

DOI: 10.5902/1983465936254

SOCIO-TECHNICAL TRANSITIONS TO SUSTAINABLE URBAN MOBILITY IN BRAZIL

TRANSIÇÃO SOCIOTECNOLÓGICA PARA A MOBILIDADE ÚRBANA SUSTENTÁVEL NO BRASIL

Submission: 02/01/2019

Accept: 15/11/2019

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ABSTRACT

This article identifies micro, meso, and macro dynamics that influence the socio-technical transitions of cities to sustainable urban mobility in Brazil. The study analyzed the content of documents such as the National Urban Mobility Policy (PNMU), and the master plans and urban mobility plans of the cities of São Paulo, Rio de Janeiro, Distrito Federal, Fortaleza, and Salvador. The research revealed that the master plans and other plans related to urban mobility of the main Brazilian capitals are developed in isolation, with no coordination among cities. At the micro level, the plans do not contemplate the adoption of alternative fuels and the effective integration among modes of public transport. At the meso level, three mobility regimes were introduced: the traditional public transport and non-motorized public transport regimes, which had a dynamic contrary to the regime of cars. At the macro level, the variables associated with the economic and social context, with the consumer market, and the industry shaped the trends of urban mobility systems. The research presents a dynamic of resistance to sustainable urban mobility and reinforces the need for greater coordination between private and public actors.

Keywords: Multilevel Approach, Socio-technical Transition, National Urban Mobility Policy, Sustainable Urban Mobility.

ACKNOWLEDGMENTS

We would like to thank the editor and blind reviewers for their valuable contribution to the improvement of this article. We are grateful to CNPq and CAPES for the grants to finance this research.

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RESUMO

O artigo avalia dinâmicas nos níveis micro, meso e macro que afetam o processo de transição sociotecnológica para a mobilidade urbana sustentável no Brasil. Procedeu-se uma análise de conteúdo da Política Nacional de Mobilidade Urbana (PNMU) e dos planos diretores e de mobilidade urbana das cidades de São Paulo, Rio de Janeiro, Brasília, Fortaleza e Salvador. A pesquisa revelou que os planos diretores e de mobilidade urbana das principais capitais do país são desenvolvidos de forma isolada e sem articulação entre os atores. No nível micro, os planos não contemplam a adoção de combustíveis alternativos e a integração eficaz de modais de transportes públicos. No nível meso, três regimes de mobilidade foram introduzidos: os regimes de transporte público tradicional e transporte público não motorizado, que tiveram uma dinâmica contrária ao regime de carros particulares. No nível macro, as variáveis associadas ao contexto econômico, sociais, mercado consumidor e indústria moldam as macrotendências dos sistemas de mobilidade urbana. A pesquisa apresenta uma dinâmica de resistência à mobilidade urbana sustentável, e reforça a necessidade de uma maior articulação entre os atores públicos e privados.

Palavras-chave: *Abordagem Multinível, Transição Sociotecnológica, Política Nacional de Mobilidade Urbana, Mobilidade Urbana Sustentável.*

1. INTRODUCTION

Urban mobility is related to commuting or moving goods daily in urban space. It involves the use of vehicles, roads, sidewalks, and other infrastructure that allows people to “come and go” (MINISTÉRIO DAS CIDADES, 2005; VACCARI; FANINI, 2011). Although transportation is considered the core of the twentieth century’s socioeconomic progress (MORADI; VAGNONI, 2018), Brazil’s large metropolitan areas have not yet been able to effectively implement their accessibility and urban mobility plans and programs, failing to integrate the different modes of transport.

Public collective transportation in Brazil has never been considered as a strategic activity by the federal, state, or local governments. Cities were shaped to serve vehicles, reducing the appeal for public transport (GOMIDE, 2006). The Metropolitan Region of São Paulo is an example of this reality. Traffic congestion occurs at times when less than 16% of all cars registered in São Paulo are on the road (ZANDONADE; MORETTI, 2012). On the other hand, according to data from the Institute of Applied Economic Research (IPEA) (2011), urban and metropolitan bus systems are the predominant mode of transport in Brazil and operate in around 85% of the municipalities.

