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Article

Evidence-Based Planning: A Multi-Criteria Index for Identifying Vacant Properties in Large Urban Centres

Thiago Corrêa Jacovine [1,*], Kaio Nogueira [2], Camila Nastari Fernandes [1], and Gabriel Marques da Silva [1]

[1] Centre for Engineering, Modelling and Applied Social Sciences, Federal University of ABC, Brazil
[2] Department of Real Estate and Planning, University of Reading, UK

* Corresponding author (jacovine.thiago@ufabc.edu.br)

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Abstract
Attempts to avoid property vacancy represent an immense challenge for local authorities and planning policy design. Despite recent normative and regulatory advances witnessed in the recent past with the recognition of the social function of the property by the federal constitution (1988) and statutory instruments included in the city statute (2001) and local master plans, Brazilian cities still experience difficulty in producing evidence-based indicators to support the implementation of progressive planning policies. This article offers a methodological approach using a multi-criteria index to identify vacancy propensity levels in the central area of São Paulo. The research results from a partnership between the municipal authority and two planning laboratories from public universities and financial support from UNESCO. The index was designed using a multi-criteria decision aid technique, PROMETHEE II. The proposed methodology involved the manipulation of eight variables related to the vacancy phenomenon and a two-phased validation process: one quantitative using statistical tests and the second qualitative through the scrutiny of the index by urban specialists. The result represents the potential vacancy levels for 3,254 urban blocks and their spatial distribution. For the 344 blocks inspected through fieldwork, 619 potential vacant properties were identified. The development and analysis of the index show that this approach provides valuable information on vacancy levels accounting for its spatial distribution. The index is a flexible tool that can absorb particular local conditions and support evidence-based policy-making.

Keywords
evidence-based planning; multi-criteria index; property vacancy; São Paulo; territorial planning; urban centres

Issue
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1. Introduction

Local and supra-local government administrations worldwide have more recently invested in human and technological resources to survey, identify, and build vacant property inventories for their urban centres. Reasons for addressing urban vacancy vary greatly and may include increasing the supply of land for housing construction, unlocking urban regeneration projects through the provision of urban infrastructure and services, estimating the economic value (or loss) caused by obsolete built stock, and others. In common, these experiences share some key practical challenges. The lack of a universal definition of what constitutes property vacancy, the scarcity of methods and strategies to identify those properties efficiently, as well as the difficulties in managing the vacant stock and enforcing (re)use can be listed as some of these main obstacles acting as impediments to the effectiveness of public policy to combat vacancy.

In order to provide a contribution to this challenge, the article offers a methodological approach for identifying unutilised properties in central urban areas, using São Paulo, in Brazil, as practical experience. The city, one of the largest in population, has achieved significant progress in addressing the issue in the recent past, both conceptually and normatively. Notwithstanding, there is still a need to develop more effective ways to locate these properties in dense areas. To this end, the São Paulo City Hall in partnership with the UNESCO office, and two laboratories in territorial planning from two public universities—LabHab (Laboratório de Habitação e Assentamentos Humanos from the School of Architecture and Urbanism of the University of São Paulo) and LEPUR (Laboratório de Estudos e Projetos Urbanos e Regionais from the Federal University of ABC)—were involved in the conceptualization of a multi-criteria vacant index (índice multicritério de ociosidade [IMO]) that shall be presented herein.

Traditionally, vacancy in urban areas has accrued more profusely old industrial sites (Ball, 1999, 2002; Walljes & Ball, 1997). Following macroeconomic restructuring movements, large cities have faced a shift pushing industrial activity away and becoming increasingly commerce- and service-driven since the 20th century (Dunse & Jones, 2005; Ferm & Jones, 2015), leaving behind a trace of easily recognisable and identifiable brownfield sites as a result (Grimski & Ferber, 2001). Nonetheless, the industrial decline does not respond solely to the total stock of vacant properties. The weakening of local economic forces, leading to the reduction of businesses and increase in unemployment, changes in the geography of businesses and government headquarters promoted by large urban regeneration projects, or even the oversupply of newly built property can also be treated as causes behind existing vacancy levels.

Besides different levels of welfare losses, land and building vacancy mutually lead to and are led by the inefficiency of urban systems (Owen & Thirsk, 1974). On one end, undeveloped or obsolete land and property located in well-serviced areas can be associated with increasing costs for expanding infrastructure investments in peripheral regions and soaring transportation costs to commute across cities. On the other hand, speculative behaviour of landowners and developers and a lack of investment in conservation policies are suggested to be driving forces behind vacancy levels and can cause market failures.

More widely, the academic literature and planning institutions see property vacancy as an obstruction to promoting equitable and efficient cities. The equity aspect is related to the fact that, increasingly, cities have been accumulating an estimated vacant built stock higher than the estimated homeless population (Habitat for Humanity, 2021; Neate, 2014). The efficiency element is related to the sustainability of public expenditures, i.e., the presence of obsolete properties in serviced areas means that ultimately, public resources invested in the past are not being exploited at their full capacity (Matsumura, 2011; Robinson & Torvik, 2005).

Due to the complex nature of the phenomenon, planning practitioners and scholars have also struggled to develop practical and effective ways to identify vacant buildings (Trigo, 2020). There is no consensus on what constitutes property vacancy either in its terminology (derelict, idleness, emptiness, obsolete, under-utilized) or the classification parameters to be employed (e.g., the location, conservation status, time in obsolescence or proprietorship; Home, 1983). Some recent experiences have focused on surveying brownfield areas and vacant land (see Ferber et al., 2006; Foley et al., 2021; Grimski et al., 2012; Newman et al., 2016; Myers & Wyatt, 2004). The authors agree that, despite the lack of definition for these types of properties, their magnitude and the extension of land they cover as well as their intrinsic physical and structural characteristics make them easy to recognise. Nonetheless, these sites respond for just a proportion of the total empty stock. On the other hand, vacant building inventories have been proven particularly challenging to create due to the wide range of property types that can be classified as such (Kohler & Hassler, 2002; Kohler et al., 2009; Thomsen et al., 2011). The nature of this type of property demands an identification strategy that inevitably relies on a clear definition of the term. Moreover, the literature also highlights that such a definition should consider the distinction between short- and long-term vacancy (Buitelaar et al., 2021; Wyatt, 2008), its spatial distribution, building types, and tenure regime (Huuhka, 2016).

Empirical and theoretical strategies to tackle the issue have emphasised, predominantly, both the underlying socio-economic motives driving the proliferation of vacancy and their implications and potential policy responses to the rehabilitation of the sites (Adams et al., 2010; Bardos et al., 2016; Tzoumis & Driehorst, 2016). However, the literature review conducted for this study has found somewhat fragmented examples of specific studies and projects aiming at creating techniques that allow for the strict identification of sites and buildings, with a clear proposition for the construction of inventories. Drake et al. (2016), for example, have proposed the development of a smartphone GIS survey tool to be used by university and community members to register vacant buildings in Trenton, New Jersey. The study highlights the importance of current strategies to combine data collection tools with spatial analysis and reiterates the relevance of developing comprehensive fieldwork to confirm vacancy status. Nevertheless, it is heavily reliant on volunteer users' interaction, lacking a more systematic and spatially widespread approach.

