



The governance of E-waste recycling networks: Insights from São Paulo City

Ernesto Giglio^{a,b,*}, Fernanda Pedro^a, Luísa Cagica Carvalho^{c,d}, Duarte Xara-Brasil^c

^a Paulista University- UNIP, São Paulo, Brazil

^b Rua Renato Egídio de S. Aranha, 736, Rio Pequeno CEP 05353-050, Brazil

^c Instituto Politécnico de Setúbal, Centro de Investigação em Ciências Empresariais (CICE), 2910-761 Setúbal, Portugal

^d Centro de Estudos e Formação Avançada em Gestão e Economia (CEFAGE), University of Évora, 7000-809 Évora, Portugal

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ABSTRACT

Electronic waste is an environmental problem because its production volume exceeds its recycling capacity. Academic and managerial production affirm two reasons: (a) dominant market logic and; (b) unresolved asymmetries among actors, causing conflicts to work together. Following the qualitative methodology, we investigate the e-waste situation in São Paulo City. The results allow us to propose that governance constructed by local actors could be a thoughtful way to promote e-waste recycling. Examples from around the world sustain this proposition. The theoretical principle is that the social process of constructing the mechanisms for collective action can solve challenges because the rules, roles, and actions are discussed and assumed by the actors working together. We present a matrix of indicators to be used in future studies in order to refine the proposition of constructed governance.

1. Introduction

Electronic waste (e-waste) is a growing global environmental problem because the increase in e-waste generation is greater than the recycling capacity (Mahat et al., 2019). The fundamental question is: Considering that most countries have defined policies for the control and disposal of e-waste, why is the global recycling rate less than half of the waste produced, approximately 35%, and 3% in Latin America (Balde et al., 2017)?

The authors point out reasons such as lack of fiscal control (Wang et al., 2022), lack of commitment by industries to adopt the circular economy (Cesaro et al., 2018), lack of awareness and commitment by consumers (Borthakur and Singh, 2022), and dominance of market logic, with a focus on profit (Kama, 2015).

Conflicts of interest occur between various opposing public programs due to their sustainability, social, or economic objectives (Hrubec, 2019). In addition, the recycling e-waste chain is extensive and complex, with both formal and informal channels (Cruz-Sotelo et al., 2017).

Conversely, most countries have developed detailed e-waste plans to address these challenges (Kumar, 2022). Reports on the global situation show low sustainable, social, and commercial results (Forti et al., 2020; Geneva Environment Network, 2022).

The Solid Waste Plan has regulated recycling in Brazil since 2010. The plan sets goals for sustainable (correct disposal of recyclable waste), social (doing away with street pickers, creating cooperatives), and economic results (following the principles of circular economy). According to the federal law, each state made its own text. São Paulo edited its project plan in 2014 (Secretaria Meio Ambiente de São Paulo, 2014). In the following years, the state promoted technical training and environmental education initiatives, established tax incentives for recycling actions, and demanded that each municipality create its solid waste plan, including e-waste.

In 2014, the São Paulo State government surveyed the recycling situation, and the result was that of the 645 municipalities in the state, 54% had inefficient recycling rates, below 2%. In 2020, São Paulo edited a new plan, adding waste management at sea, the circular economy, and adjustment of actions following Agenda 2030 (Secretaria de Meio Ambiente do Estado de São Paulo, 2020). A new survey showed that the situation worsened, with 78% of the municipalities having inefficient indices.

After 19 years, the plan did not show results, be it in general waste or e-waste. The causes remain the same: market logic dominance, consumer unconsciousness, conflicts of interest between the government and enterprises, and lack of structure and human resources. According

* Corresponding author at: Paulista University- UNIP, São Paulo, Brazil

E-mail addresses: ernesto.giglio@gmail.com (E. Giglio), fernandacontato9@gmail.com (F. Pedro), luisa.c.carvalho@esce.ips.pt (L.C. Carvalho), Duarte.brasil@esce.ips.pt (D. Xara-Brasil).

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to this report, the e-waste category presented the same negative results. Why do the results not improve, even if the causes are known?