Urban commuting by car is one of the most used methods of transport in Brazil (SOARES et al., 2017). Car production in the country grew differently from Europe and other mature markets and has led to increasing traffic saturation, even in medium-sized cities (SOARES et al., 2017). Also, the transport sector has negative impacts on the environment, such as the high greenhouse gas emission, especially carbon monoxide (CO) and carbon dioxide (CO₂) resulting from incomplete burning of fossil fuels (MORADI; VAGNONI, 2018). In 2011, the transport sector accounted for 22% of global CO₂ emissions. By 2030, global emissions are projected to increase by 50%, and by 2050, more than 80% of emissions will come from this sector, according to the International Energy Agency (2013).

The pollution from excessive use of cars causes a series of respiratory allergies, affecting the quality of life, and burdening the public health system (SALDIVA, 2000; VIANNA et al., 2008). These environmental and social issues have increased the awareness toward sustainable urban mobility amongst agencies involved in urban transport management (JIMÉNEZ-HERRERO, 2011). Sustainable urban mobility, therefore, consists of the ability to make the necessary journeys to maintain citizens’ rights, with the lowest possible energy expenditure and the least impact on the environment (MINISTÉRIO DAS CIDADES, 2007).

The transition from the current model of “urban mobility” to “sustainable urban mobility” involves the socio-technical transition to low carbon urban transport from a multilevel perspective (CROZET; LOPEZ-RUIZ, 2013; DHAR; SHUKLA, 2015). Studies on transitions should be conducted from three levels: micro (niche), meso (regime), and macro (landscape). The multilevel perspective evaluates how to replace existing socio-technical regimes with those that have a lower social and environmental impact (GEELS; SCHOT, 2007). The multilevel perspective has been used in studies about changes in society resulting from the introduction of new technologies (GEELS, 2010) such as waste management in the manufacturing process, recycling, reduction of greenhouse gas emissions, and the use of alternative fuels (ZORPAS; INGLESAKIS, 2012; BIELACZYK et al., 2015; HOSSEIN et al., 2015).

This study was based on the research question: *To what extent do urban mobility plans include micro, meso, and macro dynamics that contribute to sustainable urban mobility?* It examined the *Política Nacional de Mobilidade Urbana* (PNMU) (National Urban Mobility Policy), and the *Planos de Mobilidade Urbana* (PMUs) (Urban Mobility Plans) of the five most populous cities in Brazil, as well as other documents and instruments related to urban mobility in the cities. The task of analyzing the sustainable urban mobility of a region means examining its urban mobility plan. In Brazil, PMUs have become instruments for the implementation of the PNMU. Therefore, municipalities with more than twenty thousand inhabitants need to present their PMU to the federal government as a condition to receive funds for urban mobility projects. In addition to being integrated with the City’s Master Plan of Urban Development, the PMU must present the actions designed to achieve the objectives and goals related to the population’s problems and needs, which must be established after participatory diagnostic processes (OLIVEIRA, 2012).

This study offers two contributions. First, it shows the paths of transition to sustainable urban mobility from a systemic perspective involving technological, material, organizational, institutional, political, economic, and socio-cultural dimensions. It was possible to observe the need to promote joint actions of the agents involved in the Brazilian urban mobility, especially of the agents operating at the niche level, in designing the paths of the transition process. As for the second, this research contributes to expand the currently limited body of knowledge about the paths and driving forces engaged in this transition, since it works with the urban mobility plans of the most populated cities in Brazil, analyzing practices of public managers, private organizations and other actors in Brazilian society (MORADI; VAGNONI, 2018).

This article is organized in five sections including this introduction. The next section presents the elements needed for the transition to sustainable urban mobility. The third section shows the methodology adopted, followed by the results found in the assessment of the PNMU and the PMUs of São Paulo, Rio de Janeiro, Distrito Federal, Fortaleza, and Salvador. Finally, the study discusses the dynamics of resistance and those that favor the implementation of projects that enable sustainable urban mobility.