Given the pressing significance of the topic and the presented gaps in research and policy-making strategies to combat urban vacancy, this article aims to provide a methodology for an instrumental technique to help local governments build vacant property inventories at the intra-urban scale. The choice of the city of São Paulo as a concrete case for exploration is associated with a set of normative and regulatory advances promoted both at the national and municipal level in the recent past, which ultimately overcome the initial barriers indicated by the literature, for instance, with a set definition for property vacancy. The city, currently the 11th largest urban agglomeration in the world, its economic relevance—nationally and in the Global South—and its legacy as being at the forefront of planning strategies in the country reinforce the choice. In addition to this introduction, where some of the main concerns regarding the identification of vacant buildings are presented, Sections 2 and 3 provide a brief introduction to the Brazilian regulatory context and the study area, respectively. Section 4 describes the methodological design behind the construction of the IMO. Finally, Section 5 provides the main results from the implementation of IMO, and Section 6 provides some concluding remarks.

2. A Brief Overview of São Paulo's Experience

Over the past three decades, Brazil has promoted important juridical and regulatory milestones while consolidating a set of norms and legislation on urban policy at the federal level. It began with the country's latest federal constitution, approved and enacted in 1988 after the end of the military dictatorship that ruled the country for 21 years. This was following a series of intense rounds of discussions and negotiations amongst various society groups during the Constituent Assembly between 1986 and 1987. The new constitutional law established a new juridical foundation for the legal understanding of land ownership regimes, officially represented by the detachment of building rights from the exercise of property ownership (Fernandes, 2007, 2014). The new designation is underpinned by the concept of the social function of the property (SFP), through which private property rights are protected subject to collective interests (Friendly, 2020). In other words, the SFP implies that private proprietorship's social and collective benefits must prevail. Pragmatically, such a right is exercised through the concession of building rights (negotiated using building rights levy payments) and through the control of vacant properties in urban areas. Both controls are coordinated and implemented by the municipal authority according to specific regulation defined by the city's Master Plan.

Based on the principle of the SFP, 13 years later, a national framework for urban development was enacted—the city statute (Federal Law N. 10.257/2001). The framework offers municipal governments an array of statutory planning instruments to feature within their local planning regulations and guidelines to support the SFP's fulfilment. The definition of what constitutes the social function and choice for which set of instruments to be implemented are defined in the local master plan and the zoning ordinance. In particular, amongst these instruments stands out the compulsory parcelling, building, and utilisation of land (*Parcelamento, Edificação e Utilização Compulsórios* [PEUC]), explicitly conceived to control, avoid, and give use to vacant urban properties. To implement PEUC, municipal authorities must identify and notify landowners of vacant and obsolete sites, enforcing the re-establishment of land use consistent with the existing local provision of infrastructure and amenities. For instance, in central areas, given their historical pattern of concentrating public investment and diversity of land uses, vacancy can be interpreted as a loss of efficiency and resources.

Having proprietors not taken any action in the first year after the notification, progressive taxation incurs during the following five years. Lastly, PEUC allows the public authority to expropriate the site under public debt claims if the property remains vacant. To be notified, the property must fall within one of the three classifications of vacancy: unbuilt, underused, and unutilised properties, which are always defined by local regulation. In its current version, the city's Mater Plan (Municipal Law N. 16050/2014) defines these three categories as follows: *unbuilt*—properties larger than 500 sqm, in which the floor area ratio used equals zero; *underused*—properties larger than 500 sqm, in which the floor area ratio used is lower than the required minimum; *unutilised*—buildings and other properties with at least 60% of its built area vacant for more than one year.

In São Paulo, PEUC was first incorporated in 2002 in the city's planning regulation and revised in 2014. In its most recent implementation experience, since 2014, the municipal administration has allocated institutional and personnel resources devoted to the notification of vacant properties in specific perimeters across the city, resulting in approximately 1,400 official notifications between 2014 and 2019 (Figure 1). The strategy focused mainly on obsolete sites located within urban redevelopment projects perimeters in the central area, the historical centre, as well as in inclusionary zoning districts. After this first round of notifications, a concrete issue emerged from the fact that an updated inventory of vacant properties in the city was inexistent, decelerating the flow of notifications. This presents a policy deadlock whereby a well-defined regulatory framework aiming to promote the SFP encounters practical impediments to its effectiveness. On the other hand, this scenario also highlights opportunities for local governments to invest in mechanisms and strategies using existing resources, which can facilitate the implementation of progressive planning policies. In the instance explored herein, the availability of an extensive set of spatial data and property information, combined with interdisciplinary expertise and the existence of clear property ownership regimes, allows for the development of effective evidence-based methodologies to identify vacant stocks in urban areas.

This study, therefore, offers one relevant contribution in the attempt to improve the implementation of one particular planning policy that tackles property vacancy in urban centres by using existing empirical evidence—a multi-criteria index— that can map out and help to identify vacancy in urban areas, based on well-defined parameters and existing datasets. Such an approach aligns with the idea that data has never been as widely available as it currently is, placing data analysis proficiencies at the centre of policymaking. This also represents a praxis experience reinforcing Faludi and Waterhout's (2006) view of an evidence-based turn in planning whereby a set of evidence (data and information) is collected and used within the planning process and emphasises more pragmatic rather than ideological (Davoudi, 2006) form of governing.

3. The Study Area

The chosen study area for this methodology covers the central part of the São Paulo municipality and its metropolitan region. The city's administrative limits are divided into sub-prefectures, each of those divided again into districts. In total, there are 32 sub-prefectures, summing up 96 districts. The study area where this study was implemented correspond to two sub-prefectures: Sé (formed by the districts of Bela Vista, Bom Retiro, Cambuci, Consolação, Liberdade, República, Santa Cecília, and Sé) and Mooca (and its districts of Água Rasa, Belém, Brás, Mooca, Pari, and Tatuapé districts). The perimeter also includes the Água Branca district (pertaining to the Lapa sub-prefecture). Essentially, it is a diverse and heterogeneous area that contains a wealth of infrastructure hubs and services, a high concentration of jobs and dwellings, old industrial districts along the river margins, and an assortment of buildings of historical and cultural relevance.

