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Proposal of a dynamic model to evaluate public policies for the circular economy: Scenarios applied to the municipality of Curitiba

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ABSTRACT

In Brazil, the National Solid Waste Policy (NSWP) does not encourage incineration. Thus, all the waste generated is disposed of in landfills or recycled. However, currently, around 94% of all the waste generated in Brazil, which is the 4th largest waste generator in the world, is disposed of in landfills. The aim of the article was to develop a dynamic model that allows an analysis of different scenarios involving the tradeoff between investment in new landfills and policies to increase the recycling rate. The methodology used was the technical of analysis of dynamic systems to develop scenarios, following a survey of the data relative to Brazil. The use of dynamic systems enables an understanding of the changing relationships in the waste value chain over time. From the current situation, scenarios have also been developed for Curitiba for 40 years. Curitiba is one of the most important Brazilian capital cities in terms of public policies for waste management. Because it is a dynamic system, the base theory for understanding the relationship between the variables and agents was the circular economy. The variables and relationships of the model were validated specialists, followed by a focal group of specialists in Brazil. By constructing two scenarios, with changes in terms of increasing investments in the public policy for environmental education, it was possible to gauge the impact throughout the value chain of paper and cardboard in Curitiba over a period of 40 years. The results show that the cost of disposal on land will increase, due to the volume generated and the cost of the land. The alternative of investing in recycling policies will reduce this impact in the future. The result shows that the long-term cost of not taking action is higher than the cost of a public policy. If annual investments increase from 315 thousand to 3,15 million (American dollars in 2016), the cost of disposal by 2055 will be reduced by 50 million of dollars per year. Moreover, the recycling rate can be increased by 23%, with the impact on positive externalities for the environment, and reduce the need to increase the use of new land to dispose of more waste. However, even with increased investments in environmental education policies, the 25% recycling rate is not achieved. This shows the need for further actions linked to the organization of the chain. The circular economy is complex, but it transforms problems into opportunities for municipalities such as Curitiba. In cities like Curitiba, where there is no regulated incineration, this analysis model allows an evaluation of the relationship of this tradeoff to propose state policies, transforming this problem into opportunities for municipalities.

1. Introduction

The issue of urban solid waste is an important theme for society, government and a growing field of study as a multidisciplinary theme in academia (Callan and Thomas, 1997). The size of the population and its respective waste generation are growing in a process that involves different agents (Saphoresa and Nixon, 2014; Othman et al., 2013; Mo et al., 2009; Matsumoto, 2011; Moh and Manaf, 2014; Lin, 2008; Lakhan, 2014). This is an important issue because it involves environmental, social, economic and institutional matters (Santiago and Dias, 2012; Wan et al., 2014; Pires et al., 2011; Silva et al., 2015a, 2015b, 2017; Zurbrugg, 2003; Soltani et al., 2015; Guerrero et al., 2013; Plata-Díaz et al., 2014; Bing et al., 2016).

However, the cost of not taking action to increase recycling by public administrators is not addressed (Dye, 2011). Currently around 95% of all the waste generated in Brazil, which is the 4th largest waste generator in the world, is disposed of in landfills (ABRELPE, 2014). Increasing recycling is a possible solution to a municipal public administration problem when it is necessary to deal with budget constraints. In Curitiba, for example,

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6% of the municipal budget is earmarked for waste collection and disposal (Silva, 2016). Contracts are usually based on the volume of waste collected and this is disposed of in a landfill, which generates other costs. In Brazil, only 5% of waste is recycled, and the cost of not having adequate recycling and placing all the waste in landfills is almost 2,5 billion dollars a year (IPEA, 2010). There are two losses involved in this process: one involving the cost of disposal (around U$ 11,25 per ton – Silva Neto et al., 2011) and the cost of not selling this waste. The latter, however, depends on the waste that is generated and the prices different types of waste can fetch in their respective markets. Therefore, this is a complex economic problem because it involves the rationalization of public funds and the consolidation of a value chain that generates work and wealth.

Thus, for the percentage of waste to increase, there must be a public policy oriented by environmental education, which is a continuous public investment, so that people are aware of the importance of recycling and more effective separation of waste. With increased waste, the cost of disposal can be reduced and better local development can be gained by structuring this value chain for socio-economic benefit (creating work and income). There will also be environmental gains (through the reduced extraction of new raw materials), cultural gains (greater perception and collective action in the community) and political gains (collective efficiency due to social action).

However, a problem becomes economic when there is a notion of its opportunity cost. If this cost is low, it does not require immediate public or private action as a collective issue. In other words, it is not high on the public policy agenda. The problem lies in understanding the total cost of generating and disposing of waste in order to gauge how much investment is required and whether it will be a priority to increase the percentage of recycling and reduce the cost of disposal.

