



GOVERNANCE AND OPERATIONAL COORDINATION OF REVERSE LOGISTICS: A MULTIPLE CASE STUDY IN RECYCLING COOPERATIVE NETWORKS

GOVERNANÇA E COORDENAÇÃO OPERACIONAL DA LOGÍSTICA REVERSA: UM ESTUDO DE CASO MÚLTIPLO EM REDES DE COOPERATIVAS DE RECICLAGEM

GOBERNANZA Y COORDINACIÓN OPERATIVA DE LA LOGÍSTICA INVERSA: UN ESTUDIO DE CASOS MÚLTIPLES EN REDES COOPERATIVAS DE RECICLAJE

ABSTRACT

Background: The increasing complexity of reverse logistics systems requires coordination mechanisms capable of integrating multiple actors and reducing operational inefficiencies across recycling chains.

Objective: This study analyzes how the governance exercised by the REICLAMP Network influences operational coordination, logistics efficiency, and social inclusion within recycling cooperatives located in Campinas, São Paulo, Brazil.

Method: The study adopted a qualitative approach based on a multiple-case study design. Three semi-structured interviews were conducted with managers of the participating cooperatives, which were selected through convenience and accessibility sampling. The interviews were complemented by documentary analysis of operational reports and weighing records. Data were analyzed using Thematic Content Analysis.

Results: The findings demonstrate that the centralization promoted by REICLAMP reduces operating costs, enhances the cooperatives' bargaining power, and standardizes waste sorting and disposal procedures. However, a trade-off between operational efficiency and social inclusion was identified, as the governance mechanisms adopted create barriers to the participation of informal waste pickers in the network.

Contributions: Theoretically, the study contributes to the collaborative governance literature by providing empirical evidence of the role of central cooperatives as coordination structures within second-tier networks. From a managerial perspective, it highlights the importance of source sorting in reducing rejects and enhancing operational efficiency.

Originality: The article demonstrates how second-tier network arrangements can effectively mitigate transaction costs and power asymmetries between individual cooperatives and the industrial market by functioning as a central coordinating mechanism that helps balance relationships among actors.

Keywords: Collaborative governance; Reverse logistics; Circular economy; Recycling cooperatives; Interorganizational networks.

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RESUMO

Contextualização: A crescente complexidade dos sistemas de logística reversa exige mecanismos de coordenação capazes de integrar múltiplos atores e reduzir ineficiências operacionais nas cadeias de reciclagem.

Objetivo: Analisar como a governança exercida pela Rede RECICLAMP influencia a coordenação operacional, a eficiência logística e a inclusão social em cooperativas de reciclagem localizadas em Campinas/SP.

Método: A pesquisa adotou uma abordagem qualitativa por meio de um estudo de caso múltiplo. Foram realizadas três entrevistas semiestruturadas com gestores das cooperativas participantes, selecionadas por conveniência e acessibilidade, complementadas por análise documental de relatórios operacionais e registros de pesagem. Os dados foram analisados mediante a Análise de Conteúdo Temática.

Resultados: Os resultados demonstram que a centralização promovida pela RECICLAMP reduz custos operacionais, amplia o poder de negociação das cooperativas e padroniza procedimentos de triagem e destinação de resíduos. Entretanto, observou-se um trade-off entre eficiência operacional e inclusão social, uma vez que os mecanismos de governança adotados dificultam a participação de catadores informais na rede.

Contribuições: Teoricamente, o estudo contribui para a literatura sobre governança colaborativa ao evidenciar empiricamente o papel das cooperativas centrais como estruturas de coordenação em redes de segundo grau. Gerencialmente, destaca a importância da triagem na fonte para redução de rejeitos e aumento da eficiência operacional.

Originalidade: O artigo detalha como os arranjos em redes de segundo grau mitigam com sucesso os custos de transação e as assimetrias de poder de cooperativas singulares frente ao mercado industrial, atuando como um elemento centralizador e equalizador de forças.

Palavras-chave: Governança colaborativa; Logística reversa; Economia circular; Cooperativas de reciclagem; Redes interorganizacionais.

RESUMEN

Contextualización: La creciente complejidad de los sistemas de logística inversa exige mecanismos de coordinación capaces de integrar a múltiples actores y reducir las ineficiencias operativas en las cadenas de reciclaje.

Objetivo: Analizar cómo la gobernanza ejercida por la Red RECICLAMP influye en la coordinación operativa, la eficiencia logística y la inclusión social en las cooperativas de reciclaje ubicadas en Campinas/SP.

Método: La investigación adoptó un enfoque cualitativo mediante un estudio de casos múltiples. Se realizaron tres entrevistas semiestructuradas con gerentes de las cooperativas participantes, seleccionadas por conveniencia y accesibilidad, complementadas con el análisis documental de informes operativos y registros de pesaje. Los datos se analizaron mediante el Análisis Temático de Contenido.

Resultados: Los resultados demuestran que la centralización promovida por RECICLAMP reduce los costos operativos, amplía el poder de negociación de las cooperativas y estandariza los procedimientos de clasificación y disposición de residuos. Sin embargo, se observó una compensación (*trade-off*) entre la eficiencia operativa y la inclusión social, ya que los mecanismos de gobernanza adoptados dificultan la participación de recolectores informales de residuos en la red.

Contribuciones: Teóricamente, este estudio contribuye a la literatura sobre gobernanza colaborativa al demostrar empíricamente el papel de las cooperativas centrales como estructuras de coordinación en redes de segundo nivel. Desde una perspectiva de gestión, destaca la importancia de la clasificación en origen para la reducción de residuos y el aumento de la eficiencia operativa.

Originalidade: El artículo detalla cómo los acuerdos en redes de segundo nivel mitigan con éxito los costos de transacción y las asimetrías de poder de las cooperativas individuales frente al mercado industrial, actuando como un elemento centralizador e igualador de fuerzas.

Palabras clave: Gobernanza colaborativa. Logística inversa. Economía circular. Cooperativas de reciclaje. Redes interorganizacionales.



INTRODUCTION

Growing concern over the management of municipal solid waste (MSW) and waste electrical and electronic equipment (WEEE) has driven the adoption of reverse logistics strategies, which are essential for mitigating the environmental and social impacts of improper disposal (Lara & Grimm, 2023). In Brazil, the National Solid Waste Policy (Política Nacional de Resíduos Sólidos – PNRS), Law No. 12,305/2010 (Brasil, 2010), established guidelines for managing these materials and encouraged the participation of waste picker cooperatives and associations as key actors in this process. These organizations make significant contributions to urban sanitation and environmental preservation while promoting social inclusion and generating income for vulnerable communities.