With 6,635 hectares and approximately 220,000 dwellings, the country's last census informs that nearly 800,000 residents lived in this region in 2010 (Instituto Brasileiro de Geografia e Estatística [IBGE], 2011). The area also hosts several urban regeneration projects, such as the Água Branca Urban Operation, the Central Urban Operation, and the Central urban intervention projects. Due to this diversity, urban fabric patterns change considerably from district to district within the study area, demonstrating the diversity of existing building typologies in the area. This provides initial evidence of the type of vacancy expected to be found in each district. Below, Figure 1 depicts some of the aforementioned urban projects, the special social interest zones, and the PEUC notified properties. Even though there is an overlap in the study perimeter and the bulk notification, it is essential to remind that the municipal strategy in applying PEUC focuses mainly on the city's central areas. Figure 2 shows the study area and its administrative subdivisions.

4. The Multi-Criteria Vacant Index – IMO

As explored previously, one of the main challenges in tackling vacant properties and speculative land retention is identifying the phenomenon's spatial distribution. The IMO may be one available alternative to this end. It consists of an index able to capture the various aspects related to vacancy and provides an instrumental tool that informs the propensity of the presence of vacant buildings at an intra-urban scale. In this study, the IMO concentrates on the identification of unutilised buildings.

The decision to develop the IMO is based on two premises: the first is that the index should be conceived

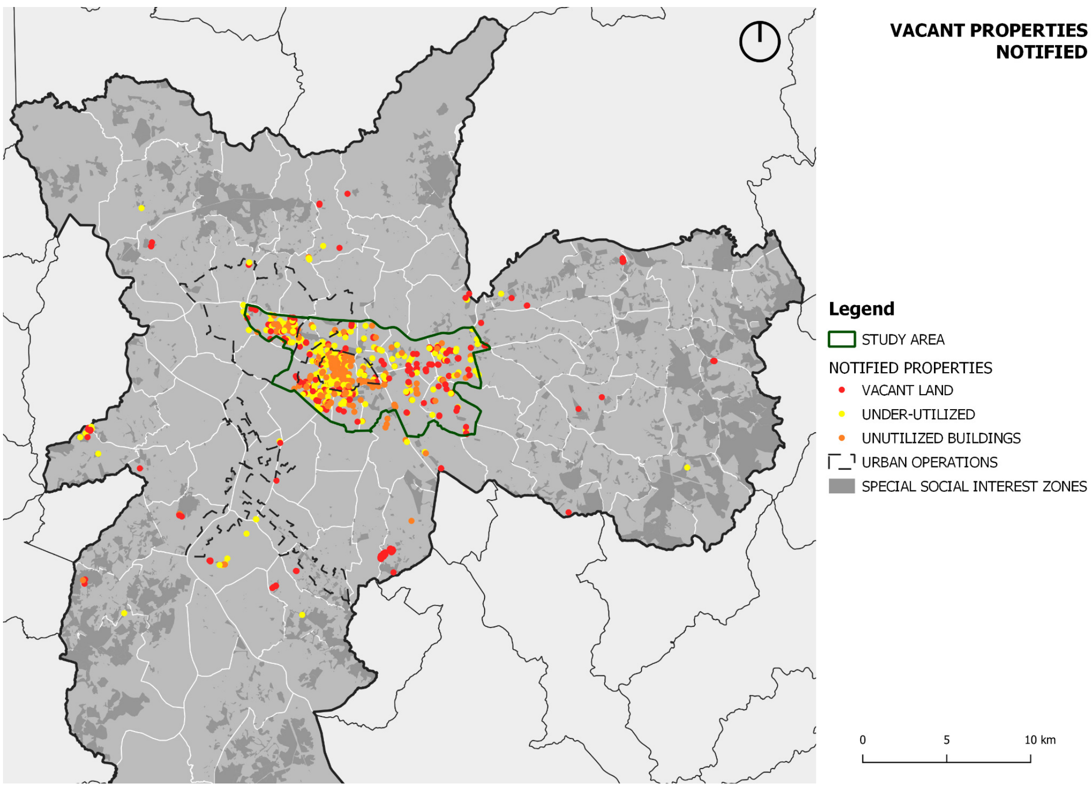


Figure 1. Distribution of vacant properties notified for PEUC purposes in the city of São Paulo between 2014 and 2019. Source: City of São Paulo (2021).