2. UNDERSTANDING THE MULTI-LEVEL PERSPECTIVE IN TRANSITION TO SUSTAINABLE URBAN MOBILITY

Different initiatives and interventions to reduce greenhouse gas (GHG) emissions and stimulate economic development are an attempt to advance to a more sustainable society. It is important to recognize that structural changes in social systems are sometimes required to achieve the UN sustainable development goals (KERN, 2012; HAMNETT, 2015). These movements can occur through a slow incremental change (slightly modifying the macro level), or they

may happen as a transition, which means a significant change toward a new landscape. These changes may also represent a significant transformation, paving the road for a fundamentally different future (ELZEN et al., 2002; GEELS; SCHOT, 2007). This process of transformation can find resistance from those actors who are unable to adjust to a radical, rapid change.

The 'transition' process is different from an incremental change because (i) transitions require multiple changes in society's systems; (ii) transitions are multi-actor processes, i.e., they involve interactions between social groups such as companies, citizens, scientific community, public policymakers, social movements; (iii) transitions are radical changes (in terms of scope, rather than speed); (iv) transitions are long term processes (40 to 50 years), but impacts can be relatively fast (10 years) (GEELS, 2010).

Transition theory seeks to solve the paradox of 'radical changes' in 'incremental steps.' The theory has been used to analyze past and present transition processes (GEELS, 2005), or to design transition paths and develop future scenarios (DHAR; SHUKLA, 2015; MARLETTO, 2014; SPICKERMANN et al., 2014). Transitions involve a wide range of actors and typically unfold over a long time. During the transition, new products, services, business models, and organizations emerge, complementing or replacing existing ones. The consumer's understanding of a particular service, product, or technology may change substantially (CHIARINI, 2014, 2015; TURNHEIM et al., 2015). Transitions imply changes in the production of goods and services, in technologies adopted, and in the economic and social systems that are connected to the use of such technology (GEELS, 2004). Transitions involve changes in the practices of technology users, in regulations and infrastructure, in the structure of industrial networks, and in symbolic and cultural meanings.

For Lachman (2013), the most widely used transition approaches are the multi-level perspective, strategic niche management, transition management, innovation systems, techno-economic paradigm, and socio-metabolic transitions. Geels (2002) pointed out that the understanding of the transitions between socio-technical regimes is better represented from a multi-level perspective, which proposes the study of the transition from three interrelated levels of analysis, namely at the micro (niche), meso (regime) and macro (landscape) levels.

At the micro (niche) level, innovations emerge and develop. This level is constricted to a company or group of companies (RIP; KEMP, 1998) and works as a sophisticated environment for still incipient technologies to develop. Niches are also understood as protected spaces, i.e., specific markets or fields of application, where radical innovations develop independently of the pressures from the current regime. Niche innovations can gain momentum and eventually compete with established technologies (MARKARD; RAVEN; TRUFFER, 2012). According to Geels (2002), the meso level (regime) is a system of interrelated actors from different social groups and communities who follow specific rules. A technological path is defined at the regime level. Changes that occur at the socio-technical regime level are usually slower and more incremental than changes at the niche level. The actors that make up the existing regime are interested in maintaining the current technology model rather than adopting the new one.

The macro level (landscape) is defined from a wide range of external factors but related to the socio-technical regime (GEELS, 2002; TURNHEIM et al., 2015). This level incorporates economic pressures, cultural values, social trends, international conflicts, and environmental issues. Change occurs at a slower pace, and ultimately represents a broad transition in the way society or part of it, operates within the landscape. The multi-level perspective involves multiple dimensions, such as technology, industry, markets, consumer behavior, politics, infrastructure, and cultural values. It is an approach that contemplates interactions among different stakeholder groups and focuses on complex dynamics, not just linear cause and effect relationships (CHIARINI, 2014).

2.1 Conceptual elements of sustainable urban mobility

Urban mobility encompasses multiple services, equipment, and opportunities that cities offer to citizens to move around safely and comfortably. There are several transport alternatives for commuting, such as walking, biking, driving vehicles, or using public transport systems (RESENDE, 2017). In Brazil, urban mobility is regulated by Law 12,587 of January 3, 2012, which established the *Política Nacional de Mobilidade Urbana* (PNMU) (National Urban Mobility Policy). The PNMU offers guidelines for the action of local, state, and federal governments and presents instruments to manage urban mobility. The legislation established the obligation for cities with more than twenty thousand inhabitants to elaborate a *Plano Municipal de Mobilidade Urbana* (PMMU) (Municipal Urban Mobility Plan). As for the concept of sustainable mobility, the Brazilian Ministry of Cities, through the National Secretariat of Transport and Urban Mobility, coordinates its diffusion nationwide (SOARES et al., 2017).