This study adopts an analytical perspective grounded in collaborative governance and interorganizational network theory to examine how second-tier cooperative structures influence the operational coordination of reverse logistics. To this end, it analyzes three recycling cooperatives affiliated with the REICLAMP Network in Campinas, São Paulo, Brazil, seeking to understand how shared governance mechanisms affect the efficiency of material flows, the standardization of operational processes, and relationships among the different actors within the recycling chain. In this context, REICLAMP is examined as a focal organization responsible for coordinating logistics flows and affiliated cooperatives, as well as mediating relationships with private companies and public institutions.

Despite the growing body of research on the National Solid Waste Policy (PNRS), the current literature on solidarity-based reverse channels focuses predominantly on cooperatives operating in isolation. Although studies have addressed reverse logistics, the circular economy, and recycling cooperatives, there remains limited understanding of how central cooperatives operate as governance structures capable of coordinating multiple actors, reducing transaction costs, and managing tensions between operational efficiency and social inclusion. This gap is particularly relevant in complex urban contexts, where the sustainability

of recycling systems depends on coordination among cooperatives, private companies, public authorities, and waste pickers.

Against this background, the following research question is posed: How does the centralization of operational governance by a second-tier cooperative influence logistics efficiency and social inclusion processes in recycling networks?

Accordingly, this study aims to analyze how the governance exercised by a central cooperative influences' operational coordination, logistics efficiency, and social inclusion dynamics within a network of recycling cooperatives organized under the REICLAMP structure.

The findings indicate that the centralization promoted by REICLAMP generates economies of scale, enhances operational standardization, and strengthens the bargaining capacity of participating cooperatives. However, it also reveals tensions between logistics efficiency and social inclusion, particularly regarding the participation of informal waste pickers. These findings suggest that second-tier governance structures can simultaneously enhance the efficiency of reverse channels and create mechanisms of organizational exclusion.

The remainder of this article is organized into five sections. Following this introduction, the theoretical framework addresses reverse logistics, collaborative governance, and cooperativism. The methodological procedures are then described, followed by the presentation and discussion of the empirical findings from the cooperatives investigated. Finally, the article presents its conclusions, limitations, and directions for future research.

THEORETICAL FRAMEWORK

The increasing complexity of reverse logistics systems has intensified the need for mechanisms capable of coordinating the different actors involved in waste collection, sorting, processing, and disposal. Although the circular economy literature emphasizes the environmental and economic benefits of recycling, the effectiveness of these systems depends on the capacity for coordination among public, private,



and collective organizations, whose interests, resources, and levels of professionalization often differ. In this context, governance emerges as a fundamental mechanism for reducing conflicts, aligning incentives, and ensuring the continuity of reverse material flows.

In Brazil, the implementation of the National Solid Waste Policy (Política Nacional de Resíduos Sólidos – PNRS) strengthened the role of recycling cooperatives as key actors in reverse logistics, assigning them responsibilities related to selective collection, sorting, and the reintegration of materials into the production cycle. However, the increasing operational complexity of these systems has fostered the formation of cooperative networks and second-tier coordination structures responsible for integrating different organizations and enhancing their bargaining and operational capacities. Despite this institutional development, studies examining how such governance mechanisms simultaneously influence operational efficiency and social inclusion processes within reverse chains remain limited.

In light of this issue, the theoretical framework is structured around four complementary dimensions: (i) the context of recycling and the circular economy; (ii) relationships between cooperatives and waste pickers; (iii) partnerships with municipal governments and private companies; and (iv) collaborative governance in second-tier networks. The integration of these dimensions provides the theoretical foundations for analyzing REICLAMP's role as the coordinating structure of a network of recycling cooperatives.

The Context of Recycling and the Circular Economy

A crescente adoção de tecnologias e a consequente crescente adoção de tecnologias e a resultando automação have enhanced agility and flexibility across a wide range of economic and social sectors, exerting a substantial influence on the global economy (Forti et al., 2020). According to the authors, these same production and consumption dynamics have led to exponential growth in waste electrical and electronic equipment (WEEE) worldwide, with global consumption of electronic

products increasing by 2.5 million metric tons annually. However, a substantial proportion of these materials is discarded without appropriate handling, potentially generating waste containing toxic substances and heavy metals that are harmful to the environment and human health (Balde et al., 2024; Gollakota, Gautam, & Shu, 2020; Wirtu, Godana, & Tucho, 2025).

The improper disposal of post-use or post-consumer products is therefore a critical issue. Materials improperly discarded in dumpsters, vacant lots, on sidewalks, or mixed with organic waste can cause a range of environmental impacts and public health problems. This underscores the importance of reverse logistics processes, which involve the planning, implementation, and control of flows of raw materials, finished products, and waste from the point of consumption back to the point of origin (Dias, Vieira, & Silva, 2024).

In Brazil, the management of these wastes is governed by the National Solid Waste Policy (PNRS), Law No. 12,305/2010 (Brasil, 2010), while the appropriate management of solid waste is also addressed by the Federal Basic Sanitation Law, Law No. 11,445/2007 (Brasil, 2007). While organic waste is considered general waste and sent to sanitary landfills, other recyclable solid waste can be reprocessed and reused in the production of new products (Barbacovi, Pereira, & Machado, 2021; Dias, Vieira, & Silva, 2024).