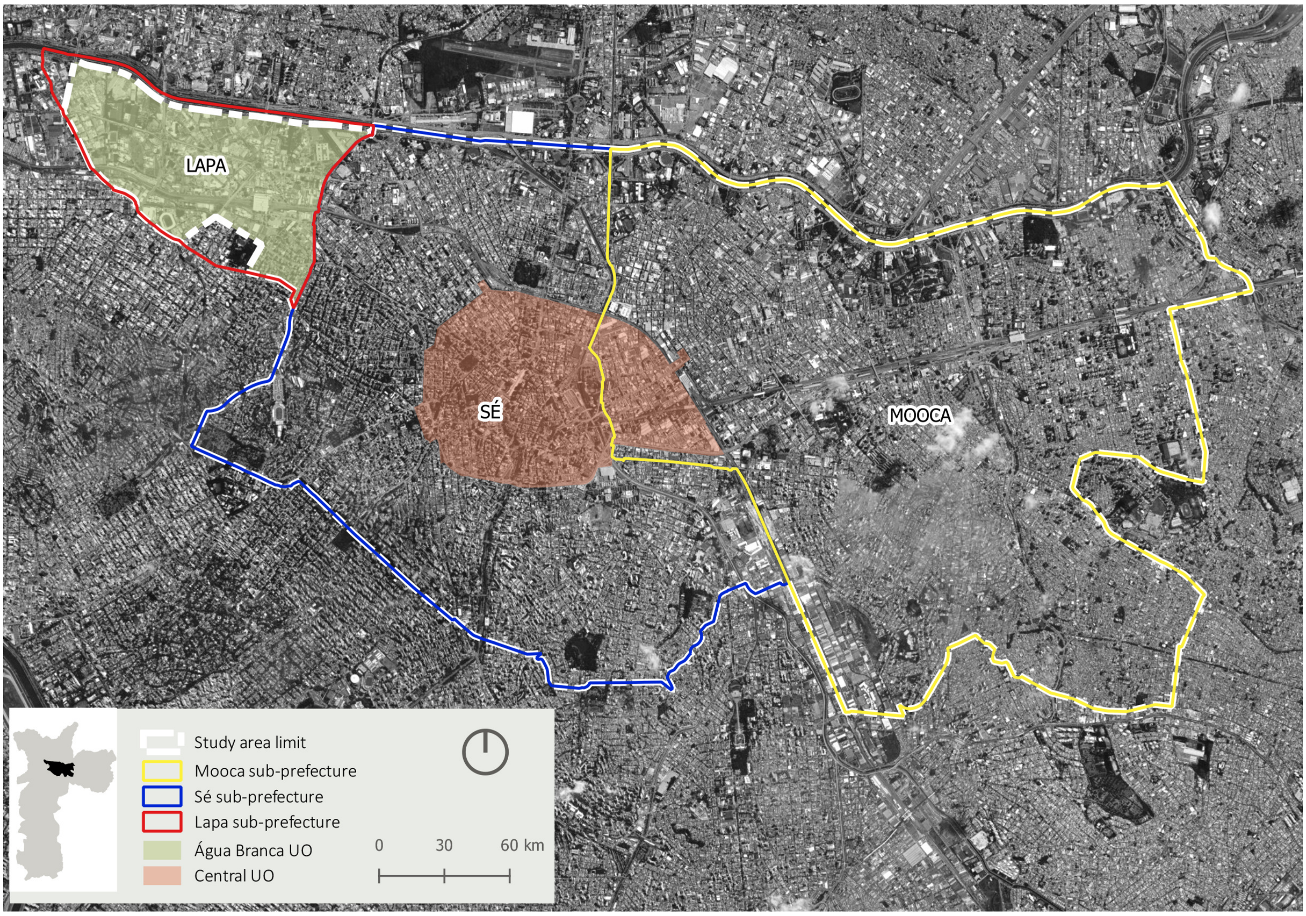


Figure 2. Study area in the central region of São Paulo.

as a tool that allows working with the complexity and diversity of vacant properties, which ultimately requires a multitude of indicators that can capture the various causes behind vacancy and its many forms of manifestation. Secondly, the index results can aggregate different knowledge, perceptions, and experiences in one single instrument. Once observed in the development of the IMO, these two premises facilitate the communication of outcomes in an effective and simple form that can supply public policy formulation and implementation. These premises shall be explored in more detail in the following subsections.

4.1. The Multi-Criteria Vacant Index and Its Variables: Working With Multidimensional Vacancy

One of the advantages of working with indices is the possibility of aggregating different dimensions of an object or phenomenon into a single instrument (Nardo et al., 2005; Wong, 2006). Given the complexity and the nature of the vacancy phenomenon, as well as the lack of methodologies focused on its identification, capturing its manifestation directly can be considerably difficult and burdensome—for example, conducting city-wide on-site inspections. Therefore, observing it through its different indicative signs, by using available secondary data, is a form of unifying available information in a timely and financially efficient form. This evokes a multidimensional perspective to looking at vacancy, whereby using an index is an appropriate resource.

Notwithstanding, despite the benefits a tool like an index can bring, such as the richness and diversity of representation forms, this methodological approach presents at least two caveats that are worth mentioning: firstly, the choice of the variables—or the index's dimensions—that should be taken as proxies for the representation of the phenomenon, i.e., there must be theoretical reasoning behind the definition of variables, and their limitations must be explicit; secondly, the level of the relationship among these variables. The index will represent the interactions amongst the chosen variables.

Addressing the first issue involves selecting variables that can correctly represent the phenomenon of interest. This is crucial because it defines the index horizon whereby the selected variables posit what the index will be able to capture and convey. They are the index's looking glass. In the IMO case, after extensive exploration, eight different databases were investigated, spatialised, and analysed (Table 1). They have been selected considering their theoretical relationship with vacancy, spatial coverage, temporal scales, and accessibility. Although potentially interesting, some variables selected at the

Table 1. List of variables employed in the index.

Variable (Database/Institution)	Year	Description
Water supply (Sabesp/service concessionaire)	2020	Connections that had their service supply contract terminated or that were permanently excluded from the supply network for at least one year
Dengue outbreak reports (Sistema de Controle do Zoonoses/São Paulo Municipality)	2020	Properties classified as abandoned or unoccupied by agents who carried out property inspections with reports of standing water and/or dengue outbreaks
SP156 complaints (Secretaria Municipal de Inovação e Tecnologia/São Paulo Municipality)	2020	Complaints related to the presence of waste, rubble, and physical degradation of the property and its immediate surroundings
Active fiscal debt (Property Tax System [IPTU]/São Paulo Municipality)	2020	Properties listed in the active IPTU debt register of the Municipal Attorney General's Office
Vacancy rate (IBGE/federal agency)	2010	Measurement of vacant properties obtained from the 2010 census
Overcrowded dwellings (HabitaSAMPA/São Paulo Municipality)	2010–2019	Reports of properties classified according to the degradation status of housing conditions
Real estate launches (EMBRAESP/consulting company)	2020	The number of new approved residential development schemes used to identify areas with low construction dynamics
Paulista social vulnerability index—IPVS (Seade/São Paulo's state agency)	2010	Characterisation of the living conditions of population groups, with emphasis on social vulnerability

beginning of the study had to be excluded (such as piped gas and electricity consumption by household) due to the impossibility of the data to conform to any of the three prerequisites above.

After the variable's selection, the resulting data set underwent extensive management to filter observations in the study area, select and transform unities of analysis, and run spatial aggregation so each variable could be represented in the urban block scale (hereafter referred to as blocks)—the most appropriate intra-urban scale for the IMO. The analysis of each variable aimed at exploring and understanding their individual characteristics, such as spatial distribution and variability before aggregation into the index. The results are shown in Figure 3. The illustration shows, for each variable, the aggregation of observations in terms of dwellings per block, except the *vacancy rate* that is shown in proportional terms (empty properties per the total of properties in each census block) and the Paulista social vulnerability index, which is an index varying from 1 to 5 (from *low vulnerability* to *high vulnerability areas*).

The internal relationship amongst variables was statistically investigated. Pearson's correlation matrix indicates no strong correlation between any particular pair of variables. It was found that the highest correlation was between dengue outbreak reports (SISCOZ) and active debt (IPTU) data—0.3. The second highest value is 0.29 (water supply and dengue outbreak reports). The remaining correlations stay between 0 and 0.2, indicating that the chances of two variables covering similar aspects are considerably low, corroborating their inclusion in the index.

4.2. Variables and Scenarios: Integrating and Evaluating the Formulation of the IMO

The conceptualization of the IMO's structure consisted initially in the definition of the extent to which each variable contributes to the index considering their theoretical reasoning to the phenomenon and, subsequently, in the actual integration process through the chosen statistical method.