On the other hand, examples of local projects in Mexico (Cruz-Sotelo et al., 2017) and Brazil (Laffranchi et al., 2021; Pedro et al., 2021), with small networks focused on e-waste show that it is possible to minimize the usual causes of failure, obtain network functionality and achieve better results.

The common feature in these examples is that the actors involved in the task constructed the governance. They discussed, planned, and decided on their roles, rules, and modes of operation. In this way, the group has cohesion and control of actions, obtaining better results than the standard local rates of e-waste recycling.

These examples demonstrate how to change the e-waste recycling situation and the results. Analyzing the literature on e-waste recycling and successful examples, we present a plan based on locally constructed governance by the actors directly involved in the task.

This proposition is based on dynamic group principles (Partelow and Nelson, 2020; Shrestha, 2013). When actors decide their own rules as a group, an environment of cohesion, fewer conflicts, and task-oriented focus is created, positively influencing the improvement of the results. There are few examples of dynamic group concepts applied to recycling networks (Liu et al., 2019; Ramjattan et al., 2020). However, research has not analyzed the construction of governance.

We present a model to develop the governance of e-waste recycling networks. The constructed governance solves asymmetries, create group cohesion (Partelow and Nelson, 2020) and obtain results (Rispen et al., 2020). In addition, in the academic production of public policy governance, there is a convergence that formal governance is insufficient to carry out the recycling task (Villegas Pinuer et al., 2021).

2. Proposition of constructed governance

Collective actions present asymmetries that can generate conflicts, such as diverse interests (Pedro et al., 2021). One solution is collective discussion that decides what to do (Spaho, 2013). Decisions about rules of collaboration, communication, and inclusion in the group, are examples of governance constructed to solve conflicts (Piatak et al., 2018).

Governance is a mechanism that organizes collective actions through rules (Provan and Kenis, 2008) and controls opportunistic behavior (Spaho, 2013). However, the literature shows that local adjustments are necessary, creating mechanisms that consider local reality (Kickert, W.; Klijn, E., & Koppenjan, J., 2012).

E-waste recycling is an example of a formal governance limitation. Many countries have extensive formal rules, laws, roles, and modes of implementation. However, this is not enough, and local actors must agree on the resources, logistics, and ultimate destination (Milagres et al., 2019). Thus, they must construct their governance.

Analyzing the theoretical affirmatives about governance and the context of e-waste recycling, we created propositions linking constructed governance and e-waste recycling networks. Our proposition 1 is:

P1. The dominance or exclusivity of formal governance in e-waste recycling networks hinders the structure and functionality because local conditions and conflicts are not foreseen through formal agreements.

Academic works about governance constructed by the actors involved in the task affirm a relational and decision process (Vihma and Toikka, 2021) to solve asymmetries and facilitate collective actions (Pedro et al., 2021).

The relational process is the object of dynamic group theories (Giglio et al., 2020; Ramjattan et al., 2020). The principle is that if a group decides its own rules and roles, it can solve asymmetries, increase group cohesion (Chandra and van Hillegersberg, 2018), and improve focus on the task rather than on personal interests (Lianu et al., 2022). Under these conditions, the group becomes operational (Castanho, 2022). Our proposition 2 is:

P2. The governance constructed by the actors leading with the e-waste

recycling task is a necessary social process to solve asymmetry conflicts, with consequences to group cohesion and operability.

During this process of solving conflicts, the constructed governance organizes the roles and functions of actors, that is, the category of the network structure (Chandra and van Hillegersberg, 2018; Thibaut and Kelley, 2017). Our proposition 3 is:

P3. Constructed governance establishes the roles, functions, leadership, and hierarchy, that is, the network structure of connections.

The second network category, functionality, is related to variables, such as ways to share information, perform tasks, and solve new problems. These variables are organized according to the evolution of the constructed governance (Croxatto et al., 2020) and are influenced by group dynamics. Our proposition 4 is:

P4. Constructed governance of an e-waste recycling network serves as the basis of the modes of production, control of actor behavior, and functionality of the network.

