City Form, Mobility and University Students in Post Pandemic Era

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Abstract. The relationships between the shape of the city, proximity and mobility have always been the subject of study for urban planning and urban geography, however more oriented towards finding treatments than causes to be solved. What role does centrality and urban attractiveness determine in consideration of daily actions and therefore of access to the main services? The urban mobility of university students is the focus of this paper while the aim is to develop a methodological proposal to build an index of centrality (Uni_City Index) of the Italian Universities as a function of a set of open data indicators of innovation, socio-economic, mobility and land use to support city–university integrated policy actions in the context of post-pandemic recovery and the recent energy crisis.

Keywords: City form · City of proximity · Mobility · University students · Post pandemic city

1 Introduction

What is the relationship between the shape of the city and mobility? Is it a relationship of mutual cause and effect?

The question of the relationship between the shape of the city and mobility has always been the subject of study for urban planning and urban geography. The mobility of university students is the focus of the paper while the objective is to develop a methodological proposal to build a centrality index of the University as a function of a set of socio-economic indicators, mobility, innovation and land use to support policy actions integrated city–university.

The rest of the paper is organized as follows: first section: Introduction and Literature review (paragraphs 1.1 and 1.2); Sect. 2: Materials and Method and discusses the topic

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(paragraphs 2.1 and 2.2); Sect. 3: case study (paragraphs 3); Sect. 4: Results and Discussion, reports and discusses the main research results carried out (paragraphs 4); Conclusions are drawn in the Sect. 5, where the major findings are presented, together with the future developments of the research (paragraphs 5).

1.1 The University and the City

The relationship between cities and their universities is not a trivial one, and a particular attention needs to be put onto the functions played by cities as providers of services. From an urban and economic geography point of view, in fact, a university as a service can be seen as a higher order service provided by cities as market centers, attracting users from both the city itself and a 'regional', wider hinterland, given the relative scarcity of places in a territory where such an activity is provided and carried on [1]. Universities therefore play a role both on a local community, and on a wider community of users from a regional hinterland but also from other parts of the national and international contexts. From a Christallerian point of view, universities play their role as city serving activities, dedicated to the local community, and city forming ones, operating on a wider range of regional and national/international users, and therefore characterizing the city and its functions as a higher order center, competing with other national and international ones [2].

However, within cities, university campuses can play a territorialization role, that of transforming an urban and regional territory, also having different impacts on different sites within a same city—region—i.e., with nodal roles played by different major campuses and agglomerations of facilities in different parts of a city. University campuses and cities can be considered as nodes of a transport network with profound similarities even if of different rank and potential for generating and attracting travel [3, 4]. In fact, university campuses can be considered a small urban model in which to study and adopt more efficient sustainability strategies than the widespread university model. More generally, universities are a development factor for society and encourage the economy of the territories in which they are located [5], through a continuous process of innovation:

- for the diffusion of training for young people in a nation increasingly characterized by a population over 65 that needs generational change;
- for the commitment in research and for the ideas they produce, potentially capable of optimizing the choices and strategies to be implemented in the context both from a territorial and economic point of view;
- for the circuits they generate at national, European and World levels in which cities, with their activities, could usefully enter;
- for the economic, social, artistic-cultural value they produce and make available to the communities to which they belong.

The location choices of universities, the contribution in terms of increasing the cultural offer of a city, the ability to attract students and staff, the indirect economic impact generated by the needs of the latter and the increase in jobs, are all examples of how the multiple roles and functions of a university are closely linked with the transformations of

an entire city or individual neighborhoods. Although universities are seen as an increasingly fundamental presence for the growth of a territory, the choices and actions carried out by a university do not always have entirely positive implications. The presence or, even more so, the opening of a university center brings with it inevitable social, urban and economic changes in which it is located, leading to the so-called "studentification" of the area [6].