As aforementioned, each variable contributes differently to the representation of vacancy. Thus, expressing their intrinsic capacity to measure one particular aspect (or manifestation) of property vacancy and their potential overall contribution to the aggregate index is essential. For the latter, a group of 22 planning specialists, 11 from the São Paulo Municipal Authority and 11 from universities and research laboratories—LabHab and LEPUR—answered one questionnaire ranking the relevance of each of the eight variables in reporting vacancy. The goal was not only to capture the various perspectives from different data sources but also to integrate into the methodology an interdisciplinary interpretation of the phenomenon. With values varying from zero (absolute

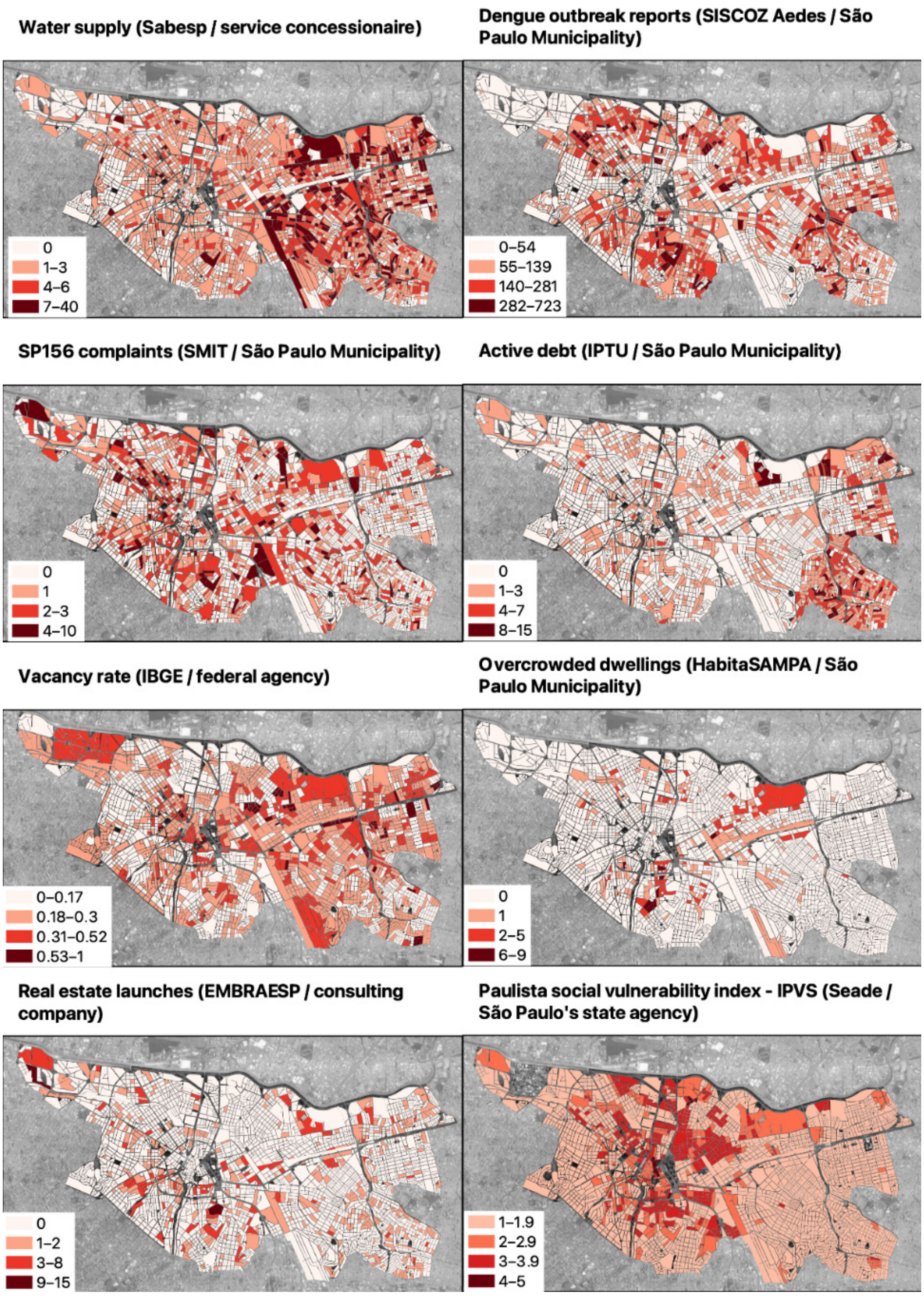


Figure 3. Spatial distribution of primary variables for the index.

irrelevant) to four (the most relevant), the questionnaire aimed at ranking from least to most relevant the weight of each variable within the index. The weight, therefore, was defined by the mean value of the 22 responses to each variable. The final weights are shown in Table 2.

The weighting of variables completed the preparatory steps for the index calculation. The following phase consisted in combining and integrating all the variables into IMO. In this study, it was decided to employ a multi-criteria decision analysis technique, which accounts for the variety of variables used and the number of specialists consulted. More specifically, it was decided to use the preference ranking organisation method for enriched evaluation (PROMETHEE II).

Classified as a method that responds to ranking issues, PROMETHEE II allocates decision-makers at the centre of the analyses (Ishizaka & Nemery, 2013, p. 2). Aiming at consensual solutions, the technique seeks not the best but a satisfying arrangement amongst stakeholders (Januzzi, 2017; Januzzi et al., 2009). Furthermore, the

Table 2. Distribution of variables' weights according to questionnaire responses.

Selected variables	Weight distribution (questionnaire responses)					Mean
	0	1	2	3	4	
Water supply (Sabesp/service concessionaire)	—	—	—	2	20	3.91
Dengue outbreak reports (SISCOZ Aedes/São Paulo Municipality)	—	—	2	8	12	3.45
SP156 complaints (Secretaria Municipal de Inovação e Tecnologia/ São Paulo Municipality)	—	3	8	8	3	2.50
Active debt (IPTU/São Paulo Municipality)	—	6	8	5	3	2.23
Vacancy rate (IBGE/federal agency)	2	6	10	4	—	1.73
Overcrowded dwellings (HabitaSAMPA/São Paulo Municipality)	2	10	8	2	—	1.45
Real estate launches (EMBRAESP/consulting company)	4	9	6	3	—	1.36
Paulista social vulnerability index—IPVS (Seade/São Paulo's state agency)	6	10	5	1	—	1.05

choice for this method is based on its flexibility, the possibility to join different agents and experiences in the decision process, and the evaluation of distinct scenarios. With this, the relationship and possible gaps between evidence and action or diagnosis and decision-making process—an essential and not always well-defined issue (Faludi & Waterhout, 2006, pp. 8–9)—may be incorporated and expressed into the IMO's results.

The method was used to rank all the 3,254 blocks in the study area according to their estimated vacancy propensity. Implemented by the PRADIN software, two main parameters had to be set: the variables' weights and the participants' weights. For the former, the overall mean for each variable after the questionnaire application was adopted. For the latter, it was decided that all respondents would receive the same weight due to their varied but equally relevant experience with the topic. With this, the index acknowledges the diversity in knowledge and distinctiveness in the professional perception of all participants. Therefore, based on the defined preferences and the characteristics of the blocks in the city's central area, PROMETHEE II makes a pairwise comparison between the blocks within the study area and creates a ranking. The result is a set of ordered blocks considering the estimated propensity of vacant properties to existing.