In 2016, the Ministry of Cities conducted a survey with the participation of 3,342 Brazilian municipalities to verify compliance regarding the PMMU. Of the 2,066 respondents, only 189 municipalities had prepared the document. Consequently, the municipalities that did not prepare the PMMU were no longer eligible to receive financial resources from the federal government, to finance improvements in the cities' urban mobility. Soares et al. (2017) clarify that the municipalities that did not prepare the PMMU find it challenging to coordinate the transport and circulation policy with the policies related to urban development.

According to the Brazilian Ministry of Cities, sustainable mobility is a group of transport and circulation policies that aim to provide broad and democratic access to urban space, by prioritizing effective, socially inclusive and ecologically sustainable modes of collective and non-motorized transport (MINISTERIO DAS CIDADES, 2005). The introduction of the concept of sustainable urban mobility is a breakthrough in the traditional way of dealing with traffic, planning, and regulation of public transport, the logistics of distribution of goods, and highway construction.

Studies divide the analysis of sustainable urban mobility initiatives into four different possibilities (PARKHURST et al., 2011; DIJK; ORSATO; KEMP, 2013): i) electro-mobility: development and production of electric-powered vehicles, hybrid electric vehicles (HEV), or pure electric vehicles (PEV); ii) car sharing: short-term car-sharing schemes, usually charged by the hour; iii) intermodal transport: integration management systems of different modes of transport in a single trip; iv) innovation in public transport: initiatives involving quality, reliability, and improvements in traffic flow, and comfort for users. Innovations in technology, organization, and management, such as the Bus Rapid Transit (BRT), are explored in this niche.

Among these modalities, intermodal transport and public transport innovation stand out, with the development of studies focused on the introduction of less polluting motorization (YUE, 2012), development of technologies involving alternative fuels (ZORPAS; INGLESAKIS, 2012), and electric cars (HØYER, 2008; KIMBLE; WANG, 2012; HILDERMEIER, 2016). These studies are relevant because the transition to sustainable urban mobility involves the generation of innovative solutions aimed at the use and combined use of cars with other modes of transport (BANISTER, 2008).

3. METHODOLOGY

This study is qualitative, descriptive, and exploratory. It is based on document analysis to investigate the extent to which PMUs include dynamics at the micro, meso, and macro levels

for sustainable urban mobility. The use of qualitative data is recommended when the phenomenon studied is new, and when the researcher seeks to answer “why” and “how” questions (YIN, 2014). The PMUs of Five Brazilian cities were selected. The cities chosen were the most populated in the country, in the following order: São Paulo, Rio de Janeiro, Distrito Federal, Salvador, and Fortaleza. The data obtained was available online, on the websites of the municipalities, or on specific portals created by local governments to display information about urban mobility (or transportation), presenting the plans and research subsidizing the city’s plans. After an initial analysis of the PMMU, it was identified the need to complement information available with the public officials in charge, in the PNMU, and other documents and instruments related to urban mobility, as listed in Table 1.

Table 1 – Documents analyzed for each of the researched cities

City	Documents analyzed	Year of implementation	Time horizon
São Paulo	Urban mobility plan	2015	15 years
	Strategic master plan	2014	16 years
Rio de Janeiro	Sustainable urban mobility plan	2016	10 years
	Master plan	2011	10 years
Distrito Federal	Master plan of urban transport and mobility	2011	10 years
Fortaleza	Mobility plan	2015	10 years
	Master plan of the integrated bikeways system	2014	15 years
	Urbanistic plan for mobility and environment	2016	25 years
Salvador	Mobility plan	2017	32 years
	Master plan of urban development	2019	33 years

Source: Elaborated by the authors.