The areas located near a university are in fact often subject to the increase in demand for houses for rent or for sale for students. Also in these areas, moreover, the commercial offer is moving towards activities that contribute to spatially reproducing a certain model of "university life". Both the negative impact on access to homes by resident families and—and above all—the negative effects that accompany the transformation of a neighborhood into a "university neighborhood" often generate conflicts between students and the resident population; conflicts that arise around the use of public space, the different rhythms of life, habits and behaviors related to nightlife.

In recent years, the city–university combination and the common goal of attracting a growing number of students has also become evident in the boom in private university residences (the so-called PBSA—Purpose Built Student Accommodation) [7].

On the one hand, the construction of this type of residences makes it possible to increase and diversify the supply of beds, in the face of a sector of public residences which, in an era of cuts and austerity policies, is unable to adequately satisfy the 'increase in demand'; on the other hand, the construction of residences or the conversion of former industrial buildings are often an integral part of urban regeneration projects.

Furthermore, numerous international and national universities have set environmental, social and economic objectives such as the reduction of the carbon footprint, the use of green technologies, the design according to principles oriented towards the balance between man and the environment, the use of systems green transport, the reduction of collective costs and the progressive reduction of social injustices [8–11].

A systematic and non-systematic type of student travel behavior emerges from the city–university framework in Italy. In other words, the presence of university students is strictly connected both to the concept of commuting [12] and to city users [13] depending on the period of stay in the cities and campuses.

In particular, the definition of city users includes those who move to a city to use its public and private services for: buying entertainment, tourism, bureaucratic procedures, etc. Instead, the concept of commuter includes workers or students who move daily from their place of residence to reach that of their business/study building-area.

This difference makes it possible to underline the trend of travel demand and the relative frequency (for example temporality and frequency) as well as the possibility of implementing a series of actions/activities within the university cities (for example travel habits). Furthermore, the demand for mobility of university students affects in some cases the travel habits of a city and in others increases the need to enhance public transport LPT and multimodality, within the framework of student economic availability.

It is no coincidence that many universities have closed agreements with mobility service companies for the creation of ad hoc services and rates for students, often free to encourage the use of public transport or shared mobility (cars, bikes or scooters.) [14, 15] with respect to the use of the private vehicle [16, 17].

1.2 University, Mobility, and Covid-19

The COVID-19 epidemic has disrupted daily life very quickly. Transport is one of the sectors most affected by the pandemic and for this reason, the changing demands of users in its various segments need to be carefully examined in order to undertake effective post-pandemic transport policies [18]. In particular, after the lockdown there was a reduction in the use of public transport and an increase in private transport, especially by workers and university students. In addition, several studies have shown that COVID-19 has caused an increase in the use of e-scooters/hoverboards and active travel modes [19, 20]. Some Action Plans are based on a context analysis, a road map model and make use of the use of ICT tools capable of improving the capacity of decision makers and university mobility managers in order to plan the best mobility solution sustainable. The integration of student mobility in the Sustainable Urban Mobility Plans (SUMP) allows the development of a long-term strategy based on services dedicated to students and the spread of multimodality. The students' mobility must be ensured, and, at the same time, it must be acceptable, accessible, affordable, and available, always verified in the proximity city model [21–24]. Furthermore, universities with or without campuses are able to generate a significant number of trips. From the Travel Demand Management (TDM) strategies of the nineties focused only on employees, we have moved on to the mobility managers of the years, introducing policies that are also and above all student-oriented, with the aim of improving the university's sustainability standards. Furthermore, universities with or without campuses are able to generate a significant number of trips [25]. From the Travel Demand Management (TDM) strategies of the nineties focused only on employees, we have moved on to the mobility managers of the years, introducing policies that are also and above all student-oriented, with the aim of improving the university's sustainability standards. If on the one hand the presence of a university campus brings benefits to the cities that host them, on the other there are still some critical issues connected to the demographic decline and the lack of mobility/connection services for some regions. This forecast scenario will have a decisive impact on many Italian universities, given their poor ability to attract foreigners, and considering that the majority of students enrolled are not only Italian but also mostly from the province in which the university has legal office [26]. Several studies in the literature have focused on the accessibility of campus areas by analyzing the modes of transport available to students [27], others have focused on travel habits and frequency [28].