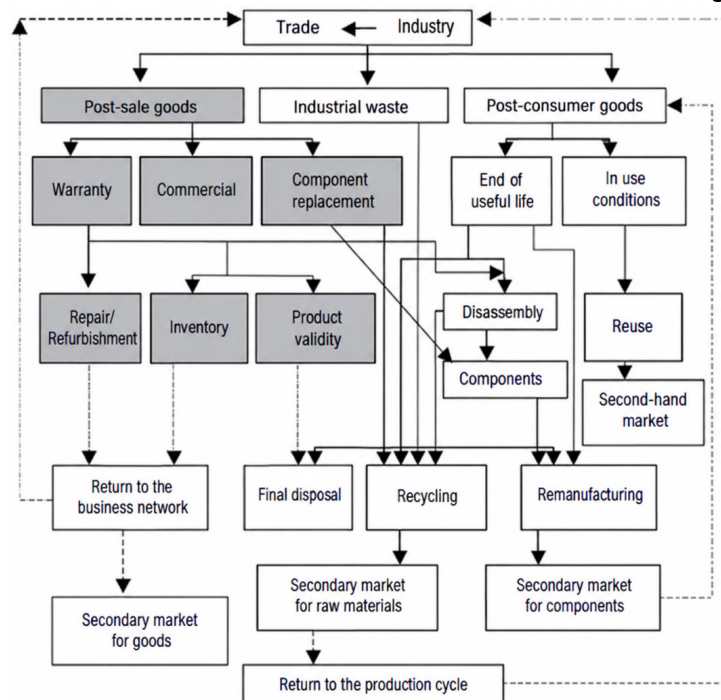
Recycling thus emerges as a vital alternative for managing urban waste, enabling materials to be recovered, reducing the depletion of natural resources, and generating social benefits by providing income opportunities through waste collection for socially marginalized individuals (Bonjardim, Pereira, Palmisano, & Kubo, 2022; Ferraz, Gomes, & Busato, 2012). Common recyclable materials include glass, paper, metals, plastics, and other materials such as beverage cartons, polystyrene, and electronic waste (batteries, rechargeable batteries, and smartphones), as indicated by Agostini and Busato (2022). In addition to recycling, Dias, Vieira, and Silva (2024) identify reuse (retaining the product's original function), repurposing (assigning a new function), and reduction (using returnable or recyclable packaging) as appropriate alternatives to disposal.



Product repurposing and reduction are associated with the flows of post-sale and post-consumer reverse channels, encompassing the different stages and sequences of processes from points of consumption to the reintegration of materials into their original production cycle. In this context, the framework proposed by

Leite (2009), presented in Figure 1, highlights the post-sale reverse logistics processes in gray, distinguishing them from post-consumer reverse logistics. In addition, Paula and Souza-Pinto (2012) emphasize that, within this framework, industrial waste is sent directly for recycling, without the possibility of internal recovery by the companies.

Figure 1.
Reverse Channel Flows: Post-Use and Post-Consumer Logistics



Source: Adapted from Leite (2009, p. 249).

As shown in Figure 1, post-consumer reverse logistics processes involve multiple actors that comprise reverse supply chains and collectively contribute to improving overall performance, enhancing the use of organizations' internal and external resources, and optimizing operational processes. Accordingly, supply chain management performance depends on the individual performance of each actor involved (Luana & Viana, 2019).

Relationships Between Cooperatives and Waste Pickers

Since the final decades of the twentieth century, the collection of recyclable urban waste has intensified, with these activities performed primarily by low-income waste pickers (Ferraz, Gomes, & Busato, 2012; Cabral & Veronese, 2020). From the 1990s onward, society increasingly recognized the contribution of these informal workers to reducing urban waste.

Often operating without support from public authorities, waste pickers relied on this activity as a source of income, albeit under precarious conditions (Ferraz, Gomes, & Busato, 2012; Cabral & Veronese, 2020; Agostini & Busato, 2022). The first associations and cooperatives began to emerge in the 1990s, followed in 1999 by the establishment of the National Movement of Recyclable Material Waste Pickers (Movimento Nacional de Catadores de Materiais Recicláveis – MNCMR), as reported by Okano and Panza (2020). According to the authors, however, waste picking was not officially recognized under the Brazilian Classification of Occupations (Classificação Brasileira de Ocupações – CBO) until 2000, thereby providing waste pickers with access to labor rights and benefits.

Waste pickers nevertheless face several challenges, including inadequate infrastructure for the disposal and sorting of collected materials, poor working conditions, lack of



personal protective equipment (PPE), insufficient protection against occupational accidents, and limited public awareness regarding proper waste disposal (Agostini & Busato, 2022). To improve these conditions and strengthen their collective position, waste pickers have organized themselves into cooperatives. As legally constituted organizations, these cooperatives provide formal employment or cooperative membership arrangements and undertake the receipt, sorting, and selection of materials for reintegration into the market (Panza & Okano, 2018).

Partnerships with Municipal Governments and Private Companies

Some cooperatives operate through subsidy arrangements or formal partnerships with municipal governments and private companies, which establish such partnerships in recognition of the significant social contributions made by these organizations (Okano & Panza, 2020). Collective and self-managed work within cooperatives contributes to building a more sustainable and inclusive future by creating opportunities for socioeconomic advancement (Dias, Vieira, & Silva, 2024).

Many companies, required under the PNRS (Brasil, 2010) to implement reverse logistics for their waste, outsource these activities to cooperatives that possess the necessary expertise, thereby contributing to compliance with environmental legislation, corporate social responsibility, and sustainability requirements (Panza & Okano, 2020). The reverse logistics activities performed by cooperatives include collection, sorting, dismantling, processing, distribution, and final disposal (Dias, Vieira, & Silva, 2024), as well as coordinating the physical and information flows of products at the end of their useful life (Okano & Panza, 2020). Reverse logistics offers substantial potential for economic value creation, driven by the volume of discarded materials that can be reintroduced into the economy at relatively low cost, while fostering social entrepreneurship and the local solidarity economy (Cabral & Varonese, 2020; Agostini & Busato, 2022; Dias, Vieira, & Silva, 2024).

To strengthen their bargaining capacity, enhance their market position, and manage threats and opportunities, recycling cooperatives

have formed solidarity-based sustainable business networks (Pisano, Demajorovic, & Besen, 2022; Cruz, Lima, & Giglio, 2024). Governance, understood as the rules and norms established to mediate conflicts and regulate relationships among actors is crucial to these networks and may develop either from their inception or throughout their evolution (Giglio, Cruz, & Deroldo, 2024; Cruz, Lima, & Giglio, 2024).

A critical aspect of coordinating relationships among actors, as proposed by Vieira et al. (2020) and subsequently corroborated by Cano, Iacovidou, and Rutkowski (2022) and Cruz, Lima, and Giglio (2024), is the recognition that waste pickers, cooperatives, recycling companies, industries, public authorities, consumers, and society constitute key stakeholders in this process. From this perspective, these actors should interact dynamically within network structures and follow governance principles to collectively fulfill their social role in mitigating improper waste disposal.

