STRATEGIC ANALYSIS AND IMPLEMENTATION PROPOSAL FOR REVERSE VENDING MACHINES FOR RECYCLING CANS AND PLASTIC BOTTLES

1 INTRODUCTION

The volume of urban solid waste worldwide is growing exponentially and may reach 3.40 billion tons annually by 2050 (Kaza et al., 2018). Among the challenges in waste management are the low coverage of collection services, the lack of appropriate disposal methods for all generated waste, pollution caused by improper practices (irregular disposal, open dumps, open burning, etc.), and the lack of essential financing/resources (ISWA, 2022).

In Brazil, the recycling rate remains low, accounting for only 4% (CBC, 2023). It is estimated that approximately 33.3 million tons of waste were inadequately disposed of in 2022, with 27.9 million tons sent to open dumps and 5.3 million tons not collected, being discarded in improper locations. Nationally, the Southeast region of Brazil represented 49.4% of urban solid waste generation in 2022 (ABREMA, 2023). In light of this, it is evident that Brazilian organizations need to incorporate sustainable practices into their strategies by encouraging waste reduction, circular economy, the use of green products and services, and the adoption of renewable energies. This is particularly important given that more than half of Brazilians are deeply concerned about environmental issues (CBC, 2023).

In September 2015, the United Nations (UN) developed 17 Sustainable Development Goals (SDGs) (Le Blanc, 2015; Beynaghi et al., 2016). The SDGs represent a global call to action to protect the environment and climate, enable people to live in peace and prosperity, and end poverty (López et al., 2023; UN, 2015). Recycling is directly related to SDG 11 – Sustainable Cities and Communities, precisely item 11.6, which aims to reduce the adverse per capita environmental impact of cities, including issues related to municipal waste management, by 2030. Additionally, it is related to SDG 12 – Responsible Consumption and Production, mainly target 12.5, which calls for a substantial reduction in waste generation through prevention, reduction, recycling, and reuse (UN, 2015). Finally, recycling plays an essential role in SDG 13 – Climate Action, as reducing waste production and recovering materials leads to a decrease in greenhouse gas emissions associated with the extraction and production processes of new materials (UN, 2015).

"Reverse Vending Machines" (RVMs) have been developed in this context. These automated machines can receive, compact, and store aluminium cans and plastic bottles in exchange for financial incentives or benefits in the form of credits to encourage and facilitate the recycling of these materials. This promotes the circular economy and raises awareness about the importance of environmental sustainability (Sambhi & Dahiya, 2020). Implementing RVMs for recycling cans and plastic bottles offers a practical and convenient technological approach to engage the general public in plastic waste management, encouraging proper disposal and material reuse (Zia et al., 2022).

However, limited information remains related to RVMs in Brazil, whether regarding the current situation or projections for short—and medium-term growth, indicating that this market niche is still emerging. For this reason, investment in this sector is a promising strategy from a financial perspective and environmental and social viewpoints, contributing to a more sustainable and responsible future in waste management.

In light of the above, this study aims to conduct a strategic analysis and assess the feasibility of implementing a reverse vending machine in the Brazilian market, specifically in the Southeast region, targeting the recycling of cans and plastic bottles. The analysis will consider successful cases in other regions of the world and evaluate the potential contribution of this initiative to sustainability.

2 METHODOLOGY

To develop the study, an initial literature review was conducted to search for and review published materials supporting the scientific study's theoretical foundation (De Sousa et al., 2021). The literature review aimed to explore the concept of Reverse Vending Machines (RVMs), their history of implementation in various contexts, and their environmental and economic impacts. Additionally, case studies and technical reports related to the effectiveness of this technology in other regions and markets were analyzed.

After defining the topic and selecting studies relevant to the theme, a content analysis of the bibliographic material was conducted. Thus, the literature review played a crucial role, providing a solid foundation and essential information supporting the research environment's choice.

The empirical stage of the study took place in January 2024 and involved 158 respondents. A market survey was conducted to gather information about the consumer profile in the Southeast region of Brazil and evaluate the recycling habits of a segment of the population in that region. The goal was to achieve more efficient effort targeting and to map the most suitable opportunities.

Subsequently, to structure the strategic analysis and implementation proposal for RVMs for recycling cans and plastic bottles, strategic tools and financial feasibility analyses were applied. Methods such as VRIO analysis and SWOT Matrix were detailed throughout this study. Additionally, the initiative's feasibility was evaluated based on six implementation scenarios, considering the monthly revenue of RVMs about the number of units processed per minute and the total hours worked by the machine per day concerning its capacity.

3. RESULTS AND DISCUSSIONS

3.1 CONSUMER NEEDS MAPPING

Considering the surveyed population, it was found that most people incorporate recycling into their routine. Specifically, 43.7% reported recycling cans and plastic bottles once a week, while 29.7% recycled more than once a week. Regarding the volume recycled, 69.6% of respondents indicated that they recycle fewer than ten cans or bottles at a time, while 23.4% recycle between 11 and 29 cans or bottles. For 1.9% of respondents, the volume recycled at a time exceeds 100 cans or bottles.

