measure for governments interested in increasing the refillable market share at the lowest possible welfare cost.

Although consumers' recycling attitudes and practices are not modelled in this paper, where the emphasis is on regulations available to policy makers to induce a switch from non-reusable to reusable containers in light of the recent debate over packaging mix, any policy should also be evaluated with respect to its ability to generate the appropriate incentives to ensure that containers are returned. In fact, if the claim that refillable bottles are better for the environment based on life cycle considerations is valid (as suggested by regulations of the type used in Ontario), increasing the market share of reusable packaging is necessary but not sufficient for its advantages to be fully captured, and therefore, inducing consumers to recycle and return packaging becomes an essential facet of the problem. In view of this, an energy use constraint should be accompanied by a curbside disposal fee per unit of waste generated with either a reasonably high penalty on litter or a monitoring mechanism capable of deterring people from illegal disposal. Figure 3 is thus constructed to include the effect of an energy use constraint (upward shift and flattening of the cost function for $q > 0$, as depicted in Figure 2), with q_1^*, q_2^*, and θ_{12}^* as the resulting equilibrium, and the effect of a curbside fee (upward shift and steepening of the zero-$CS(\theta)$ loci), with q_1^{**}, q_2^{**}, and θ_{12}^{**} as the prevailing equilibrium. In Figures 2 and 3, the equilibrium qualities of refillable and non-refillable containers are also given under the assumption that the market shares of the types of packaging are constant, that is, for a fixed θ_{12}, in the presence of an energy use constraint (q_1^E and q_2^E) and a curside fee (q_1^r and q_2^r), respectively. In addition to contributing to affect the market share of refillable containers, user charges provide consumers with the proper incentives to return packaging.

5 Concluding Remarks

Although the equilibrium packaging mix resulting from the policy recommendations discussed above consists of a higher market share of refillable containers, this paper does not aim at supporting the claim of those advocating reusable glass bottles as the most environmentally friendly soft drink packaging, but tries to address the importance of consumer heterogeneity and producers' response to this reality in the evaluation of various packaging regulations (for a given policy direction). The choice of the container type to be favoured because of its least environmental impacts is certainly difficult, but it is also an empirical issue, worth pursuing, which is independent of the market mechanism, and therefore does not alter the theoretical rationale of any policy formulation.

The fact that consumers differ in their tastes for packaging quality is often recognized on the basis of sales percentages by both the soft drink industry and policy makers, with the risk, however, of overestimating the extent to which sales volume is a reflection of consumer preferences, and of erroneously attributing the downward trend in the consumption of soft drinks in refillable glass bottles to the presence of very few individuals preferring these containers. Indeed, a 1992 Angus Reid survey, shows that "31 per cent of Ontarians would buy refillables 75 per cent of the time, and 13 per cent would purchase them half the time,"[25] thus conflicting with the claim of soft drink manufacturers that consumers prefer cans and plastic bottles. The role of consumer heterogeneity on the market share performance of reusable containers is undeniable and more than simply a justification for current packaging trends. It is then by understanding how economic forces link production and consumption decisions, when consumers have differing preferences and producers cannot distinguish among them, that policy makers can gain useful insights and formulate more efficient regulatory measures.

Endnotes

1. Waite (1995), p. 134.
2. Canadian Soft Drink Association, CSDA, (1993a).
3. Muris, Scheffman, and Spiller (1993), p. 56; CSDA (1978, 1992, 1995).
4. The declining trend of soft drink sales in refillable bottles has been witnessed not only in North America but also in Europe. For details, see Appendix A.
5. Beverage Industry (1991), cited in Muris, Scheffman, and Spiller (1993), p. 63.
6. Research Triangle Institute (1975), cited in OECD (1978), p. 20.
7. Globe and Mail (1992).
8. For example, Champsaur and Rochet (1989) show that in a two-stage non-cooperative game of quality and price choices there is always a subset of intermediate qualities that are not offered for sale under a duopoly although they would be produced under both competition and monopoly.
9. Packaging mix and quality can be viewed as the choice variables in the second state of a two-stage non-cooperative game. In the first stage, the duopolists and competitive fringe compete by offering differentiated products to consumers who differ in their tastes over product quality; in the second stage, given the market share and product quality determined in the first stage, each firm decides upon packaging mix and quality in view of the differing valuations of consumers over packaging quality. As the emphasis of the paper is on packaging mix and quality, the analysis focuses on the second stage of the game and the assumption of a monopolistic structure is thus reasonable.
10. These indifference curves are vertically parallel by the quasilinear nature of the utility functions, which implies that there are no income effects; in other words, additions to consumers' incomes do not affect their decisions over q.
11. By the single-crossing property (SCP), or the assumption that $V(q, \theta_{12}) > V(q, \underline{\theta})$ and $V_1(q, \theta_{12}) > V_1(q, \underline{\theta})$, according to which any given indifference curve of the type-θ_{12} consumer crosses any given indifference curve of the type-$\underline{\theta}$ consumer at most once, it can be shown that only (4) and (7) are binding constraints. If (6) is binding, then $V(q_1, \underline{\theta}) - p_1 = V(q_2, \underline{\theta}) - p_2$ and the two equilibrium quality-price pairs are on the same indifference curve for the type-$\underline{\theta}$ agent. On the other hand, if (7) is binding, then $V(q_2, \theta_{12}) - p_2 = V(q_1, \theta_{12}) - p_1$ and the two equilibrium quality-price combinations are on the same indifference curve for the type-θ_{12} agent. This contradicts the SCP, and therefore, not both (6) and (7) can be binding. Since the type-θ_{12} consumer is more willing to pay for an increase in quality, (7) must be binding, and this, in turn, implies that (5) is not binding, as $V(q_1, \theta_{12}) - p_1 > V(q_1, \underline{\theta}) - p_1 \geq 0$, and thus, $V(q_2, \theta_{12}) - p_2 = V(q_1, \theta_{12}) - p_1 > 0$. With only (4) and (7) as binding constraints, the monopolist's objective is to maximize (3) with respect to q_2, q_1, and θ_{12}, where