In addition, various actions to support and protect the mobility of university students have been carried out in Italy by the ERSU (Regional Agency for the Right to University Education) with a 50% discount on the cost of the urban and extra-urban transport season ticket. o reduction of train fares or actions such as in Fig. 1.

The recent pandemic has put a stop to student mobility, nearly emptying entire university towns of their temporary inhabitants. However, since September 2021, the private rental market has registered a new increase in demand, which has led to an aggravation of the problem of the lack of affordable rooms already registered before the pandemic in some of the most attractive destinations for students. Particular attention was paid in the recent pandemic phase to the psycho-social aspects connected to movement and to the sensations of stress, fear and anxiety in moving [29, 30]. The main difficulties

Mode of transport	Action	City and Integration of interventions with SUMP
Local Public Transport	Discount for urban and extra-urban buses	Camerino_no SUMP Bologna_SUMP2019 (integration of the activities in the proposal) Catania_SUMP2020 being drafted Turin_SUMP2011 not definited Rome (metropolitan) _PUMS2020 being drafted Trento_SUMPS2020 being drafted Brescia_SUMP2018 not definited Perugia_SUMP2019 (integration of the activities in the proposal)
Shared Mobility	Discounted rates (50% reduction) for booking car-sharing and bike sharing cars	Perugia_SUMP2019 (integration of the activities in the proposal) Palermo_SUMP2019 Enna_SUMP2020 being drafted
Rent and Parking	Facilities relating to bike rental, guarded parking for bicycles, bicycle repairs and auto repairs	Bologna_SUMP2019 (integration of the activities in the proposal)
Car pooling	Creating an APP	Perugia_SUMP2019 (integration of the activities in the proposal) Cagliari_SUMP2021 (integration of the activities in the proposal)

Fig. 1. Mode of transport, action and integration with SUMP (Authors: T. Campisi and G. Balletto, 2022).

encountered in the home-university journey concern traffic congestion, excessive crowding of public transport and their absence or low frequency, regularity and punctuality, especially after the lockdown due to the recent pandemic. In the post-pandemic phase, there was a vigorous acceleration of local administrations in the initiatives aimed at promoting active and sustainable mobility [31], intervening in a regulatory framework in the process of evolution (and which can still be improved).

The gradual exit from the most critical phase of the infections of the first wave has stimulated various reorganization initiatives necessary to continue the social distancing, in view of the resumption of the spread of the virus (as promptly occurred after the summer) but, at the same time, able to go beyond the temporary or exceptional nature of the measures and guarantee safe travel for millions of people in the future by alternative means. Despite the technical, legal and administrative challenges, the measures have been implemented demonstrating in some cases how local authorities can be responsive and agile in times of need, as well as the fact that existing avenues to promote active travel do not always require substantial economic funding, no complex planning or lengthy administrative processes. Furthermore, once the effectiveness of the policies adopted for the critical phase has been assessed, it is possible that the temporary measures may be permanent. In any case, administrative innovation and the experience of cooperation between structures and entities may be useful in the future for long-term strategic planning paths. The theme of student mobility involves about eighty Italian universities-cities, for a total of 566 faculties, with different spatial distribution: scattered and/or concentrated, producing positive and negative externalities in the context [32].

2 Materials and Methods

2.1 University as an Urban Centrality

More generally, universities belong to the main urban hierarchies that can be associated with the theory of central places [33]. The Italian university system can therefore be summarized as in Fig. 2.