Considering these four propositions, we affirm that the governance constructed by the actors involved in e-waste recycling is the axis to organize the structure and functionality of the network, which facilitates achieving results, be it commercial, social, or sustainable. Fig. 1 shows the design of these propositions. The main proposition, P4, is that constructed governance improves structure and network functionality.

To investigate these propositions, we followed a qualitative strategy. We chose the city of São Paulo, the largest e-waste producer in Latin America.

3. Materials and methods

The research strategy was qualitative, descriptive, explanatory, and historical. The literature review was the first step. Data from 2016 to 2022 from the Scopus portal indicated that empirical research on the social process of constructed governance is rare, and there are no operational indicators.

The second step was to create an indicator matrix, as shown in Table 1. We considered the above four propositions as starting points, and selected the indicators found in academic productions. In the first group- 1. Asymmetries, and the second, 2. Constructed Governance, we present examples selected from previous research data of our group of studies, in the University.

We selected São Paulo city because it is one of the largest economic centers in Latin America, generating products with high added value (Abbondanza and Souza, 2019) and the largest generator of e-waste. Besides, after 19 years of the São Paulo Waste Plan, the plan did not obtain results. Reports show that the causes remain the same: market logic dominance, consumer unconsciousness, conflicts of interest between government and enterprises, and a lack of structure and human resources (Secretaria de Meio Ambiente do Estado de São Paulo, 2020).

To understand this context, we collected data from secondary sources, especially Brazilian organizations: (a) Yearbook of the National Association of Recyclable Material Collectors (ANCAT, 2020); (b) Coopermiti Coop (Coopermiti, 2021); (c) CEDIR/USP (Cedir, 2021); (d) United Nations (United Nations, 2021), (e) Reverse Brazilian Logistic Agreement (Brazil, 2020); and (f) websites with information about recycling in São Paulo.

To gain a deeper understanding of the recycling network, we interviewed ten individuals with more than five years of involvement in the task, representing different segments. Saturation criteria were used to end the interviews (Guest et al., 2020). Data were analyzed using content analysis (Neuendorf, 2020).

3.1. Data analysis

The data show that governments of most countries have created solid waste solution programs, including electronic category (Cruz-Sotelo et al., 2017). However, global e-waste recycling is approximately 35% and 3% in Latin America (Forti et al., 2020), and the e-waste generate is

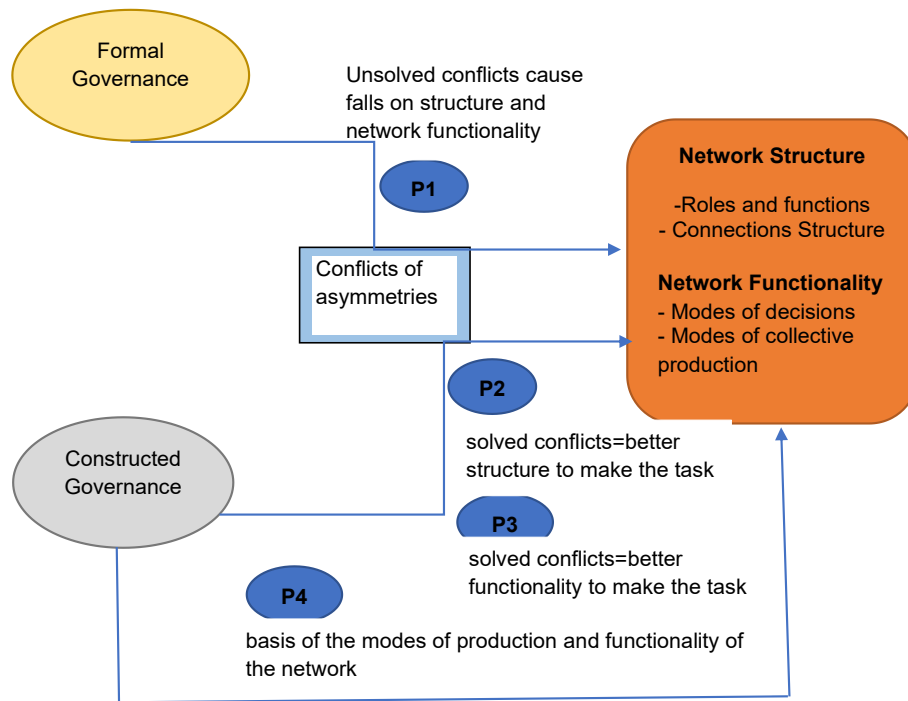


Fig. 1. Proposition design of constructed governance of e-waste recycling.

increasing yearly (Balde et al., 2017). Something seems not to be working.