Collaborative Governance and Second-Tier Networks

The literature on collaborative governance suggests that organizations embedded in interorganizational networks tend to achieve higher levels of coordination when mechanisms are in place to reduce conflicts, align incentives, and standardize operational procedures (Ansell & Gash, 2008). In such arrangements, governance is understood not merely as a formal authority structure but rather as a set of collective coordination processes.

In the context of recycling cooperatives, this discussion is particularly relevant because material flows depend on the simultaneous involvement of multiple actors, including cooperatives, waste-generating companies, recycling companies, public authorities, and consumers.

Recent studies indicate that second-tier networks structured around central cooperatives can reduce transaction costs, enhance bargaining power, and promote operational standardization among autonomous organizations (Pisano, Demajorovic, & Besen, 2024; Cruz, Lima, & Giglio, 2024). However, the literature also suggests that professionalization processes may create exclusionary mechanisms for actors with lower



organizational capacity, thereby generating tensions between economic efficiency and social inclusion.

ding on these findings and adopting this perspective, the present study examines RECICLAMP as a collaborative governance structure responsible for coordinating a second-tier network.

METHODOLOGY

This study is characterized as theoretical-empirical, descriptive, cross-sectional, and qualitative, given that the nature of the research object involves subjective phenomena and human relationships influenced by emotions and feelings (Figueiredo, 2008).

To achieve the proposed objective, an applied qualitative approach was adopted and operationalized through a multiple-case study design. The empirical scope encompassed the operations of the RECICLAMP Network and three of its affiliated cooperatives located in Campinas, São Paulo, Brazil.

The study was conducted under conditions of anonymity for both the cooperatives and the interviewees to preserve their privacy and ensure the confidentiality of the information provided. Accordingly, the organizations are identified as Cooperative A, Cooperative B, and Cooperative C, while the managers who participated in the interviews are referred to as Manager 1, Manager 2, and Manager 3.

The cooperatives were selected through non-probability convenience and accessibility sampling. Among the organizations formally listed by the municipal government, only Cooperatives A, B, and C agreed to provide access to their facilities and share internal weighing records.

Primary data were collected between October and December 2024. Semi-structured interviews were conducted with the senior managers of each cooperative (presidents or operations directors), using a previously validated interview protocol administered face-to-face. The protocol comprised 12 open-ended questions covering three dimensions: material flows, network governance, and relationships with large waste generators. Each interview lasted approximately 60 minutes, resulting in a total of 180 minutes of audio material. With participants'

consent, the interviews were recorded and transcribed verbatim for subsequent analysis.

The documentary corpus, comprising RECICLAMP material-receipt spreadsheets and the cooperatives' annual waste-disposal reports, was analyzed using Thematic Content Analysis. Following Bardin (2011), the analysis involved the stages of pre-analysis and material exploration, followed by treatment, inference, and interpretation, allowing the coded content to support reflective analysis. The coding process was conducted systematically and resulted in three analytical categories developed a posteriori: (a) Operational Flows and Reverse Channel Efficiency; (b) Governance Mechanisms and Network Coordination; and (c) Social Impact and Barriers to Inclusion. The findings were validated through data triangulation by comparing managers' accounts, weighing records, and the theoretical literature.

RESULTS ANALYSIS

The main findings reveal that logistics centralization provides substantial economies of scale for the affiliated cooperatives but entails a significant trade-off by creating entry barriers for independent waste pickers.

The central role of the Central Cooperative for the Collection of Recyclable and Reusable Materials of Campinas and Region (RECICLAMP) represents a significant finding, demonstrating how organization around a central cooperative optimizes logistics, reduces administrative and operational costs, and prevents internal competition. Network governance, supported by elected boards of directors and councils, promotes the professionalization of the sector and the development of cooperative members. Common characteristics observed across the cooperatives, including standardized cooperative governance, the predominance of women among cooperative members, standardized sorting processes, and the absence of formally employed workers and independent waste pickers, indicate a formalized and effective operational model.

Furthermore, the findings show that operational efficiency is directly influenced by the sorting model adopted at the waste-generation source, thereby reducing the operational costs associated with rejects sent to sanitary landfills.



The capacity to collect, sort, and properly direct materials, through partnerships with public authorities (the Municipality of Campinas and CEASA) and private companies (such as Pirelli, Unimed, SENAC Campinas, and UNIODONTO), is crucial to the effectiveness of reverse logistics in the region. The high material recovery rate, particularly in Cooperative C, which reaches 100% due to source sorting, underscores the importance of awareness and education among waste generators.

The National Solid Waste Policy and Municipal Solid Waste Generation

A Política Nacional de Resíduos Sólidos (PNRS) The National Solid Waste Policy (Política Nacional de Resíduos Sólidos – PNRS), Law No. 12,305/2010 (Brasil, 2010), represents a significant milestone for recycling cooperatives in Brazil. Article 33 establishes mandatory reverse logistics requirements for municipal solid waste and waste electrical and electronic equipment. More importantly, Paragraph 3, Item III encourages the engagement of waste picker cooperatives and associations as partners of public authorities and private companies. These partnerships are crucial for the collection, separation, sorting, and appropriate destination of municipal solid waste (MSW), whether for recycling or final disposal, thereby contributing directly to urban sanitation and environmental preservation.

According to the Panorama of Solid Waste in Brazil – 2024 report, published by the Brazilian Association of Waste and Environment (Associação Brasileira de Resíduos e Meio Ambiente – ABREMA, 2024), Brazil generated approximately 81 million metric tons of MSW in 2023, equivalent to an annual average of 382 kg of waste per capita. The Southeast region, which generates the largest volume of waste in the country, recorded a 0.6% increase in per capita generation between 2022 and 2023, reaching 1.237 kg per inhabitant per day.

In 2023, 93.4% of the MSW generated in Brazil was collected, of which 87.8% was collected through public services and 5.6% through informal collection, while the remaining 6.6% was not collected. Of the total MSW generated, 8.3%, equivalent to 6.7 million metric tons of dry materials, was sent for recycling. Notably,

informal collection by waste pickers is estimated at 4.5 million metric tons of MSW. Because these activities focus exclusively on materials with recyclable value, it is assumed that 100% of the materials collected by waste pickers are effectively recycled (ABREMA, 2024). This distinction underscores the vital role played by waste pickers and cooperatives within the recycling chain.