The mobility plans of the five capitals were developed in different years and, mostly, after the publication of the PNMU, the policy that made it mandatory for cities to present such planning as a condition to receive transfers from the federal government. In Distrito Federal, the master plan does not include guidance on the occupation of urban land but presents the instrument of urban mobility planning and management, which was considered enough for the purpose of this study. As shown in Table 1, the plans have different names and scopes, as well as covering a diversity of time horizons. In Fortaleza, Distrito Federal, and Rio Janeiro, the instruments were developed considering a time horizon of ten years. As for São Paulo and Salvador, the period of implementation of urban mobility initiatives is extended for 15 and 32 years, respectively).

The distribution of data in categories of analysis for each of the three levels studied was carried out based on the literature. The category for the micro level included data about the integration of modes of transport (GEELS, 2012; TURNHEIM et al., 2015), investment in sustainable propulsion technology (TURNHEIM et al., 2015), investment in fuel cells, biofuels, and hybrid vehicles (CHIARINI, 2014), sharing transport (MORADI; VAGNONI, 2018), and the innovations in public transport (GEELS, 2012).

The category for the meso level included data on controlling the use of vehicles (TURNHEIM et al., 2015; MORADI; VAGNONI, 2018), bus transport infrastructure (MORADI; VAGNONI, 2018), and non-motorized transport (MORADI VAGNONI, 2018). Finally, at the macro level, the category included data on traffic education programs (TURNHEIM et al., 2015), public authorities’

awareness (TURNHEIM et al., 2015), debates on climate change, and investments related to adaptation and mitigation of the effects of climate change (MORADI VAGNONI, 2018).

The content analysis technique (BARDIN, 1977) was used to evaluate the information collected in the ten documents listed in Table 1. The analysis started after reading the documents, by identifying and grouping the components of the dynamics at the micro, meso, and macro levels and verifying the structure and relevance of the categories established. After that, documents were printed and coded, distinct colors were attributed to data included in each category, and excerpts from the documents were underlined. Finally, excerpts from the documents from different cities were grouped and compared to verify the contribution of the identified elements to the transition to sustainable urban mobility at their respective levels.

4. RESULTS

The content analysis showed that the master plans and urban mobility plans of the most populated cities in the country are developed in isolation, i.e., there is no connection among them, as well as low coordination between the local plans and the PNMU. At the micro level, there is a concern about the adherence of the PMMU to the PNMU regarding the integration of “buses and subways” in São Paulo, Rio Janeiro, and Distrito Federal. At the meso level, it was possible to observe the integration of PNMU with PMMU in all cities regarding accessibility to buses, fast transportation, and public incentives to increase the number of users of collective public transport. Finally, at the macro level, the study identified a concern about integrating public agencies.

The study demonstrated that commonalities in the PMMUs of the five cities. There is an emphasis on the prioritization of collective public, non-motorized, and shared modes of transport over individual motorized modes of transport. The increase in the use of bicycles as a mode of transport, the implementation of an integrated transport network, the reduction of energy consumption, and the creation of instruments to control the supply of parking spaces in public and private areas are less emphasized in the PMMU. On the other hand, the integration between the subway and bus systems, and programs limiting the use of cars are incipiently mentioned in the PMMU, as shown in Table 2.

Most innovations remain a “niche” at the micro level, and do not get enough government support to move to the meso or macro level. Niche innovations can manifest in different ways, such as integration among different modes of transport, development of clean technology for vehicle propulsion, adoption of biofuels and electric cars, innovations in public transport, and car and bicycle sharing. Regarding the micro level, the findings suggest that the cities’ urban mobility plans do not address four themes that are relevant to transition, in all three levels. The themes are vehicle environmental certifications, legislation encouraging the purchase of bicycles, awareness of public managers on sustainable urban mobility, and the participation of civil society organizations in decision-making on urban mobility.

The meso level is the core of transitions. The level is marked by the network of actors and social groups; the set of formal and informal rules; and the material and technical elements. Some authors define it as the “heart” of socio-technical transitions (GEELS, 2004; 2012; CHIARINI, 2014). Proposals for sustainable propulsion technology, carbon credit, and fuel cell technology, addressed in previous studies as alternatives to the transition to sustainable urban mobility, were not found in the PMMU and other documents analyzed.

