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Economic incentives reduce plastic inputs to the ocean

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A B S T R A C T

Mismanaged waste and marine debris have significant detrimental effects on wildlife, public health, and the economy. Container deposit legislation (CDL) is one of the many legislative actions proposed by lawmakers to curb the amount of debris entering the ocean. Beverage containers are consistently among the most commonly littered items, so effective legislation could prove a significant lever to reduce debris inputs to the marine environment. The effectiveness of CDL at reducing the amount of beverage container litter on the coasts of two countries, Australia and the United States, was evaluated by comparing results of debris surveys in states with and without cash incentives for returned beverage containers. The proportion of containers found in coastal debris surveys in states with CDL was approximately 40% lower than in states without CDL. Additionally, CDL states had a higher ratio of lids to bottles, further demonstrating the effectiveness of the incentives in removing bottles from the waste stream. The reduction in beverage containers in the presence of CDL was greater in areas with low socio-economic status, where debris loads are highest. These results provide strong evidence that fewer beverage containers end up as mismanaged coastal waste in states that provide a cash refund for returned beverage containers. Findings are discussed in the context of global governance, social license and opportunities to reduce land-based litter inputs to the ocean.

1. Introduction

Land-based waste and its downstream cousin, marine debris, have been demonstrated to have negative impacts on wildlife, tourism, public health, and the economy [1]. Nearly 700 species of wildlife are known to have interacted with debris, often with lethal consequences [2]. In one area of Los Angeles, California alone, marine debris costs an estimated $68 M per year from lost tourism revenue [3]. Similarly, in South Korea, the economic tourism revenue loss from a single major rainfall event resulting in high coastal debris was between $29–37 M USD [4]. To mitigate these impacts and to target specific items that are frequently mismanaged, local and national government bodies have considered and implemented a number of different legislative and regulatory actions [e.g. [5], this issue].

There are essentially two varieties of legislation used to reduce waste in the environment. These include "*command and control*" measures, and market-based economic instruments [6]. Command and control measures are defined as direct regulation of activities or unwanted items by legislation, such as bans on plastic microbeads in facial products or prohibitions on single use plastic bags. Conversely, economic instruments set financial incentives or disincentives aimed at influencing human behaviours. Economic incentives such as container deposit legislation (CDL) or disincentives such as plastic bag levies or disposal taxes are both considered effective ways to control land-based waste. Incentives are sometimes more expensive to execute, but they avoid some of the potential negative aspects of disincentives, such as increases in illegal dumping to avoid taxation [7]. Furthermore, it has been shown that refund schemes or positive incentives can substantially increase the recovery of materials, whether they are beverage containers, printer cartridges, or old cars [8].

This research focuses on CDL, which has been widely implemented in countries around the world. The impetus for lawmakers to pass deposit legislation can arise from one of two main drivers. First, from an economic outlook, reducing the amount of waste in landfills or increasing the re-use of refillable containers is desirable. Second, from an environmental standpoint, reducing litter and increasing recycling rates are primary objectives [9,10].

There has been substantial scholarship on the economic benefits of such programs, both direct and indirect [7,11–13]. Economic outcomes include the reduction of disposal costs by diverting containers through the recycling stream, reduction of costs associated with illegal dumping or disposal, and job creation. Some studies also impute an economic

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value to the environmental benefits of the legislation, such as a reduction of pollution and energy costs due to the substitution of recycled materials for virgin materials, or decreased public health risks and cleaning costs coupled with an increase in aesthetic value resulting from less litter in public places [13].

While the economic impacts of CDL are well-studied (see above), there is little scientific research that has demonstrated the effectiveness of CDL in reducing mismanaged waste. In the United States, highway litter surveys in Iowa, Maine, Michigan, Oregon, Vermont, and New York showed a 40–80% reduction in container litter (10–39% overall litter reduction) following introduction of container deposit laws [14–16]. International Coastal Cleanup (ICC) data in Hawaii also showed a significant decrease in container litter post-CDL implementation [17]. In Australia, data from the Keep Australia Beautiful (KAB) national litter index similarly found a 50% decrease in beverage container litter in the Northern Territory after CDL was introduced [18]. These analyses have focused primarily on littering sites. To date, no peer-reviewed study has examined whether container deposit legislation leads to an overall reduction in mismanaged beverage container waste, particularly on the coasts.

1.1. Container deposit legislation in the United States and Australia

In the United States, ten of the fifty states currently have some form of CDL; California, Connecticut, Hawaii, Iowa, Maine, Massachusetts, Michigan, New York, Oregon, and Vermont. While the legislation varies slightly between states, typically a 5-cent surcharge is placed on glass, aluminium and plastic beverage bottles. This cash refund is returned when the consumer brings the container back to an appropriate facility. Often dairy bottles are excluded, and sometimes wine or spirits. Notably Michigan has the highest deposit, 10 cents, and the highest rate of redemption of containers attracting this incentive (Table 1).