$$p_2 = V(q_2, \theta_{12}) - V(q_1, \theta_{12}) + V(q_1, \underline{\theta})$$

and

$$p_1 = V(q_1, \underline{\theta}).$$

Similar proofs are available in Cooper (1984), p. 570-571, and Srinagesh and Bradburd (1989), p. 100-102.

12. Besanko, Donnenfeld, and White (1987), p. 746.

13. If point B happens to be to the left of the first intersection point between the zero-$CS(\underline{\theta})$ locus and the cost function (point D in Figure 1), then the lower bound of the relevant portion for equilibrium is such a point.

14. More precisely, the required percentage of drinks in refillable bottles varies in accordance with the recycling target. For a target of 60 per cent in nine of the previous twelve months, the minimum refillable sales is 30 per cent; for a target of 50 per cent and less than 50 per cent, it is 35 per cent and 40 per cent, respectively.

15. An important source of market imperfection to which beverage packaging gives rise relates to the use of resources that are considered to be socially underpriced in the current market, essentially because their current consumption involves an opportunity cost, termed "user cost" (loss of benefits incurred by future generations through a reduction in their consumption possibilities), which is not reflected in their market prices. Energy and water are the most significant examples of these resources.

16. In a study on beverage packaging energy usage by the Research Triangle Institute (1975), as cited in OECD (1978), reusable glass bottles with a trippage rate of 10 are found to require much less energy than aluminum cans and plastic bottles do (3.6 therms versus 18.7 therms and 11.5 therms per 100 litres, or 3,798 MJ/KL versus 19,728.5 MJ/KL and 12,132.5 MJ/KL, respectively), based on 1975 energy requirements for soft drink 12-oz containers in the United States. A more recent study by First Consulting Group (1992), which is based on 1974 through 1991 data from the Ontario soft drink industry, confirms that refillable glass bottles are less energy-consuming than cans are, even when the latter are not assumed to be manufactured out of 100 per cent virgin metal, unlike the 1975 study, and therefore even when the savings in energy usage from recycling and material recovery are taken into consideration. This supports the claim that refillable bottles are indeed more environmentally sound, thus justifying the assumption that they constitute the high-quality packaging and that consumers perceive this but may not be willing to pay for it.

17. The density function is equal to $F'(\theta)$.

18. As suggested in note 9, packaging quality and mix can be considered the second-stage choice variables in a two-stage non-cooperative game. For simplicity, however, the analysis assumes away the possibility of policy repercussions on the first-stage choice variables.

19. Given the assumption of quasilinear utility functions, income effects do not play any role in the decision-making process of consumers, hence, the probability of returning containers, which is likely to be affected by income levels, is constant across consumers, and the additional expected cost imposed by a deposit/refund system is increasing in the deposit level and decreasing in the refund level.

20. The DSD was formed by over six hundred companies in response to the 1991 Packaging Waste Ordinance (or Toepfer Decree) to collect recyclable packaging materials. In trying to meet the high recycling goals mandated by the German government (50 per cent by January 1994 and 80 per cent by July 1995), the DSD was unable to keep up with the flow of collected plastic packaging materials because of their difficult and expensive recyclability and forced to store them in warehouses, risking becoming insolvent as a result of the additional storage costs.

21. This would explain why soft drink producers keep stacking empty refillable glass bottles instead of reusing them, as recently found in some major bottling plants in Ontario (The Toronto Star, 1996).

22. The upper limit may be set equal to the energy required to achieve the socially optimal packaging mix, hence, the constraint would be relevant only if the monopolist's packaging mix differed from the social optimum.

23. Along with the incentive to reduce waste generation, user charges also provide the incentive to increase illegal disposal or litter. However, as long as the expected benefit from littering is kept very low, or equivalently, its expected cost is kept high, the impact of these fees on illegal disposal is likely to be negligible. Hence, the only cost associated with switching to a user fee refuse collection system is the additional cost of imposing the charges (or administrative cost).

24. This result contradicts the finding by Dinan (1993) and Fullerton and Kinnaman (1995) that a deposit/return system is theoretically consistent with the incentives provided by a disposal charge programme. The difference stems from the additional costs that a deposit/return system may impose on the production side.

25. Globe and Mail (1992).

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