Considering that one of the goals is to make the IMO easily applicable and interpretable to other realities, the final ordered results were classified into three propensity groups using Jenk's (1967) natural breaks method, which aims to minimise the differences between data in the same class and maximise the difference between classes. These classes of the IMO were defined as *low to medium*, *high*, and *very high* propensity.

To improve the design of the IMO, the initial results were submitted to the scrutiny of a second group of specialists that included 11 managers and planning practitioners from the municipal authority, 11 experts from the University of São Paulo and the Federal University of ABC, 10 members from the work team, and four external guests. They were invited to a workshop to discuss alternative scenarios for constructing the IMO and its outcomes. The workshop was conceived as a moment to qualitatively explore and validate different aspects of IMO, its conceptualisation, the variables selection, and its spatial distribution. The discussion led to the development of two different scenarios for the IMO: one that includes all eight variables and the other with two variables ranked highest. The main goal was to evaluate which index formulation would be the most appropriate. The discussion involved questions and comments related to the reproducibility of the proposed index, the possibilities for extrapolation into other regions of the city, and the need for adjustments or analysis by the index components.

The index using all the eight variables was chosen from two scenarios presented in the workshop. This choice underpins the phenomenon's complexity and the absence, to date, of a systematic multi-criteria methodology to identify vacant properties. The results with the IMO estimation are shown and commented on in Section 5.

4.3. Implementation and Statistical Validation

The IMO's results were also submitted to statistical validation. The process verifies whether the index estimates correctly represent the phenomenon of interest—property vacancy. The idea is simple: comparing the estimates produced by the index, i.e., the three propensity classes of vacancy, against a scenario of reference deemed correct (i.e., verified vacant properties in the study area). To this end, the collecting data on existing vacant properties was necessary. Thus, a sampling inspection strategy had to occur as a project development phase. A key requisite at this stage was that enough data could be collected to allow statistical and spatial validation of the index.

To define the sampling blocks, two main aspects were considered. The first is related to the possibility of making inferences about vacancy in the entire study area (internal validation), quantifying the associated errors and successes. The sample was then calculated using probabilistic techniques. Another key aspect was the spatial dimension, considered one of the IMO's cornerstones, as the territory matters. Thus, spatial dynamics, patterns, and specificities were considered during the validation process. These conditions drove the adoption of a stratified sampling strategy by city districts. The final sample consisted of 344 blocks randomly divided across all districts.

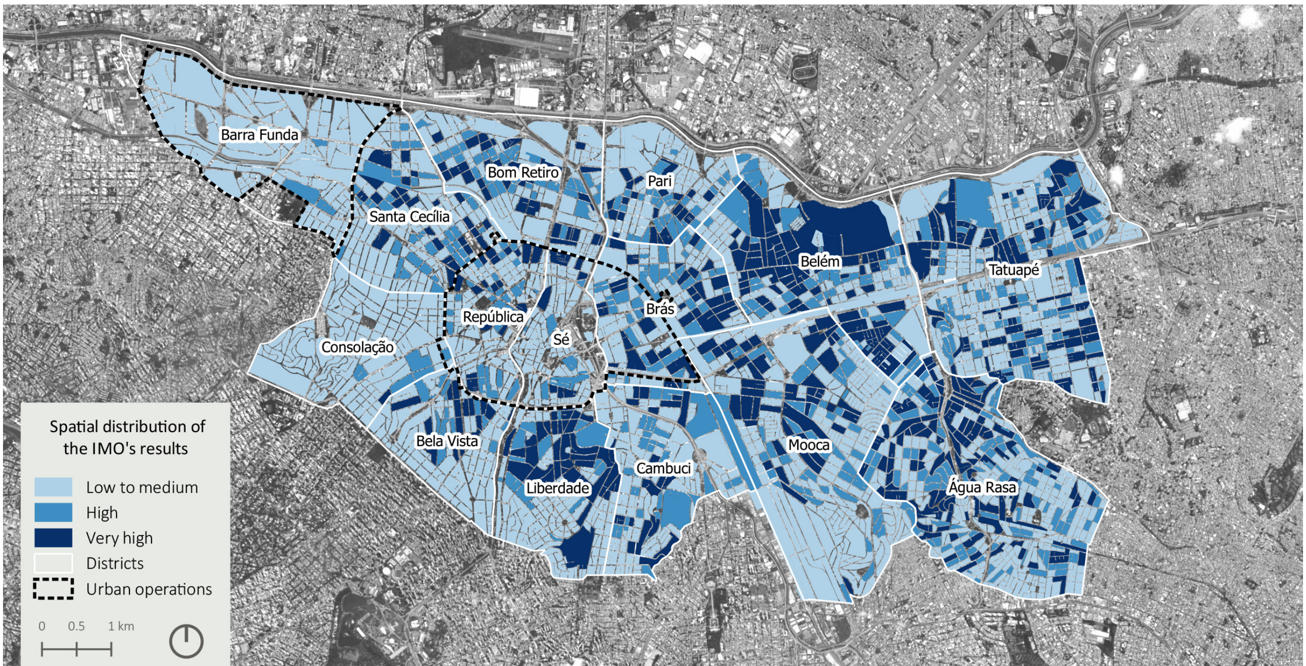
Statistical sampling strategies and techniques were employed to validate the index once the necessary premises and criteria were observed, which gives validity to the test results (Lohr, 2021, p. 15). Considering the nature and type of the data, different non-parametric correlation tests were computed. Here, the results of Spearman and Kruskal-Wallis were applied. Whilst the first one measured the association between the data collected in the field (observed data) and index estimates (estimated data), the second one evaluated how consistent the index classes are. The results are presented in the following section.

5. Results: Notes on the IMO's Estimates and Its Statistical Validation

The spatial distribution of the IMO's propensity levels is represented in Figure 4. The map depicts the propensity of each block in the study area to present at least one vacant property based on the combination of indicators in the index.

The IMO's results allow for a series of notes on how the propensity of vacancy is distributed in the study area. First, when considering the entire perimeter of the study, the two classes *High* and *Very high* combined estimate that 35% (1,140 blocks) of all blocks have at least one vacant property. This figure, however, does not seem to be uniformly distributed across the study area, with a seeming concentration in the eastern region.

Secondly, and correlated to the first note, the results across the Mooca sub-prefecture stand out when considering the sub-prefecture level. The *Very high* vacancy class individually corresponds to 71% of the blocks (262 blocks). Whereas for the Sé sub-prefecture, the proportion of blocks falling within the same class is only 28.4% (105 blocks). The portion from the Lapa sub-prefecture at the western-most limit of the study area (only its district of Barra Funda) does not include any block classified within the *Very high* class of the IMO.