After almost 8 years following the implementation of the National Solid Waste Policy (NSWP), Federal Law 12.305/10, most municipalities have not drafted and implemented their own Municipal Policy. Furthermore, only 58.4% of urban solid waste are disposed of in landfills, with the rest being deposited in inadequate or unsuitable places (ABRELPE, 2016).

Moreover, the municipal cost of waste management is the third highest element in terms of expenses, equivalent to almost 6% of the entire budget of Brazilian capital cities (SNIS-RS, 2016). Although the National Solid Waste Policy reinforces the importance of environmental education, municipal expenditure is concentrated on collection and disposal services. Therefore, the aim of this article is to envision scenarios from a dynamic system that simulates the impact of investing in a public policy for environmental education to increase recycling and its relationship with the total cost of waste management.

It is based on the precepts of the circular economy, which will be presented, as theoretical support for discussion, considering that this article is restricted to only one of its precepts: recycling. Another delimitation of the study is that it includes only the paper and cardboard markets, as these account for almost 50% of the entire volume of waste collected for recycling, compared with all other resources (SNIS-RS, 2016). This model was developed and applied to the municipality of Curitiba, from a theoretical model validated in Silva et al. (2017), justified in Section 3.

This article is divided into five section, including this introduction. The next section defines the field of the circular economy and outlines the relationship between this theme and the development of cities as a complex system. This theoretical basis supports the research methodology, which is divided into two techniques: an analysis of efficiency and the system dynamic model. The fourth section presents and analyzes the results of the applied techniques and the scenarios developed in answer to the proposed objective. Finally, the conclusions are presented in the fifth section, with proposals for further research.

2. Circular economy: new foundations for development

The rising population, the growth of economic activity and rapid urbanization are reasons for changing consumption patterns and the fast-growing generation of urban solid waste around the world, especially in developing countries like Brazil (Guerrero et al., 2013). Song et al. (2015) illustrate this with the volume of waste generated in the world in 2011, which was around eleven billion tons per year, meaning 1.74 tons per capita annually. This volume of waste has put considerable pressure on government for more sustainable management. However, waste management systems have not received as much attention in the urban planning of cities as water and energy. These elements are articulated with the assumptions of the circular economy, which link the issue of reduction, reuse and recycling. This involves viewing urban development as a complex issue.

The circular economy seeks to transform waste into resources and return them to the production and consumption systems. However, research in this respect remains limited (Witjes and Lozano, 2016). It is based on closing loops with different levels of recovery of materials and products in services useful for transformation through resource efficiency (Yong, 2007; Yuan et al., 2006; Witjes and Lozano, 2016; Brocklehurst, 2016; Klettner et al., 2013; Webster, 2013). This concept is not contemporary, but its scope and importance is, being under discussion in the countries of the OECD (Organization for Economic Cooperation and Development), as in the case of the project known as Towards a Circular Economy for Europe: a zero waste program for Europe (EC, 2014).

The topic is relevant because there is a context favorable to rethinking the current linear economic model with the unstable prices of commodities and the growing demand for raw materials, which has posed a challenge to the conventional linear economy of extracting, making, using and disposing (Brocklehurst, 2016). Furthermore, the results of a linear economy have shown that 80–90% of what is consumed becomes waste for final disposal or incineration in under twelve months, and 20% of extracted natural resources become waste every year for the same purpose (Newman, 2016).

Nevertheless, there are several risks involved in the circular economy, as highlighted by Bilitewski (2012). On the other hand, there are positive results, including the implementation of a new national policy, as highlighted by Geng et al. (2012) and Murray et al. (2015) in China, for instance, or explained by the ISWA in the study synthesized by Newman (2016). However, as yet, there have been few studies on the theme, as pointed out by Witjes and Lozano (2016), involving environmental, economic, social and institutional aspects with strong socio-cultural relationships through relationships and cooperation in a territorial dynamic. Some authors address these principles as a circular economy (e.g., Murray et al., 2015; Jun and Xiang, 2011; Yuan et al., 2006; Silva et al., 2015a, 2015b), others as a zero waste strategy (e.g., Song et al., 2015). However, these different concepts are associated with the same principles and opportunities for the planning and development of cities.

The circular economy is a recent attempt to integrate economic activity associated with the environmentally responsible use of resources in a process of development, as pointed out by Murray et al. (2015), although the origin of the term is controversial and dates back to the earliest discussions on commercialism or capitalism. Jun and Xiang (2011) view the circular economy as a new kind of economy and a new economic development model, with reflec-