Container deposit legislation in Australia is very similar to that in the United States. In both countries, policies are enacted at the state or territory level. CDL has been in place in two of the eight Australia states and territories for a number of years; the Northern Territory (implemented in 2012) and South Australia (since 1977). New South Wales rolled out its scheme on December 1, 2017, while Western Australia and Queensland are planning to implement CDL in 2018–2019.

Lids are manufactured in equal proportion to containers, but do not attract a deposit in either country. If CDL causes a decrease in containers in the environment, it is unlikely to cause a similar decrease in lids. There could potentially be an increase in awareness in CDL states that encourages people to think more carefully about how they dispose of lids, but there is not an economic incentive to do so. Therefore, if decreases in containers can be attributed to this economic incentive, the proportion of containers in the waste stream would be expected to be lower in states with a CDL, while the ratio of lids to containers would be expected to be higher.

Coastal debris surveys from states with and without container deposit policies in the United States and in Australia were compared to assess the effectiveness of CDL. Specifically, the study evaluated whether states with CDL had lower proportions of containers and a higher ratio of lids to containers, based on survey data from coastal sites.

2. Material and methods

The Ocean Conservancy International Coastal Clean-up (ICC) provided data from surveys conducted in the United States between 2007 and 2015. ICC events include beach (coastal) surveys, underwater surveys, and surveys conducted from watercraft. They are further classified as freshwater or saltwater by the surveyors. Only coastal surveys were selected, as any water-based surveys will be biased in terms of floating or sinking objects. In Australia, Keep Australia Beautiful and Keep South Australia Beautiful (hereafter referred to collectively as KAB) provided data from their land-based waste surveys conducted between 2005 and 2015. Only data from 2007 onwards were analysed, because data collection methods have been consistent since that year. To assess the effects of CDL specifically on coastal litter, the ICC data were subset to include only saltwater sites. Note that surveys on the Great Lakes are also characterised as saltwater sites. In Australia, KAB surveys are conducted at a wide range of different site types, many of which can be adjacent to the coast. Therefore, surveys conducted less than 5 km from the coast were selected for analysis.

For surveys in both countries, the total number of containers that would potentially be eligible for incentives (container deposit legislation) was calculated for each survey. In the United States, ICC surveys tally the total number of glass beverage bottles, plastic beverage bottles, and beverage cans. In Australia, KAB data is split into many more categories, including container size and beverage type. A total of 25 categories are eligible for cash refund under the SA and NT schemes. The number of lids and caps were also counted. ICC data tallies metal bottle caps, plastic bottle caps, caps/lids, and plastic lids, while KAB categories include metal bottle tops, can pull rings, and plastic bottle tops.

Table 1
Characteristics of CDL programs in the United States and in Australia [19–21].

Country	State	Start Year	Container deposit value	Containers included	Containers not included	Redemption rates
USA	CA	1987	5c (10c for over 24 oz)	Beer/malt, wine and spirit coolers, non alcoholic beverages	Milk, vegetable juices over 16 oz	84% (2015 84% (2014)
USA	CT	1980	5c	Beer/malt, soft drinks, bottled water	Containers over 3 L, HDPE containers	
USA	HI	2005	5c	Non-alcoholic drinks, beer, malt, mixed sprits, mixed wine	Milk, dairy	73% (2006 – 15)
USA	IO	1978	5c	Beer, soft drinks, mineral water, wine coolers, wine & liquour		86% (2009–11) 93% (2000)
USA	ME	1978	5c (15c for wine/liquor	All beverages except dairy	Dairy, unprocessed cider	90% (informal estimate)
USA	MA	1983	5c	Beer, malt, soft drinks, water		59% (2015 64% (2014)
USA	MI	1976	10c	Beer, soft drinks, water, wine coolers, cocktails		94% (2014)
USA	NY	1983	5c	Soft drinks, beer, malt, wine, water (without sugar)		645% (2015)
USA	OR	1972	10c (increased from 5c in April 2017	Beer, malt, soft drinks, water	Wine, liquor, milk	65% (2015)
USA	VT	1972	5c (15c for liquor)	Beer, malt, soft drinks, mixed win, liquor		75%
Aus	NT	2012	10c	Soft drinks, water, beer, cider, mixed drinks, wine in casks or sachets	Unflavoured milk, concentrated juice, cordial, wine and spirit bottles	46% (2014)
Aus	SA	1977	10c	Soft drinks, water, beer, cider, mixed drinks, wine in casks or sachets	Unflavoured milk, concentrated juice, cordial, wine and spirit bottles	79.9% overall