	Sé	República	Bom Retiro	Santa Cecília	Consolação	Bela Vista	Liberdade	Cambuci	Brás	Pari	Belém	Tutuapé	Mooca	Água Rasa	Barra Funda	
Low to medium	122	111	101	117	146	96	114	113	96	81	123	267	239	274	114	**2,114**
High	15	35	48	56	7	21	34	43	54	34	71	145	69	138	3	**773**
Very high	4	13	26	17	-	13	19	13	22	17	49	63	33	78	-	**367**
Total	**141**	**159**	**175**	**190**	**153**	**130**	**167**	**169**	**172**	**132**	**243**	**475**	**341**	**490**	**117**	

Figure 4. Spatial distribution of IMO's estimates on vacancy propensity.

Narrowing down the analysis to the districts level, by combining the *High* and *Very high* classes together, the Água Rasa (216 blocks), Tatuapé (208 blocks), and Belém (120 blocks) districts are those with the highest absolute numbers of blocks within this classification, while the Barra Funda district remains the district with the lowest indication of vacancy propensity-only—3 blocks in these same classes. The situation slightly changes if the relative numbers are considered (the proportional terms in each district). In this case, the top three districts with the highest levels of propensity vacancy are the ones of Belém (49.4% of its blocks), Brás (44.2%), and Água Rasa (44.1%). In the Barra Funda district, only 2.6% of the blocks are classified in the same range.

Due to its disaggregated spatial resolution, the estimated vacancy propensity can be assessed for other spatial scales, for example, at urban intervention programme levels. The Central Urban Operation has a total of 377 blocks, out of which nearly one quarter (91 blocks or 25.7%) were classified as having a *high* or *very high* probability of at least one vacant property. These different levels of representation of the IMO's results suggest that the instrument allows for different forms and scales of analyses that have the potential to subsidise bespoke policies, projects and actions combating property vacancy by the São Paulo Municipal Authority.

The results from the fieldwork that was undertaken show the distribution of inspected vacant property in a selection of blocks across all districts. The number and distribution of inspected and confirmed vacant properties we considered in the statistical validation of the IMO are displayed in Table 3. From the total of 344 inspected blocks, 130 returned with zero vacant property identified (37.8% of the blocks). For the remainder of inspected blocks—214 blocks— it was found that, at least, one vacant property existed. The distribution of inspected blocks with and without vacant properties by districts is depicted in Figure 5.

Table 3 shows the distribution of 634 vacant properties identified in the 344 sampled blocks—619 by field research and 15 already notified for PEUC by the municipal authority in the past. Observing the distribution of vacant property across the inspected blocks, nearly two-thirds of those (62.2% of blocks) have at least one vacant property. Nearly three-quarters of the sample contains between zero to two confirmed vacant properties, confirming that searching for vacancy in urban areas can be a meticulous and precise job, due to the scattered nature of the phenomenon. At the other extreme, only five blocks have 10 or more vacant properties, i.e., low levels of clustering behaviour inside the blocks.

When the territory is explicitly considered (Figure 5), the bar graph shows that all districts have at least one block with vacant property. In 10 of the 15 districts, the number of blocks with at least one vacant property exceeds the number of blocks where there is no indication of vacancy. The Pari district calls for attention, where 92.9% of the blocks (13 of 14) have at least one vacant property. On the opposite side, Bela Vista registers no signs of vacancy in 71.4% of its visited blocks.

Finally, the two statistical validation tests were applied—Spearman (ρ = 0.5653334, $p < 0.0001$) and Kruskal-Wallis (χ^2 = 75.555, $p < 0.0001$)—to confirm the validity with statistical significance of the outcomes from the comparisons between the estimates from the IMO and the sampling strategy. They indicated that the IMO could be considered a relevant tool to represent vacancy levels and guide local authorities' field inspections.

Table 3. Vacant properties identified through fieldwork aggregated by blocks.

Number of vacant properties aggregated by blocks*	Frequency	Proportion (%)
0	130	37.80%
1	80	23.30%
2	42	12.20%
3	31	9.00%
4	22	6.40%
5	9	2.60%
6	8	2.30%
7	8	2.30%
8	8	2.30%
9	1	0.30%
10	2	0.60%
13	1	0.30%
14	1	0.30%
20	1	0.30%
—	**344**	**100%**

Note: * The values used here are the result of the sum between the total of properties identified by the fieldwork survey (619) and the previously vacant properties notified by the municipality in the same blocks (19), making a total of 634.

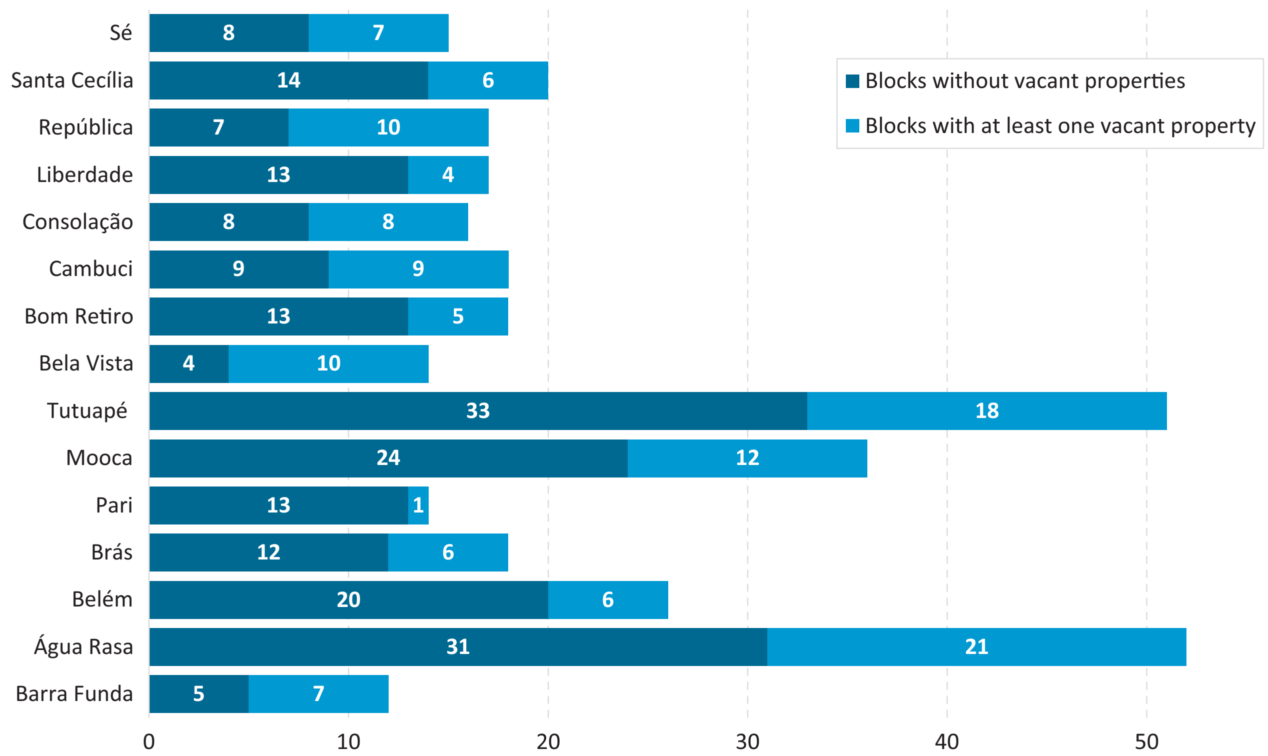


Figure 5. Distribution of blocks with and without vacant properties by district.