At the macro level, every PMMU (and the PNMU) mentions the need for integration of public agencies. Education for sustainability was only observed in São Paulo, Rio de Janeiro, and

Fortaleza. The debate on climate change was found in the PMMU of São Paulo and Rio de Janeiro. However, issues that require greater stakeholder coordination such as the acquisition of carbon credits, public authorities' awareness of the need for the transition to sustainable urban mobility, and the encouragement of participation of organizations of civil society, were not observed in the PMMUs of the researched cities.

São Paulo's Urban Mobility Plan has more elements linked to the transition to sustainable urban mobility than the other cities analyzed. The document provides on initiatives aimed at public and private passenger transport, bikeway system and road systems, parking management, environmental management, individual motorized transport, and social participation and accountability instruments. However, when addressing the participation of community members, the plan informs that public hearings and consultations have the intention to comprehend in-depth the thematic or regional approaches to the plan, not mentioning participation regarding the plan's implementation.

Table 2 – Transition to sustainable urban mobility vs. urban mobility plans

Level	Categories of analysis		National plan	SP	RJ	DF	SA	FO
Micro	Integration of modes of transport	Train and taxi						
		Bus and subway						
		Bike and subway						
		Integrated ticket						
	Sustainable propulsion technology							
	Fuel cell							
	Biofuel							
	Hybrid vehicle							
	Shared products	Cars						
		Bikes						
Innovation in public transport	Use of mobility applications							
Meso	Regular Vehicles	Programs to restrict the use of cars						
		Traffic congestion						
		Awareness about car pollution						
		Punishment for car pollution						
	Vehicle environmental certification							
	Bus	Accessibility						
		Bus Rapid Transit (BRT)						
		State's financial incentives						
		Exclusive lanes						
		Panels with real-time information						
	Non-motorized transport	Exclusive paths for bicycles						
		Integration with other modes of transport						
		Laws stimulating bike purchasing						
Macro	Education for citizens about sustainability							
	Raise awareness among public authorities about sustainable urban mobility							
	Investments in urban mobility technology							
	Integration of public agencies							
	Debate on climate change							
	Carbon credits							
	Participation of Civil Society Organizations							

Source: Elaborated by the authors from the content analysis

The program to restrict the use of cars in São Paulo has been in place since 1997, which justifies the inclusion of the program in the city's urban mobility plan. The initiative restricts cars to drive on certain days according to the car license plate. There are no similar initiatives in the other cities analyzed. Rio de Janeiro stands out for its subway integration with other modes of transport. The mobility plans of Fortaleza, Distrito Federal, and Salvador do not mention the integration among the subway, buses, and bicycles.

5. DISCUSSION

The study of the transition to sustainable urban mobility was conducted based on the multi-level perspective, considering the three interrelated levels of analysis, micro (niche), meso (regime), and macro (landscape). Transition theory assumes that transitions are long processes that result in structural changes in a society since they involve multiple social actors. The National Urban Mobility Policy (PNMU) should stimulate the transition to sustainable urban mobility by establishing guidelines for municipal urban mobility management. However, the legal instrument lacks elements needed for the transition in all levels, as well as failing to offer clear guidelines for the elaboration of municipal plans. The dynamics that stimulate or resistance toward this transition were presented in Table 3.

Table 3 – Dynamics at the micro, meso, macro levels that influence sustainable urban mobility

Level	Dynamics of resistance to sustainable urban mobility	Dynamics that stimulate sustainable urban mobility
Micro	Financial benefits obtained by purchasing vehicles that use diesel	Increasing number of users and drivers adopting urban mobility applications
	Low energy efficiency of vehicles that use ethanol	
	Deterioration and misuse of shared bikes	
	Political lobby opposing car sharing	
Meso	Increase in bus fares	Utilization of urban mobility applications that inform the trip duration, routes, and prices of buses.
	Few bus routes	
	Unsafe bus stops and terminals	
	Car and bus drivers are disrespectful toward cyclists	Expansion of the bikeway system.
	Lack of punishment instruments for drivers that endanger cyclists' lives	
	Construction of bikeways in few parts of the city, without connection among the paths	
Macro	Use of motorbikes as an alternative to cars' high costs and slowness	Closing roads during weekends, privileging the use of bikes.
	Tax incentives for the car industry	
	Growth in vehicle purchasing rates	
	Feeling unsafe when using public transport	Organization of international sport events

Source: Based on the research results

Despite the flaws in the operationalization of the PNMU, transition theory also assumes the emergence of organizations and services that replace existing ones, due to the transition society is experiencing. The emergence of organizations that provide car and bicycle-sharing services in the last decade indicates the beginning of the transition process towards sustainable urban mobility in Brazil. In line with Geels and Schot (2010), who argue that the impacts of a transition can manifest rapidly (within ten years), the operation of such organizations is changing how citizens of large Brazilian cities currently move around the cities.