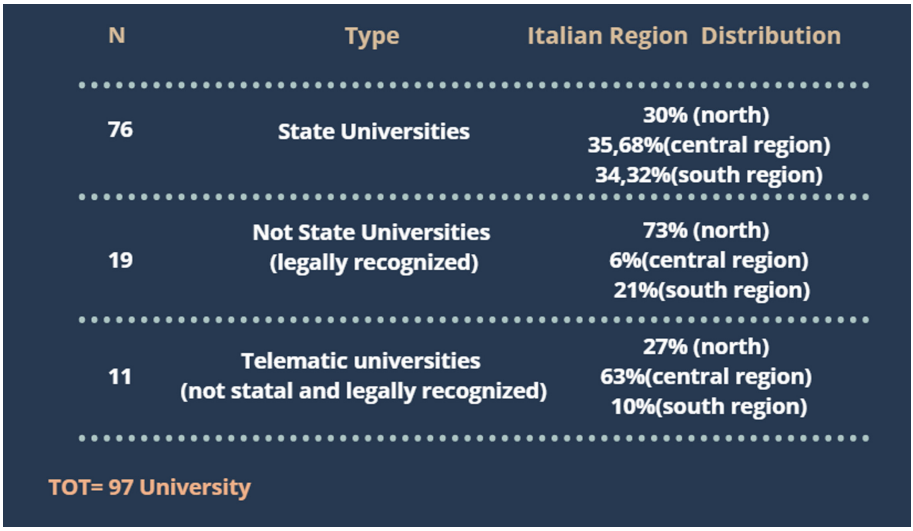

Fig. 2. Overview of universities in Italy (elaboration: T. Campisi; G. Balletto, 2022) [34].

It is worth noting that universities represent important elements in the organization of territory and particularly in providing services to urban areas. The idea is that higher education institutions, as universities and research centers, can have an effect on cities on two different scales or points of view. From the point of view of the concept and functions played, the presence of a university characterizes a city has holding a higher hierarchical position in the rank of cities, in terms of the superior services provided: i.e., all the municipalities host primary, schools some municipalities offer secondary schools, few municipalities host universities. That helps in adding value to cities and metropolitan areas in providing services that characterize them in city forming activities.

A second scale and point of view is related to the spatial and local effect that universities can have in the different buildings and campuses within—or around—a certain city [35–37], remembering that students are the main supporters of the 15 min city. In particular, according to Badii et al. (2021) urban centrality in the 15 min city can be represented through the following dimensions [34]: Housing viability (H); Govern Services (G); Safety Services (SS), Culture and Cults Services (CCS); Environmental Quality (EQ); Slow Mobility Services (SMS), Fast Mobility Services (FMS), Sport Services (SS); Economy/sustainability (E/S); Food Services (FS); Health Services (HS); Education Services and Entertainment Services (EES).

However, it should be noted that the University as a central place of higher rank helps to hierarchize the city that hosts it [38], regardless of the form and distribution of the University [39]. Specifically, the University has its own or directly connected—intrinsic—characteristics that contribute to the formation of the relative role of 'central place' which in turn is inserted in the urban spatial context with its own characteristics, extrinsic with respect to the central place of the University and therefore own from the city [40]. Therefore, the attractiveness or marginality of the University can be understood as a combined result of its intrinsic and extrinsic characteristics [41–43]. In particular, the characteristics:

1) Intrinsic (own and directly connected to the University): University ranking, number of students compared to the resident population, number of the spin-offs or youth entrepreneurship, student housing;
2) Extrinsic (own and directly connected to the city): Socio-economic, public transport, cycle paths, pedestrian areas, outdoor sports and food and pleasure services.

In fact, in the last 30–20 years university campuses have spread to various Italian regions, bringing a series of benefits from an economic and social point of view, but above all to compensate for the low level of extrinsic characteristics, representative of the urban system and therefore to limit the negative externalities deriving from student mobility [44]. Furthermore, the development of urban planning and sustainable mobility of SUMPs still neglects university students [45] although they constitute the most versatile segment of the population in accepting innovation applied to sustainability [4].