6. Conclusion

The main contribution of the IMO, showcased in this study, consists in the development of a known, tested, and referenced empirical strategy to identify and estimate the propensity of vacancy in an intra-urban area. Beyond illustrating the current spatial distribution of the vacancy phenomenon for an empirical case in São Paulo—which is an innovation in itself considering that it is the first time such an approach is implemented in the city—the conceptualisation, implementation, and validation of the proposed IMO demonstrate to be an effective way to aggregate knowledge and disciplines in a coherent form. By offering a better understanding of the various forms of manifestation and spatial distribution of vacancy in São Paulo and bringing new elements to the debate on vacancy from a methodological point of view, even when tangible limitations described are considered, the IMO seems to be an effective and pragmatic tool to supply public policy combating obsolescence in the built stock.

From observing the IMO's structure and composition, the use of different variables supports a more prosperous and more diverse approach to understanding vacancy. In contexts where the scarcity of data on property vacancy is a reality, the IMO can be considered a valid alternative. Not only because the identification process may be more assertive if the chosen variables cover different aspects of vacancy at the appropriate spatial scale, but, equally, the characteristics of the phenomenon and its (different) spatial manifestations are also taken into consideration. Therefore, even though the index has been formulated as a unique instrument for a unique case study, there is an opportunity for its resulting analyses and derived policy strategies to be compared in different contexts using different variables. In the study area, for example, some variables (e.g., active debt or vacancy rate) captured vacancy better in some districts than others, which may indicate a difference in the drivers of vacancy and can express the necessity of specific policies or programs to tackle the issue in a localised way.

These findings align with what has been evidenced by the literature on the topic. For instance, in some American cities, where vacancy is shown to cluster in specific areas (Duke, 2012), the vacancy phenomenon presents differing behaviour and specific dynamics depending on the built environment characteristics and likely causes. This reinforces the understanding that diversity of variables is a better alternative to capture the distribution of vacancy and its dynamics. In other words, subject to instruments like the IMO, it is possible not only to identify where vacant properties are but also to understand the characteristics of the vacant stock and, thus, the implications for the design of public policies, i.e., different vacancy forms require different policy strategies.

Additionally, despite the improvement in access to information on spatial variables seen in recent years, some specific data may still present as a bottleneck for an enhanced design of instruments such as the IMO. Here, data on electricity consumption was initially conceived as a key predictor of vacancy, increasing the instrument's accuracy considerably. Nevertheless, access to this database required levels of institutional agreement between the municipal authority and the energy supply company, demonstrating that the success of similar strategies is subject to efforts beyond technical and personal resources.

Moreover, the index encompasses a multidimensional approach. Multi-criteria instruments like IMO incorporate different variables, assessment criteria, and professional assessment of the phenomenon of interest, making it a malleable tool to be used conditioned to particular circumstances. For vacancy, as seen with the IMO, this can broaden the identification strategy by adding more aspects beyond the physical characteristics of buildings, such as real estate dynamics and socioeconomic conditions, for example.

The IMO's level of detail is also noteworthy. The spatial scale adopted (by urban blocks) foments intra-urban scale policy implementation, allowing for multi-level analyses, actions, or programs. For the city of São Paulo, it is possible to compare vacancy behaviour by the master plan zones, zoning districts, or urban redevelopment project perimeters, for example. In the case of Brazilian cities, instruments such as the IMO can be associated with other statutory instruments from the city statute to design a more comprehensive strategy to tackle vacancy, involving, beyond the identification and notification, the management and rehabilitation of vacant buildings seeking the fulfilment of the SFP.

Considering the construction of the IMO, the use of PROMETHE II and its search for consensual solutions made it possible to incorporate different actors' views and expertise within the design. Aligned with the evidence-based planning perspective, data availability has played a central role in the development of the IMO. Nevertheless, the definition of which variables must be included, and their weighted roles were based on a diversity of qualitative perspectives and required careful consideration. During the IMO's two workshops, there was a chance to explore and evaluate variables and scenarios, question and test assumptions, and confront distinct points of view that, ultimately, were incorporated into the index in the form of consensual solutions proportionated by the chosen method—more specifically, through the responses to the questionnaire and their relative weights, the even weighting of all participants, and the proposition and assessment of different scenarios. Moreover, recognising the relevance of the process of selecting and evaluating variables and instruments seems to guarantee more transparency to the index and help to bridge the gap between diagnoses and actions.

The possibility of evaluating the results throughout the process and validating the index estimates with fieldwork data and statistical tests must also be noted. Due to the statistical tests applied, IMO's predictive ability was endorsed, showing its real potential and opening possibilities for adjustments and specific tests in due course. Consequently, the IMO could be expanded to the study area as seen from the results and taken as an initial bottom line for other regions in the city.

Finally, considering the index limitations and possible improvements, the following aspects can be highlighted: the impossibility of accessing all the promising variables related to vacancy (such as electric energy); the fact that the external validity of the index to other areas must be considered carefully, checking the necessary adjustments appropriately; the index dependency on constant updates due to dynamic nature of vacancy in urban centres; and the conditional technical knowledge on GIS software and statistical tools to implement the index, skillsets that are not always found in planning departments.

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Conflict of Interests

The authors declare no conflict of interests.

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About the Authors

Thiago Corrêa Jacovine holds a BSc in geography and an MSc in territorial planning and management from the Federal University of ABC, Brazil, and is completing a PhD degree in the same research program. Both doctoral and master's research are related to methodological proposals for identifying, characterizing, and quantifying (urban) housing stress/deficit. His main research topics are housing stress, spatial analysis, and methods and techniques applied to the territory.

Kaio Nogueira holds an MSc in territorial planning and management and is currently a PhD candidate in real estate and planning at the University of Reading. His primary focus of research is on urban regulation and residential market behaviour.

Camila Nastari Fernandes holds a PhD and an MSc in territorial planning and management from the Federal University of ABC, Brazil. She studied São Paulo's institutional aspects of urban planning policy and the planning system in her thesis. Her main topics of research are urban policies and public policies.

Gabriel Marques da Silva holds a BSc in sciences and humanities and territory planning from the Federal University of ABC, Brazil. He is also completing his MSc in territorial planning and management at the Federal University of ABC and his research focuses on precarious housing indices. His main topics of research are housing and slums.