We affirm that solutions could be developed in local situations, with local agreements, that is, local constructed governance.

3.1.1. Interviews analysis

Ten interviews were conducted with people working at various points in the chain. Using the thematic analysis, we created inferences on associations between the indicators. Table 2 shows the associations and consequences of the absence of governance and Table 3 shows the situation with the presence of governance. Clear differences were observed between the two cases. When governance is present, there is an increase in production modes and results, thus supporting proposition P1.

Table 2 shows the associations between the indicators and the negative consequences of the structure and functionality of the network when constructed governance is absent. For each interview, we present the indicator associations, with the absence of governance on the left, unsolved conflicts in the middle, and consequences on the right.

We can see that the significant consequence is 3.3. ways to collective actions, especially because of the absence of control, and not solving the conflicts of interest.

Table 3 shows that the governance construction of three variables-cooperation, coordination, and communication- leads the group to cohesion with no conflicts and improved collective actions.

We created the graphic of the relationships between actors using Ucinet Software. Fig. 2 shows the result. Formal governance is predominant, with a central logistics management actor seeking to solve and facilitate action within this formal governance bureaucracy. All respondents reported that this bureaucracy was a problem. The results support Proposition 1, regarding the consequences of the dominance or exclusivity of formal governance in e-waste recycling networks. One consequence is the absence of e-waste recycling cooperatives because of the extensive operational requirements.

An in-depth analysis of the structure shows that there were three groups. The first followed the principles of law, sustainability, and reverse economics. This group comprised government institutions such as CETESB, associations such as GestLog, universities such as São Paulo

University, and coops such as CoopMit.

The second group partially accepted the law because there are no obligations, prohibitions, or inspections. The actors followed profit logic. The third group did not follow legislation and acted in the informal recycling chain.

The data do not support Proposition 3, because formal governance establishes the network structure.

Many dyadic connections show a low network density, indicating low participation, resulting in the absence of a collective decision process. Three central actors have many connections. GestLog is a logistics management organization, Leloma is a retail company, and ABINEE represents the electric and electronic industries. They strive for companies to follow formal rules.

The data does not support Proposition 4. There is no collaborative governance that drives collective work and decision-making processes. The two groups that follow formal governance also follow a function-mode orientation. The actors of the third group, the informal ones, act according to the competitive market. Both situations seem insufficient for reverting the production/recycling rate equation.

In addition to this group division and distinct actions in the market, we found examples of locally constructed governance solving asymmetries and moderating the structure and functionality of each group. These examples support Proposition 2 that the governance constructed by actors can solve or reduce the impact of conflicts in e-waste recycling.

The following examples of local Brazilian projects signalize a third approach based on constructed governance:

(i) In Jaboticabal, State of Rio Grande do Norte, researchers, business people, and police united efforts to dispose the illegal gambling machines that were seized and stored in the police stations. Those machines are forbidden in Brazil (Laffranchi et al., 2021). They discussed the courses of action, creating an agreement with local norms, and the machines were recycled, becoming an example that spread to other regions.

(ii) In Águia Branca, State of Espírito Santo, researchers, city hall, and retail stores agreed to collect e-waste for 30 days, with wide dissemination in the city. This resulted in a significant increase in the recycling average volume (Rafaski Polese et al., 2018).

(iii) In Valparaíso de Goiás, State of Mato Grosso, researchers and IT

Table 1

Asymmetries, governance, and network organization indicators to e-waste recycling.