2.2 Methodology

The method used to construct the University centrality index as a function of intrinsic (University and innovation) and extrinsic (socio-economic, mobility and land use in urban system) characteristics is based on the framework of the Deming Cycle [46] to ensure a continuous monitoring process and result. In particular, the method is divided into the following phases: i) Plan: observation of the phenomenon (Mobility of university students) and goal definition; ii) Do: desk analysis and open dataset, index construction (Uni_City); iii) Check: comparison results—objective; iv) Act: university—city policy.

Furthermore, in agreement with Kang et al. (2021), the importance of the diversity of activities (i.e. that serve different primary functions), both temporal (i.e. that attracts people at different times of the day) and both spatial (i.e. that attracts people from different neighborhoods is highlighted) which play important roles in promoting urban life in large cities through for example the use of mobility data and the spread of crowdsourcing [47].

Below is the summary scheme of the method used (Fig. 3).

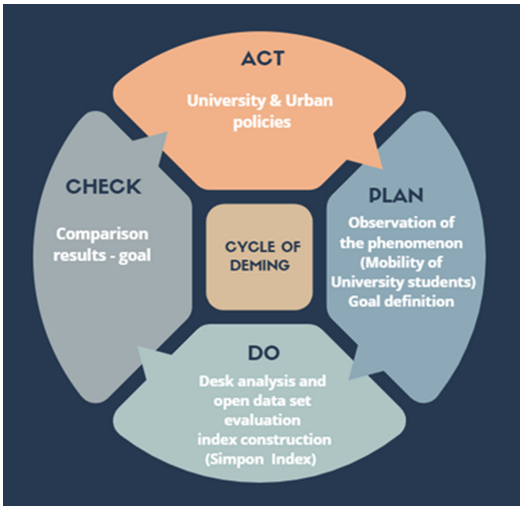

Fig. 3. Framework of methodology based on the cycle of Deming. (Source: Balletto G., 2022).

In particular, the construction of the index, called Uni_City Index, derives from the application of the Simpson formula to the whole set of selected intrinsic and extrinsic characteristics. The Simpson diversity index, in fact, is used in statistics in the case of populations with a finite number of elements and is widely applied in ecology to represent ecological environmental diversity and by analogy it has been transposed to the urban context [48, 49], in this case of the characteristics intrinsic and extrinsic that represent the combined centrality of the University and the city to which it belongs.

$$Uni_City\ Index = 1 - log \sum_{j} \frac{Nj(Nj-1)}{N(N-1)}$$

where Nj indicates the number of j-th "species"

$$N = \sum Nj$$

The Simpson index finds a wide application in ecology to represent environmental ecological diversity and by analogy it has been transposed to the university and urban system and specifically, it refers to the diversity of central locations [50, 51].

3 Case Study

What is the relationship In this context, the case study is aimed at the first test of the phases of the Deming diagram (Fig. 3) by comparing it in pairs of cities hosting medium-sized

(Cagliari and Trieste) and small (Enna and Aosta) universities, excluding the cities with large universities that deserve a different approach by virtue of national and international hierarchies. The data set was built on open indicators and published annually (Figs. 4, 5 and 6) [52].

	University and innovation	Badii et al (2021)	Cagliari	Trieste	Enna	Aosta
Intrinsic Characteristic	University ranking_2020	CCS	86.7	92	74.8	72.4
	N. of university students_2018	CCS	25450	15239	5284	1071
	N. of graduates (25-29 years) 2020	CCS - E/S	590	1000	233.7	492.5
	Youth employment rate_2020	E/S	477.6	880.5	248	840.6
	Youth entrepreneurship (% companies under 35) 2020	E/S	211.4	235.9	852.9	377.3
	Rent (% of rent on average income) 2020	H	785.1	575.5	931.0	799.6
	Gap rents between center suburbs (%) 2020	H	957.1	883.9	857.1	600

Fig. 4. Data set of international characteristics of University of Cagliari, Trieste, Enna and Aosta (Italy) (Balletto G., 2022).