The research also aimed to understand why people are motivated to recycle. A significant portion (62.7%) reported that their motivation is to reduce waste in their communities, followed by showing concern for the environment (55.1%) and keeping their homes clean and organized (40.5%).

Regarding the ideal location for a collection point, 69.6% of respondents emphasized that the RVM should be close to their residence. In comparison, 13.3% indicated that the supermarket where they shop is the ideal location. Additionally, 6.3% of respondents suggested that parks and squares would be suitable locations.

The interaction between consumers and the RVM is essential for successfully implementing this initiative. Respondents were asked to identify the machine's key value points. The main factors cited include the machine operating without stoppages due to failures and the system's ease of use. Additionally, the speed at which cans and bottles are processed and the availability of customer support were highlighted as necessary.

3.2 STRATEGIC ANALYSIS AND FEASIBILITY

Implementing a system for the return of plastic bottles and aluminum cans in the Southeast region of Brazil primarily aims to promote the recycling of these products, contribute to material circularity, extend the lifespan of products, preserve the environment, and create a sustainable revenue stream.

The VRIO model—Value, Rarity, Imitability, and Organization (Lacaze et al., 2024)—was initially employed to conduct the strategic analysis of this initiative. This tool helps assess resources' potential and capabilities to generate value for an enterprise. Applying the VRIO method (Table 1) made it possible to understand the market's competitive advantages and determine whether these advantages are sustainable.

Table 1. VRIO Analysis

	Value	**Rarity**	**Imitability**	**Organization**	**Result**
Collection and Tracking Technology	Yes	Yes	No	Yes	Temporary Competitive Advantage
Rewards and Incentives System	Yes	Yes	No	Yes	Temporary Competitive Advantage
Strategic Business Partnerships	Yes	No	No	Yes	Competitive Parity
Reputation and Credibility	Yes	Yes	No	Yes	Competitive Parity
Specialized Multidisciplinary Team	No	No	No	No	Competitive Disadvantage
Efficient Management of Collection Centers	Yes	Yes	No	Yes	Temporary Competitive Advantage

Source: Authors.

To develop a robust strategy, the SWOT matrix was employed. SWOT stands for Strengths, Weaknesses, Opportunities, and Threats, and it allows for the correlation of internal and external factors within the context of the initiative (Puyt et al., 2023). It is important to note that a competitive analysis should also be conducted by comparing strengths and weaknesses and that opportunities and threats arise from collective actions or the lack thereof in response to market changes, meaning they are not absolute but relative (Pickton & Wright, 1998). Table 2 presents the SWOT Matrix.

Table 2. SWOT Analysis

	Strengths (S)	**Weakness (W)**
	S1. Partnerships with Manufacturers and Retailers; S2. Favourable Legislation; S3. Technological Advancements;	W1. Initial Costs; W2. Need for Strategic Partnerships; W3. Knowledge of RVM Operations; W4. Dependence on Existing Recycling Infrastructure;
Opportunities (O) O1. Tax Incentives; O2. Benchmarking in Foreign Markets; O3. Research and Development (R&D); O4. Environmental Education Programs; O5. Loyalty and Rewards Programs;	S1O6 - Raise awareness based on the growing socio-environmental appeal in Brazil; S2O1 - Identify optimal ways to utilize tax incentives according to legislation;	W1O1 - Tax incentives could facilitate the reduction of initial related costs; W2O6 - Use the growing socio-environmental appeal as a narrative to establish partnerships;

O6. Growing Socio-Environmental Appeal.	S3O3 - Explore technological advancements through research and development.	W3O2 - Explore foreign markets with expertise in the machines to minimize operational risks.
Threats (T) T1. Fluctuation in Waste Sale Prices; T2. Security of Assets; T3. Competition from Government Initiatives; T4. Consumer Behavior Resistance.	S1T4 - Use partnerships as a means to reach consumers through the Programs; S2T2 - Anchor asset security issues in applicable laws; S3T3 - Utilize technological advancements in the development of innovative initiatives.	W4T3 - Encourage government initiatives that improve existing recycling infrastructure; W2T4 - Establish sustainable partnerships based on programs and initiatives that facilitate changes in consumer behaviour.

Source: Authors.

As observed in Table 2, forming connections and partnerships, combined with tax incentives and a growing consumer appeal from a socio-environmental perspective, are crucial factors for the initiative's success. Leveraging strengths and opportunities to mitigate weaknesses and minimize the impacts of threats is an action that should be considered.

Evaluating both direct and indirect competition is crucial for understanding the potential of RVMs, as the key to a company's success lies in doing more than competitors to seize this opportunity (Kotler, 2000). As this is an emerging initiative in the Brazilian market, only some players are establishing themselves. Indirect competitors include (i) conventional waste disposal methods, such as traditional bins or landfills; (ii) reverse logistics systems—though an intriguing alternative, they still represent indirect competition to the initiative; and (iii) corporate social responsibility initiatives or campaigns.