Urban Cleaning Sustainability Index – ISLU

The Urban Cleaning Sustainability Index (Índice de Sustentabilidade da Limpeza Urbana – ISLU), in its ninth edition (2024), is a statistical tool developed by ABREMA to measure the extent to which municipalities comply with the guidelines and targets established by the PNRS. Developed by ABREMA, an association comprising ABETRE, ABRELPE, SELUR, and SELURB, the ISLU provides a diagnostic assessment of urban cleaning services and identifies opportunities for improvement for public authorities, the financial sector, and industry associations.

The ISLU is recognized by the public sector and several private companies due to its statistical methodology, which incorporates indicators such as the Municipal Human Development Index (Índice de Desenvolvimento Humano Municipal – IDHM). Its primary purpose is not to rank different service delivery models, but rather to assess municipalities' compliance with the PNRS. Campinas, the empirical setting of this study, ranks among the ten highest-scoring Brazilian municipalities with populations exceeding 250,000 inhabitants in the 2024 ISLU ranking.

The Municipality of Campinas, São Paulo

Campinas is a large municipality with a strategically important logistics location in the state of São Paulo. According to Cidades-IBGE (2022), it ranks 14th nationally and third within the state in terms of population, with approximately 1,185,000 inhabitants. The municipality also ranks prominently in employment and income indicators (28th nationally), with a per capita income of BRL 59,634.21 and a Municipal Human Development Index (MHDI) of 0.805 (Brasil, 2010). The city has a well-developed industrial and technological hub, with numerous national and international companies, major shopping centers, 15 higher education institutions, and 12 private hospitals.



Campinas benefits from a strategic geographic location and is served by major federal and state highways, including Anhanguera, Bandeirantes, Dom Pedro, Ademar de Barros, and Santos Dumont, which connect the municipality to several regions of the country. It is also home to Viracopos International Airport, one of Brazil's major air cargo hubs, and has a railway network connecting the city to the state capital and the Port of Santos (Cidades-IBGE, 2022; Martins, 2024).

Currently, Campinas has 13 waste picker and recycling cooperatives registered with the municipal government, comprising approximately 500 workers engaged in the processing of MSW and WEEE (Luporini, 2024). For this study, all cooperatives listed on the municipal government's website were contacted, and three cooperatives that agreed to participate in site visits and interviews were selected for the multiple-case study.

Case Study

This section presents the data and operational processes of each of the three recycling cooperatives investigated in the municipality of Campinas. To preserve the anonymity of the managers who participated in the interviews, they are identified as Manager 1, Manager 2, and Manager 3.

Characteristics and Operations of Cooperative A

Cooperative A does not maintain its own website or online portal. Information was obtained primarily through contact with its president (Manager 1), one of the cooperative's founders, who provided the data presented below. These data were supplemented by information obtained from news and specialized online sources (Cidade On, 2023; Easycoop, 2014). The initiative originated from an entrepreneurship training program offered by Cáritas Campinas, initially conceived as a food cooperative. However, the proposal to establish a recycling cooperative came from the president of the local neighborhood association.

The initial challenge was to find a suitable location for the cooperative's operations. A decommissioned warehouse formerly used to house pigs was selected for this purpose. With support and infrastructure provided by the Department of Urban Cleaning and the then

mayor, who was subsequently honored by having the cooperative named after him, the facility was adapted for its new use. In March 2011, the Campinas City Council approved the concession of a 2,000-square-meter site. Cooperative A was the first cooperative to enter into a contract with the Municipality of Campinas for the selective collection and sorting of recyclable materials. In 2013, it participated in the PorAmérica Program (RedEAmérica), and in November 2014, it represented Brazil at an event held in Bogotá.

Currently, the cooperative operates in two shifts (7:00 a.m. to 12:00 p.m. and 1:30 p.m. to 6:30 p.m.) and has 40 cooperative members, most of whom are women. It maintains contracts with public-sector organizations (Municipality of Campinas and Correios), private companies (Pirelli, Unimed, among others), and civil society organizations and residential communities (Swiss Park complex and São Conrado Condominium).

Waste collection is not carried out directly by the cooperative. The Municipality of Campinas delivers four selective-collection truckloads per week, totaling a monthly average of 80 metric tons of MSW. In addition, RECICLAMP trucks collect materials weekly from partner companies: Pirelli (an average of 15 metric tons), Unimed (an average of 5 metric tons), and Correios (an average of 10 metric tons). São Conrado Condominium contributes approximately 5 metric tons, while Swiss Park contributes approximately 20 metric tons. Overall, the cooperative receives a monthly average of 135 metric tons of MSW/WEEE. Materials are not purchased from independent waste pickers, although members of the local community may donate recyclable materials. Internal operations comprise sorting, separation, net weighing, baling, and final destination.

During the initial sorting stage, the mixed materials received in bags are weighed to determine their gross weight. During separation, the collected materials are sorted on a sorting table by type (paper/cardboard, PET plastics, metals, scrap materials, glass, and rejects). The MSW is then compacted into bales weighing up to 300 kg. Finally, the materials are transferred to designated storage areas, from which they are collected by recycling companies on a weekly or biweekly basis. Table 1 presents the average monthly collection volume by waste type.



Table 1
MSW Collection at Cooperative A (Monthly Average)

Waste Type	Tonnage (t)	Percentage (%)
Paper/Cardboard	35	25,93
Glass	35	25,93
Plastics	15	11,11
Metals/Scrap	10	7,40
PET	05	3,70
Rejects	35	25,93
Total	135	100

Source: Research data (interview with Manager 1).

According to Manager 1, of the 135 metric tons/month of gross MSW received, 80 metric tons (59.26%) come from municipal selective collection and 55 metric tons (40.74%) from private collection contracts. The ratio between the total gross volume received and the materials ultimately sent for recycling is 74.07% (100 metric tons of net MSW/WEEE out of 135 metric tons of gross MSW/WEEE). The 25.93% reject rate is considered high by the president (Manager 1) and adversely affects operational efficiency. Rejects include non-recyclable materials (soiled packaging, ceramics, etc.) and are collected by the municipal government every 15 days for disposal at the sanitary landfill in Paulínia, São Paulo.

Characteristics and Operations of Cooperative B

Cooperative B also does not maintain its own website. Information was provided by its Educational and Environmental Coordinator (Manager 2) and supplemented by sources including Hora Campinas (2022) and Cadastro Empresa (n.d.). In 1998, a local religious institution, through its Social Pastoral Ministry, launched a project aimed at combating poverty by offering training courses. The idea of working with recycling subsequently emerged, leading to the creation of a recycling and cooperativism course for 25 participants, who began collecting recyclable materials in a public square.