1. Asymmetries	
Variable	Indicators
1.1. Asymmetry of personal vs. collective interest (Giglio et al., 2020)	Evidence from facts, documents, discourses, and reports of situations where a personal actor's interest conflicts with collective objectives. Example: individual interest in profit $\times$ group sustainable objective to select partners.
1.2. Behavior asymmetry (Chiang and Hsu, 2019)	Evidence of behavioral differences from those accepted and practiced by the group. Example: make a business contract outside the network because of profit.
1.3. Relationship Asymmetry (Giglio et al., 2020)	Evidence indicates relationship problems, disputes, hostilities, and power asymmetry, generating conflicts in the group. Example: The group doesn't agree on who can be the leader.
1.4. Asymmetries of culture and values (Pedro et al., 2021)	Evidence demonstrates cultural values that differ from those practiced and accepted in the group. Example: One specific organization facilitates the contract of another, because of friendship with the manager, without group agreement.
1.5. Asymmetry of commitment (Benítez-Ávila et al., 2018)	Evidence indicates misalignment of commitment in the group, generating opportunistic behavior. Example: Persons participate in a meeting only if they are interested in a specific subject.
1.6. Knowledge asymmetry (Pedro et al., 2021)	Evidence demonstrating differences in knowledge and capabilities, causing problems in performing tasks. Example: Someone has experience in a specific technology but doesn't share the knowledge.
1.7. Information asymmetry (Guimarães et al., 2022)	Evidence demonstrates that some actors have access to privileged information or when there is no transparency in sharing information. Example: Information about the training of technology is not shared with all participants.
1.8. Power asymmetry (Zou and Wang, 2022)	Evidence that an actor has privileges due to his power (knowledge, for example) or that one actor exerts greater authority or influence than another. Example: someone asks for facilities because of their position in the group.
2. Constructed governance	
Antecedent	Evidence that an actor helps the other in case of necessity or problem, in tasks one cannot perform alone. Example: Help a group offering knowledge about how to plan an action to clean a beach.
2.1. Cooperation (Partelow and Nelson, 2020)	
Antecedent	Situations where someone asks the other for help because of their specific resource. Example: Ask someone to be the leader of a plan to clean a beach because of their experience.
2.2. Trust (Bertóli et al., 2017)	
Antecedent	Evidence shows that people do not take advantage of the dependence and problems of others for their benefit. Offer to help someone with a problem, even without immediate self-benefit. Example: Participate in the action to clean a beach without any self-benefit.
2.3. Commitment (Bertóli et al., 2017)	
2.4. Coordination Mechanisms (Stolze et al., 2021)	Evidence that there are rules for the election of coordinators, leaders, the decision of norms, and practices that drive the tasks. Example: "The coordinator needs to be someone that participates in the group for at least three years."
2.5. Transfer and Learning Mechanisms (Sitar et al., 2019)	Evidence of rules on knowledge sharing and how this transfer process occurs. Example:

Table 1 (continued)

1. Asymmetries	
	"Every weekend, we have a meeting to report new technologies."
2.6. Control Mechanisms (Hooker et al., 2016)	Control forms of behavior and production; punishment rules when something is not fulfilled. Example: "If someone does not participate in three meetings in a row, they will be disconnected from the group."
2.7. Group Cohesion Mechanisms (Giglio et al., 2020)	Rules about group practices, values, and rituals without distinction or exclusivity. Example: "In every ordinary meeting, everybody can talk and vote, with the same score of all."
2.8 Communication mechanisms (Guimarães et al., 2022)	Rules about the information shared and the limits to outside persons. Example: "Our WhatsApp is a free instrument for manifestation, but it is forbidden to share our information with another group."
3. Network Organization	
3.1. Connection's structure (Ohara et al., 2020)	Whether there is high density and centrality, the existence of key actors without whom specific tasks doesn't carry out.
3.2. Role structure (Giglio et al., 2015)	Division of roles in the various points/steps of the task. Evidence indicates that roles and functions are performed according to defined rules. The flows and stages of the various tasks. Evidence shows whether these tasks follow legal regulations or specific agreements between the parties.
3.3. Ways of performing tasks (Velly et al., 2022)	Evidence that the participants acquire constant knowledge about e-waste recycling task.
3.4. Forms of collective learning (Sitar et al., 2019)	Evidence that actors work cooperatively, with collective process adjustments and a low incidence of conflicts and asymmetries. Evidence on ways to circulate information.
3.5 Ability to work in a group (Pedro et al., 2021)	
3.6. Communication Systems (Guimarães et al., 2022)	

Table 2

The absence of governance and the consequences in network structure and functionality.