Regarding the dynamics that affect sustainable urban mobility, some micro-level resistance dynamics mentioned in the literature were not addressed in the PNMU documents. They are the low investment in clean propulsion technologies (TURNHEIM et al., 2015) and the little economic interest in investing in the integration between cars and bicycles as modes of transport (GEELS, 2012). On the other hand, part of the dynamics that, according to Moradi and Vagnoni

(2018), stimulate sustainable urban mobility was evidenced in the PMMUs. They are the positive meaning of the use of shared bikes and the cost reduction associated with the use of shared cars.

Niche innovation (or “green innovation”) supports the transition process to achieve sustainable urban mobility. However, at the current stage of the PMMUs, there is low support of public policies. As Geels (2012) explains, these innovations are difficult to adopt because they are more expensive than existing systems and have not yet benefited from economies of scale and learning curves. Green innovation requires changes in user practices, faces challenges posed by existing regulations, or lacks appropriate infrastructure.

Discussing the Italian context, Moradi and Vagnoni (2018) found that the main drivers for the creation and development of niche innovations are public officials. A commonality between the contexts of Italy and Brazil is the uncertainty about economic productivity, which may act as a dynamic of resistance to sustainable urban mobility in both countries. Car and bike-sharing in the Brazilian context lack infrastructure of incentive, especially incentive for public authorities. In the five Brazilian capitals, there are movements contrary to the use of transport sharing apps. This is observed in the plans analyzed, which incipiently address such initiatives.

The meso level dynamics that affect sustainable urban mobility can be divided into three main groups: dynamics associated with the use of public transport (buses), the use of cars, and the use of non-motorized transport. The inefficiency of public agents in providing low cost and quality public transport is one of the main resistances to sustainable urban mobility. Insecurity is another element that makes it difficult to travel on non-motorized modes of transport. However, the harm associated with the use of cars is being discussed more frequently in the researched documents. In addition to the high costs, traffic congestion in the cities is recurring and leading citizens to question the use of cars.

Our study identified the following resistance dynamics: discounts for high-polluting cars and **automotive supply and demand are set towards car saturation peaks**. The domestic market continues to expand, and no actions were mentioned in the PMMU regarding fees applied to vehicles that pollute, or discounts for vehicles that have a lower environmental impact. On the other hand, dynamics that stimulate sustainable urban mobility, such as the low cost of public bus transportation, the expansion of BRTs and the simplification of forms of payment for public bus transportation (MORADI; VAGNONI, 2018), were identified in the analyzed documents.

Tensions over the use of vehicles do not seem to arise because of environmental concern, but for functional reasons such as traffic (congestion and parking) and plans to restrict the use of cars and limit pollution. Besides, transportation systems still lack the technological apparatus, such as access to information on travel schedules, routes, and fares. Similarly, to the reported in developed countries, Brazil also has a culture of using cars. Corroborating the observations by Turnheim et al. (2015) and Moradi and Vagnoni (2018), our study found that high investments in research and development, infrastructure, and acquisition of car companies are dynamics of resistance to sustainable urban mobility. The tax incentives that this industry receives from Brazilian public managers accentuate this problem.

At the macro level, changes occur more slowly compared to changes at other levels, and they may be cultural, demographic, and political; or in norms and rules at the micro and meso levels. However, such changes determine the stability or instability of the meso level. Changes at the macro level can lead to structural changes at the other levels and result in “breaks” at the meso level, which is the case of cultural values associated with the use of cars. Due to the widening debate on healthy lifestyles and the problems arising from the use of vehicles, the attraction for having a car is in constant debate. However, it remains a cause of resistance at the macro level.