As the volume of MSW increased, the cooperative built its headquarters and acquired equipment. The need for a larger and more suitable facility led to its relocation to a site associated with the Social Pastoral Ministry and the parish's Ministry of the City. Construction of the new warehouse and renovation of the existing building were funded by the Brazilian Development Bank (BNDES) and other partners, including resources

for the acquisition of a forklift and personal protective equipment (PPE). The cooperative's founder served as president from 1999 to 2021.

The cooperative has 39 cooperative members, most of whom are women, who work Monday through Friday from 7:00 a.m. to 5:00 p.m. It has no formally employed workers and does not receive materials collected by independent waste pickers. The cooperative maintains partnerships with public authorities (the Municipality of Campinas), private organizations (SENAC Campinas, UNIODONTO, and other undisclosed companies), as well as RECICLAMP.

Waste collection is not performed directly by the cooperative. The Municipality of Campinas delivers two selective-collection truckloads per week, totaling an average of 55 metric tons/month. RECICLAMP collects materials from partner organizations such as SENAC Campinas (an average of one metric ton/month) and UNIODONTO (an average of one metric ton/month). Approximately 42 metric tons/month are supplied by undisclosed partner companies, while approximately one metric ton/month comes from donations made by the local community through collection containers. Overall, the cooperative receives a monthly average of 100 metric tons of MSW and WEEE.

The sorting processes are similar to those adopted by Cooperative A: gross weighing; separation by waste type (paper/cardboard, plastics/PET, metals/scrap, glass, and rejects) on sorting tables; net weighing of the separated materials; compaction into bales weighing up to 300 kg; and transfer to designated storage areas, from which the materials are collected by recycling companies. Table 2 presents the average monthly collection volume.



Table 2
MSW Collection at Cooperative B (Monthly Average)

Waste Type	Tonnage (t)	Percentage (%)
Paper/Cardboard	35	35,00
Glass	15	15,00
Plastics	15	15,00
Metals/Scrap	15	15,00
PET	05	5,00
Rejects	15	15,00
Total	100	100

Source: Research data (interview with Manager 2).

Of the total 100 metric tons/month of gross MSW received, 55 metric tons (55%) come from municipal selective collection and 45 metric tons (45%) from private collection contracts. The ratio between the total gross volume received and the materials ultimately sent for recycling is 85% (85 metric tons of net MSW/WEEE out of 100 metric tons of gross MSW/WEEE). The 15% reject rate is considered acceptable by the Educational and Environmental Coordinator (Manager 2), although it still affects the cooperative's operational efficiency. The rejects, like those generated by Cooperative A (soiled packaging, ceramics, etc.), are collected by the municipal government every 15 days and sent to the sanitary landfill in Paulínia, São Paulo.

Characteristics and Operations of Cooperative C

Cooperative C, which likewise does not maintain its own website or online portal, had its history and operations described in detail by its supervisor (Manager 3). Founded in 2008, the cooperative emerged from a local initiative to formalize and organize a group of waste pickers who were already operating in the region. Access to an appropriate facility and the initial infrastructure was made possible through partnerships with the municipal government and support from programs designed to promote the solidarity economy.

A comparison of the empirical findings across the three cases reveals a clear network governance paradox that extends beyond operational differences. Cooperative C achieves a 100% material recovery rate due to its strategy of sorting materials directly at the waste-generation source and focusing exclusively on private corporate contracts. By contrast, Cooperatives A and B experience higher reject rates, comprising waste with no commercial value that increases the burden on the municipal landfill, as a consequence of dispersed residential selective collection.

This scenario demonstrates that the economic efficiency and operational standardization enabled by the RECICLAMP network require a level of technical compliance that ultimately marginalizes the most vulnerable actors in the recycling chain: informal waste pickers. To ensure stable material flows and meet the quality requirements of industrial buyers, the network adopts stringent governance mechanisms that function as market-entry barriers for independent waste pickers. This finding highlights a critical trade-off within the circular economy in emerging economies: the professionalization and logistics efficiency of second-tier networks often occur at the expense of the principles of social inclusion and grassroots empowerment advocated by the National Solid Waste Policy (PNRS).

Table 3
MSW Collection at Cooperative C (Monthly Average)

Waste Type	Tonnage (t)	Percentage (%)
Paper/Cardboard	10	33,33
Glass	08	26,67
Plastics	07	23,33
Metals/Scrap	03	10,00
PET	02	6,67
Rejects	0	00
Total	30	100

Source: Research data (interview with Manager 3).



Of the 30 metric tons/month of gross MSW received, 100% (30 metric tons) comes from private collection contracts and is already sorted at the source. The ratio between the total gross volume received and the materials ultimately sent for recycling is 100% (30 metric tons of net MSW/WEEE out of 30 metric tons of gross MSW/WEEE). The absence of rejects is a distinctive feature of Cooperative C, reflecting the effectiveness of source sorting and significantly enhancing the cooperative's productivity and profitability by minimizing the transportation and final disposal costs associated with non-recyclable waste. The supervisor (Manager 3) emphasizes that this partnership model with large waste generators, combined with REICLAMP's coordination, is a critical factor in the cooperative's success and financial sustainability.

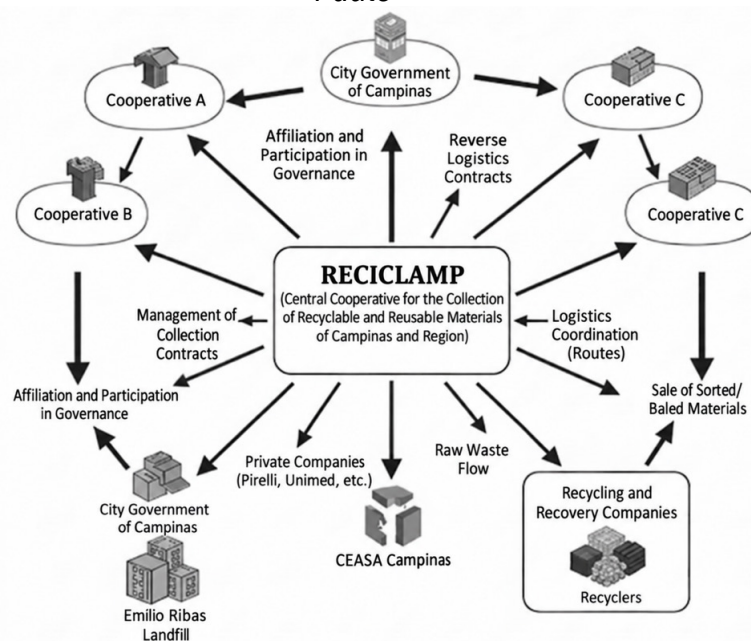
The REICLAMP Network as the Central Coordinating Structure of the Reverse Logistics System

REICLAMP (Central Cooperative for the Collection of Recyclable and Reusable Materials of Campinas and Region) emerges as a central and strategic pillar of the reverse logistics system and recycling cooperatives in Campinas. According to Manager 1 (Cooperative A), "REICLAMP is the heart of our system." This central cooperative was established to integrate and strengthen the primary cooperatives, acting as an intermediary between them, public authorities, and private waste-generating companies.