	Governance mechanisms absence	asymmetries conflicts	Negative consequences in network structure and functionality
Interview 1	2.6. Control 2.7. Cohesion	1.1. interest 1.8. power	3.2. clarity of roles 3.3. ways to collective actions
Interview 2	2.1. cooperation 2.3. commitment 2.5. transfer and learning 2.7. cohesion	1.1. interest 1.5. commitment	3.3. ways to collective actions 3.5. ability to collective
Interview 3	2.3. commitment 2.6. control	1.1. interest 1.2. behavior	3.2. clarity of roles 3.3. ways to collective actions
Interview 6	2.6. control 2.8. communication	1.1. interest 1.2. behavior	3.3. ways to collective actions
Interview 8	2.6. control	1.1. interest	3.3. ways to collective actions

technicians created a free platform that brings together those interested in offering e-waste, those that work on collection and separation, and those who transform the material into products that can be used by poor local communities, and uses part of the sales profit to train young people for the IT world. The project follows sustainability principles. (Santana, 2018).

These examples show that the agreement of local actors, considering

Table 3

The presence of governance and the consequences in network structure and functionality.

	Governance mechanisms presence	Asymmetries conflicts solved	Positive consequences in network structure and functionality
Interview 4	2.7. cohesion	No conflicts	3.3. ways to collective actions
Interview 5	2.8. communication	No conflicts	3.6. communication
Interview 7	2.1. cooperation	No conflicts	3.3. ways to collective actions
Interview 7	2.4. coordination	No conflicts	3.5. ability to collective work
Interview 7			3.3. ways to collective actions

local characteristics, is a way to obtain better results in e-waste recycling. The process of constructed governance is the thesis of this communication. Formal governance seems incapable of resolving or balancing production and recycling in all the countries. The market format also seems incapable of producing environmental consequences of adequate material treatment. We assert the necessity of changing these two e-waste recycling systems. The social process of constructing local governance is proposed.

The following statement support the main proposition: *Cooperation and joint work exist, each helping the other in whatever is necessary; for example, company XX had a parking lot to put a collection container, but it was huge and would take up half the parking lot, so Green (Logistic Co) went there and cut the box in half... this cut was done by company YY, who helped design the optimal size of the collection point container... Because of this experience, Green contacted other store entrepreneurs and adapted the size of the collection boxes according to the needs of each one*.

The respondents gave following suggestions for improving the e-waste recycling system.

(a) Improvement in control and inspection systems. The idea is to decentralize formal governance by placing local agents, such as companies, as inspectors. In return, they could receive incentives, such as bonuses and prizes. Example: Moléccola organization: Consumers

receive points when they submit recyclable waste in PEVS and can exchange those points for prizes.

(b) Partnership of companies with cooperatives and individual collectors. Companies that generate or buy e-waste can partner with cooperatives, helping them qualify for legal and technical demands. For example, in Várzea Grande, Mato Grosso State, Brazil, a company has adopted a cooperative based on a social responsibility contract. The immediate effect was the discontinuation of usage of an illegal wasteland.

(c) Funding for cooperative workers to participate in electronics recycling programs. The idea is to resolve the lack of technicians with the knowledge to separate e-wastes. This Brazilian example set by a cooperative, an ONG that collects e-waste, and São Paulo University shows a way to develop capabilities. This example can be repeated for local municipalities.

(d) Small networks to develop technology to lead with e-waste. One example is the efforts of Campinas University near São Paulo, which is developing a system to separate noble materials. The program is being developed with the participation of a local cooperative.