Regarding direct competitors, the representation is even more significant, as traditional recycling systems themselves pose substantial competition. Additionally, with the growing concern over environmental issues, companies are increasingly active in conducting campaigns and programs.

Thus, the feasibility of implementing this business model in the Southeast region of Brazil was analyzed. Six scenarios were considered based on the volume of cans and bottles processed per minute, as well as the number of operating hours versus machine downtime. The values presented in Table 3 reflect the results of these analyses.

Table 3. Summary of Monthly Revenue Scenarios

Scenario	Processed Units	% of RVM Capacity	Operation “versus” Idleness	Monthly Revenue (R$)
1	20 per minute	50%	2.8 hours per day (80% idle time)	10.978,63
2	20 per minute	50%	4.2 hours per day (70% idle time)	16.467,95
3	20 per minute	50%	7 hours per day (50% idle time)	27.446,58
4	15 per minute	37,5%	2.8 hours per day (80% idle time)	8.233,97
5	15 per minute	37,5%	4.2 hours per day (70% idle time)	12.350,96
6	15 per minute	37,5%	7 hours per day (50% idle time)	20.584,94

Source: Authors.

The RVM-1000 model and the "Factory Direct Waste Machine" compactor, available on the international market, were selected for this study. The values indicated in the processed units column correspond to the maximum production capacity of this model, which is 40 units per minute, as specified by the manufacturer. The total hours of operation per day account for a period of downtime, whether due to a lack of customers or the need for RVM maintenance,

among other factors, defining a total of 14 hours of daily operation. After evaluating the scenarios, Scenario 2 was chosen for further detail, as it proved realistically feasible.

Following this, the total investment value was estimated, considering the acquisition of the RVM and the compactor and the costs of importation and shipping from the manufacturer to the installation site. Monthly revenue estimates were also conducted based on the product of unit sales and the unit price per kilogram of processed material. The selling price reflects the reference from consultations conducted by the authors as of January 2024.

Additionally, fixed and labour costs associated with the investment were determined. Fixed costs, which are expenses that do not vary with the volume of activities over a given period, were estimated based on the market realities of the Southeast region of Brazil. The salaries used as a reference for calculating labour costs were estimated from research conducted with Brazilian economic agencies and institutes regarding the main wage floors for 2023.

With this information, it was possible to determine the business model's viability and gain insight into the financial outcomes. Table 4 provides a quarterly overview of the financial results based on the analyses conducted in the study.

Table 4. Quarterly Overview of Results

	1° Quarter (R$)	**2° Quarter (R$)**	**3° Quarter (R$)**	**4° Quarter (R$)**	**Annual Total (R$)**
1. Total Revenue	46.110,25	46.110,25	49.403,84	52.697,43	194.321,79
2. Total Variable Costs	5.910,87	5.910,87	6.333,08	6.755,28	24.910,11
3. Contribution Margin	40.199,38	40.199,38	43.070,77	45.942,15	169.411,68
4. Fixed Costs	25.499,36	25.499,36	25.499,36	25.499,36	101.997,45
5. Operating Result	14.700,02	14.700,02	17.571,40	20.442,79	67.414,23
6. Investments	3.599,64	3.617,46	8.768,45	8.768,45	24.754,00
8. Net Financial Result	11.100,38	11.082,56	8.802,95	11.674,34	42.660,23
Year to Date	11.100,38	22.182,94	30.985,89	42.660,23	

Fonte: Autores.

Based on the results, the potential for implementing RVMs in the Southeast region of Brazil is evident, and they are characterized as an economically viable business model. RVMs also represent an innovative and effective solution for promoting the recycling of specific materials, contributing to environmental sustainability, and raising community awareness about the need to adopt sustainable practices.

4 CONCLUSION

The RVMs in the Southeast region of Brazil, focusing on the recycling of cans and plastic bottles, demonstrates a positive return on investment. The study reveals that this initiative offers financial benefits and addresses the growing global demand for sustainable practices, particularly in emerging countries like Brazil.

The introduction of RVMs in Southeast Brazil represents a strategy with the potential to impact waste management and promote environmental sustainability positively. RVMs' innovative technology provides significant advantages for businesses, consumers, and society at large by facilitating selective collection and engaging citizens in sustainable practices.

Given the challenges of waste management, exacerbated by the region's high population density and intense economic activity, RVMs emerge as a viable alternative for promoting recycling and the circular economy. To ensure success, it is essential to implement strategies such as business partnerships, environmental awareness campaigns, and integration with public waste management policies.

This study emphasizes the importance of these strategies and the need for a thorough analysis of the involved stakeholders. Implementing RVMs represents an opportunity to advance sustainability and efficient waste management, offering valuable insights for businesses, governments, and organizations interested in investing in this innovative technology. This will contribute to a more sustainable and responsible future for current and future generations.

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