Figure 2 presents REICLAMP's organizational structure and its role in promoting reverse logistics through interactions among the various actors involved.

Figure 2

Diagram of the REICLAMP Reverse Logistics Network and Recycling Cooperatives in Campinas, São Paulo



Source: Research data (2025).

Figure 1 indicates that governance plays a fundamental role in the operational processes and sustainability of both the recycling cooperatives and the network established by REICLAMP by defining the flows and principles that govern interactions among the various stakeholders, cooperative members, the board of directors, councils, partner organizations, and public authorities.

Therefore, without the governance exercised by REICLAMP, there would be potential

risks of conflict, lack of strategic alignment, and operational inefficiencies among the actors within this ecosystem, which could reduce the benefits generated by REICLAMP's governance as well as those achieved by the cooperatives themselves.

One critical aspect of REICLAMP's governance that warrants further discussion concerns the cooperatives' exclusion of independent waste pickers. However, this model should be examined within the broader context of public policy to determine how these workers,



who continue to operate outside organized cooperatives, could be formalized and supported.

The controversy arises because the cooperatives' refusal to accept materials collected by independent waste pickers has twofold consequences. From a financial perspective, the cooperatives are forgoing a potential volume of materials that has already been pre-sorted by these waste pickers. As demonstrated by the findings of this study, Cooperative C achieves a 100% material recovery rate because sorting occurs at the source (CEASA). Accordingly, accepting materials from independent waste pickers, who concentrate their activities on materials with commercial value, could increase the total volume of materials recycled by the other cooperatives and, consequently, their revenues. On the other hand, the decision not to purchase materials from independent waste pickers may reflect a business model more strongly oriented toward high-volume contracts with waste generators (municipal governments, companies, and residential condominiums), which provide greater predictability in material supply and potentially lower acquisition and initial sorting costs than materials sourced from independent waste pickers. From a social perspective, however, this policy limits the inclusion and direct support of a group of workers who play a significant role in reducing urban waste and who often operate under precarious conditions without formal labor protections.

In this regard, it can be argued that integrating independent waste pickers could not only increase the volume of materials collected and generate additional revenue but also strengthen the cooperatives' social impact.

Finally, there is a clear opportunity for specialization and value creation in WEEE processing. Training initiatives and partnerships with electronics manufacturers or specialized organizations (such as Green Eletron) could transform these materials from "scrap" into a more significant source of revenue while promoting closer alignment with the PNRS.

Discussion of the Results

A comparison of the empirical findings across the three cases reveals a clear network

governance paradox that extends beyond operational differences. Cooperative C achieves a 100% material recovery rate due to its strategy of sorting materials directly at the waste-generation source and focusing exclusively on private corporate contracts. By contrast, Cooperatives A and B experience higher reject rates, comprising waste with no commercial value that increases the burden on the municipal landfill, because of dispersed residential selective collection.

This scenario demonstrates that the economic efficiency and operational standardization enabled by the RECICLAMP network require a level of technical compliance that ultimately marginalizes the most vulnerable actors in the recycling chain: informal waste pickers. To ensure stable material flows and meet the quality requirements of industrial buyers, the network adopts stringent governance mechanisms that function as market-entry barriers for independent waste pickers. This finding highlights a critical trade-off within the circular economy in emerging economies: the professionalization and logistics efficiency of second-tier networks often occur at the expense of the principles of social inclusion and grassroots empowerment advocated by the National Solid Waste Policy (PNRS).

The high material recovery rate, particularly in Cooperative C (Unidos da Vitória), which achieves 100% recovery through source sorting for some partners, underscores the importance of recycling processes as a vital alternative for managing urban waste, as emphasized by Ferraz, Gomes, and Busato (2012). The optimization of these processes, including sorting, separation, weighing, and baling, illustrates the flows of post-sale and post-consumer reverse channels described by Leite (2009) and Paula and Souza-Pinto (2012), which are intended to return materials to the production cycle. The presence of substantial reject rates (25.93% in Cooperative A, 15% in Cooperative B, and no rejects in Cooperative C) corroborates the need to improve the proper disposal of post-use and post-consumer products, as highlighted by Balde et al. (2024) and Gollakota, Gautam, and Shu (2020), and reinforces the importance of education and awareness among waste generators.



The Urban Cleaning Sustainability Index (ISLU), a statistical tool developed by ABREMA, provides additional evidence of Campinas' adherence to the PNRS guidelines. Campinas' position among the ten highest-scoring Brazilian municipalities with populations exceeding 250,000 inhabitants in the 2024 ISLU ranking indicates an institutional environment conducive to and aligned with the waste management policies emphasized in the theoretical framework.

Regarding the transformative role of cooperatives and the recognition of waste pickers, the study confirms that the cooperatives in Campinas directly reflect the formalization and organization of low-income waste pickers, a movement that has intensified since the final decades of the twentieth century (Ferraz, Gomes, & Busato, 2012; Cabral & Veronese, 2020). The emergence of cooperatives, the establishment of the first associations and the National Movement of Recyclable Material Waste Pickers (MNCMR), and the official recognition of waste picking under the Brazilian Classification of Occupations (CBO) in 2000 constitute historical milestones discussed in the theoretical framework (Okano & Panza, 2020) and reflected in the organizational structures of the cooperatives investigated.