All these suggestions contain the idea of governance constructed by local actors. The previous examples of success and suggestions indicated an alternative solution to the growing problem of e-waste.

4. Conclusion

E-waste is a global environmental problem that lacks a satisfactory solution. Reports indicate that the electronics recycling rate in South America is approximately 3%, and the generation rate is increasing annually. The causes of failure are known, but government plans cannot resolve them.

Considering the academic works on e-waste recycling networks and examples of success, we propose that governance constructed by the actors who perform the task can be a way to solve asymmetry conflicts and improve the results. Dynamic group theories suggest that if the participants of a group decide their rules and roles, they achieve cohesion and focus on the task.

The research in São Paulo, with documents and discourses of the ten interviewees, shows that the actors operate predominantly according to

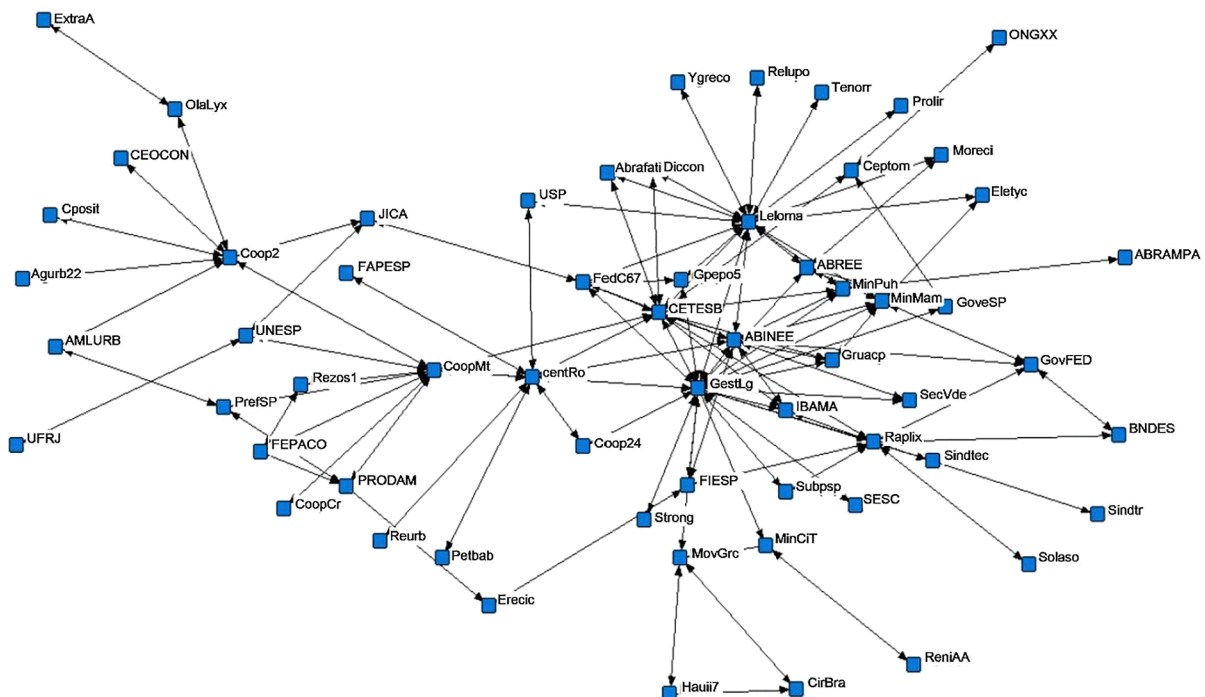


Fig. 2. The social network analysis of e-waste Brazilian actors.

market logic, with competitive behavior, and search for profit.

Otherwise, we found examples of governance constructed by local actors with better results than ordinal ones. This constructed governance process can improve theoretical knowledge about network performance, especially recycling. Dynamic group theory offers a way to understand and analyze, and the indicator matrix is one way to do so.

This study offers a reliable indicator matrix that can be used in electronics recycling research and management, especially in local projects. Our short communication shows that current recycling systems are commercially, socially, and sustainably ineffective.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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