In addition, the PNMU evidence problems in the infrastructure for bicycles. This issue was pointed out by Geels et al. (2011) as a dynamic of resistance to sustainable urban mobility at the macro level. The PMMU did not show the social engagement for the integration of different modes of transport (GEELS, 2012; TURNHEIM et al., 2015), which is considered a macro-level dynamic that stimulates sustainable urban mobility. The PMMU pointed out the existence of debates about “smart cities” (MORADI; VAGNONI, 2018) and problems related to road infrastructure (GEELS et al., 2011), which are elements that stimulate the transition to sustainable urban mobility.

Based on our findings, three insights deserve attention from researchers in the field of Brazilian public policies. First, the dynamics of the micro, meso, and macro levels that stimulate sustainable urban mobility are incipient when compared to the dynamics of resistance. Connection between public and private actors is necessary to promote sustainable urban mobility. Increasing the number of users and drivers of urban mobility applications (micro) and organizing international sports events (macro) are examples of strategies that depend on this integration.

Other strategies that could stimulate sustainable urban mobility, such as the acquisition of carbon credits and encouraging the participation of private organizations in technological development, are still disregarded by Brazilian public authorities. Finally, considering the four main initiatives related to sustainable urban mobility – electro-mobility, car sharing, intermodal transport, and innovation in public transport (PARKHURST et al., 2011; DIJK; ORSATO; KEMP, 2013) – our study shows that car-sharing and intermodal transport are dynamics of stimulus for transition to sustainable urban mobility. Thus, institutional barriers to public transport innovation and electro-mobility can be further explored in public policies.

6. CONCLUSION

Our study expands the debate on sustainable urban mobility, supported by the transition theory and using the multi-level perspective. This research indicates that the dynamics stimulating the sociotechnical transition, at the micro, meso, and macro levels, are not as expressive as the dynamics of resistance to moving toward sustainable urban mobility in Brazil. Although the city of São Paulo has the most dynamic urban mobility plan to stimulate sustainable urban mobility, the majority of the large cities analyzed do not follow the same pattern.

The dynamics of resistance to sustainable urban mobility in Brazil differ from those found in developed countries. Problems of road infrastructure and delays in subway construction, for example, are challenges faced by Brazilian public managers that have been overcome in other countries. These developed countries are currently dealing with issues such as the use of electric and autonomous vehicles, and intermodal transport connecting bicycles and subway/bus. However, some resistance dynamics like those found in European countries (TURNHEIM et al., 2015; MORADI; VAGNONI, 2018), can be observed in Brazil, such as the deterioration and misuse of shared bicycles and the drivers’ disrespect toward cyclists.

The research shows that Brazilian niche (micro) innovations need support to evolve and encompass changes at the meso and macro levels. Car and bicycle sharing are initiatives that, despite the difficulties faced, are expanding in the country, particularly car sharing. Intermodal transport, another dynamic that stimulates sustainable urban mobility, is discussed in the cities’ urban mobility plans, but still needs institutional support. When considering the benefits of these initiatives for urban mobility, it is clear that Brazilian public authorities should encourage them.

This study is not without limitations, it is important to mention that the documents analyzed refer to only five cities, even though they are the most populated capitals in the country.

Therefore, the findings obtained here may not apply to other cities that have different socio-economic characteristics. Also, the documents analyzed have undergone revisions since their first publication, and these changes were not considered in the analysis. Finally, the study did not consider the different degrees of implementation of the urban mobility plan in the cities studied.

Therefore, this research provides an overview of the transition to sustainable urban mobility. The findings offer insights on the subject, and point out areas to be further explored, such as the analysis based on the perspective of the actors involved (public managers, authorities, citizens, for instance), or based on the perspective of other documents and laws related to urban mobility.

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Contribution	[Author 1]	[Author 2]
1. Definition of research problem	√	√
2. Development of hypotheses or research questions (empirical studies)	√	√
3. Development of theoretical propositions (theoretical work)	√	√
4. Theoretical foundation / Literature review	√	
5. Definition of methodological procedures	√	√
6. Data collection	√	
7. Statistical analysis	---	---
8. Analysis and interpretation of data	√	
9. Critical revision of the manuscript		√
10. Manuscript writing	√	
11. Other (please specify)		