The challenges faced by waste pickers, including inadequate infrastructure, poor working conditions, and lack of PPE (Agostini & Busato, 2022), have been mitigated through their organization into cooperatives. The findings indicate that formalization as legally constituted organizations provides formal employment or cooperative membership arrangements, enabling the receipt, sorting, and separation of recyclable materials for reintegration into the market, as described by Panza and Okano (2018). The predominance of women among cooperative members in all three cooperatives (A, B, and C) suggests a specific social impact, contributing to empowerment and community participation, consistent with Dias, Vieira, and Silva's (2024) emphasis on the social support and improved quality of life promoted by cooperatives. The absence of formally employed workers and independent waste pickers within the cooperatives further reflects the formalization model adopted, although the theoretical framework identifies informal collection as an important component

of recycling activities in Brazil (ABREMA, 2024).

Although the study did not collect detailed accounting data, the managers' accounts suggest that operational centralization generates gains associated with economies of scale and reduced logistics costs. From a financial perspective, this indicates that logistics centralization and joint contract negotiation may result in greater economic efficiency for the cooperatives. For example, using fewer trucks to transport the same volume of materials can reduce fuel, maintenance, and driver labor costs that would otherwise be incurred separately by each cooperative.

Economies of scale may also translate into higher selling prices for recyclable materials because RECICLAMP negotiates larger volumes with recycling companies. This increased bargaining power can potentially raise the network's overall revenue, with positive implications for the income of cooperative members.

Regarding partnerships, network governance, and RECICLAMP's central role, the findings demonstrate that partnerships with municipal governments and private companies constitute a fundamental pillar of cooperative sustainability, supporting Okano and Panza's (2020) theoretical proposition regarding subsidies and collaboration. RECICLAMP's role as a "central cooperative" in Campinas is a significant finding that illustrates the materialization of network governance and the formation of solidarity-based sustainable business networks, as discussed by Pisano, Demajorovic, and Besen (2022) and Cruz, Lima, and Giglio (2024). Centralization optimizes logistics, reduces costs, and prevents internal competition, reflecting the pursuit of improved performance through the optimization of processes at each stage of the reverse supply chain, as highlighted by Luana and Viana (2019).

The reverse logistics requirements established by the PNRS encourage companies to outsource these activities to cooperatives, which possess the expertise required to comply with environmental legislation and corporate social responsibility requirements (Panza & Okano, 2020). The interviews confirmed that companies such as Pirelli, Unimed, SENAC, and UNIODONTO engage with the cooperatives



through REICLAMP, demonstrating the practical manifestation of this symbiotic relationship. The standardization of sorting processes and cooperative governance practices among REICLAMP-affiliated cooperatives also corroborates the importance of governance, rules, and norms in mediating conflicts and regulating relationships among actors, which is considered crucial to the functioning of these networks (Giglio, Cruz, & Deroldo, 2024; Cruz, Lima, & Giglio, 2024).

One of the most critical issues identified concerns the lack of digitalization and institutional visibility through dedicated websites and online portals, which constitutes a strategic gap across all three cooperatives investigated. None of the cooperatives maintains a structured institutional digital presence, potentially limiting their ability to disseminate results, attract new partners, and strengthen organizational legitimacy.

Finally, the joint participation of cooperatives, recycling companies, industries, public authorities, consumers, and society, organized within networks and operating according to governance principles, supports the perspective advanced by Vieira et al. (2020), Cano, Iacovidou, and Rutkowski (2022), and Cruz, Lima, and Giglio (2024) regarding the shared responsibility of stakeholders for mitigating improper waste disposal. In this context, REICLAMP emerges as a crucial integrator, strengthening the potential for economic value creation and local social entrepreneurship, as discussed by Cabral and Varonese (2020), Agostini and Busato (2022), and Dias, Vieira, and Silva (2024).

Furthermore, from a collaborative governance perspective, the findings suggest that REICLAMP operates as a focal organization capable of coordinating material and information flows among multiple actors. However, this coordination does not eliminate distributive conflicts. Rather, the pursuit of operational efficiency appears to favor organizational selection mechanisms that hinder the incorporation of less structured actors, demonstrating that efficiency and social inclusion do not necessarily evolve in a convergent manner within circular economy systems.

CONCLUSION

This study analyzed the governance dynamics and operational coordination of reverse logistics within the REICLAMP Network in Campinas, São Paulo, Brazil. The findings demonstrate that, despite differences in their material sourcing arrangements, the cooperatives in Campinas share standardized sorting and processing procedures and are characterized by a predominance of women among their cooperative members. The effectiveness of source sorting observed in one of the cases highlights the importance of raising awareness among both the public and companies to improve the quality of recyclable materials.

In supporting standardized sorting and processing practices, REICLAMP's role as a central cooperative constitutes an essential organizational strategy, particularly by establishing a network governance model that optimizes logistics, enhances the bargaining power of affiliated cooperatives, and reduces their operating costs. In addition to providing a centralized coordination structure, this model promotes the professionalization of the sector, prevents predatory internal competition, and strengthens the recycling chain as a whole.

Despite the advances and the experience observed in the municipality of Campinas, the study also identifies persistent challenges, particularly the substantial proportion of rejects that continue to reach some cooperatives, thereby reducing operational efficiency and generating additional costs associated with landfill disposal. This finding reinforces the need for continuous environmental education campaigns and increasingly effective selective collection systems implemented by public authorities.

Based on these findings, it can be concluded that second-tier network arrangements can effectively mitigate transaction costs and power asymmetries between individual cooperatives and the industrial market by functioning as a central coordinating mechanism that helps balance relationships among actors.

The main theoretical contribution of this study lies in empirically demonstrating that second-tier cooperative structures can operate as governance mechanisms capable of reducing



coordination costs and enhancing logistics efficiency within circular economy systems. At the same time, the findings demonstrate that these structures may generate tensions related to social inclusion, thereby extending the debate on the limits of collaborative governance within recycling networks.

From a managerial and administrative perspective, the findings suggest that public- and private-sector managers should foster the corporate source-sorting model observed in Cooperative C through fiscal incentives and cross-subsidization mechanisms. Such measures could enable cooperatives primarily engaged in dispersed collection (Cases A and B) to adopt this operational approach, thereby reducing the financial losses associated with rejects.

A key limitation of this study is its qualitative, cross-sectional design and the restriction of the sample to three organizations located in a single municipality, which precludes the statistical generalization of the efficiency findings. Future research should therefore employ longitudinal designs, incorporate detailed accounting indicators, and measure the actual financial impact of logistics centralization on the average net income of cooperative waste pickers.

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