	Socio-economic, Mobility and Land use	Badii et al (2021)	Cagliari	Trieste	Enna	Aosta
Extrinsic Characteristic	Labor Market Areas (LMA) N of Municipality_2019	E/S	42	6	4	35
	Area of LMA (Kmq)_2019	E/S	2459.52	212.5	512.17	1627.21
	Population of the LMA_2019	E/S	505533	231445	24551	77677
	Average income_2019	E/S	25681	23118	20268	24257
	Local Public Transport (LPT) offer Km / inhabitant_2020	FMS	4.05	56.22	15.03	13.1
	Car motorization rate_2020	FMS	68	54	70	64
	Motorcycle motorization rate for _2020	FMS	10	21	12	12
	Passengers, LPT year, per million_2020	FMS	32	70	0.2	12.5
	Passenger public transport (trips / person / year, 2020	FMS	147.15	200.37	41.52	11.2
	Cycle paths eq. meters / 100 thousand inh._2010	SMS- EQ	6.05	2.15	9.1	0.26
	Bar, disco, take away every 10 thousand / pop 15-35 years_2020	FS	779.5	427.7	80.5	561.1

Fig. 5. Data set of extrinsic characteristics of University of Cagliari, Trieste, Enna and Aosta (Italy) (Balletto G., 2022).

	Cagliari	Trieste	Enna	Aosta
Simpson Index (SI)	0.0915	0,137	0.444	0.244
1-SI	0.91	0.86	0.56	0.75

Fig. 6. Simpson Index (SI) and (1-SI) of Cagliari, Trieste, Enna and Aosta (Italy).

4 Results and Discussion

In the context of post-pandemic recovery strategies and actions aimed at achieving the sustainable development goals, this study presents the first results of ongoing research relating to the identification of a representative index of the interrelationship between universities and their urban environment, in support of integrated university–city policy actions.

The UniCity Index aims to focus on the evaluation of the centrality level of universities—and therefore the attractiveness of the "university-city" system—based on intrinsic and extrinsic features that characterize the universities and the cities in which they are located. The establishment of a university, in fact, certainly has an impact on the city that concerns not only the urban planning, but also the system of economic and social relations of its territory.

The intrinsic and extrinsic characteristics selected in this first step of investigation refer to the available indicators, persistent and stable over time, belonging to the fields of culture and education, economy, livability, environment, and mobility. These indicators are identified in the literature as representative of the complexity and diversity of an urban area, with reference to the concept of the 15 min city, and can be classified in the following dimensions [34]:

- Culture Services (CCS). Indicators of culture and education's quality related to the attractiveness of educational and cultural services.
- Economy/Sustainability (E/S). Indicators of economic sustainability related to average income, unemployment rate, entrepreneurship, presence of activities and services.
- Housing viability (H). Indicators of livability and housing quality of the area related to the incidence of housing costs.
- Environment Quality (EQ). Indicators of environmental quality based on pollution reduction factors such as cycle paths and networks.
- Fast Mobility Services (FMS). Mobility-related indicators for medium and long-distance travel (public transport, motorization rate for cars and motorcycles).
- Slow Mobility Services (SMS). Indicators related to active mobility for short-distance journeys (cycle paths).

The methodology applied for the index definition, based on the Deming Cycle framework, can also be used in the following steps to add more factors and details to the model in case other types of data, additional or alternative to those used in the case study, become available.

More specifically, the index relates the characteristics of the university itself or directly connected to it, which concur to define it as a 'central place', with the characteristics of its urban context, therefore external to the university but still influencing it. Through its application on four cities that host medium-sized universities (Cagliari and Trieste) and small universities (Enna and Aosta), the Uni_City Index highlights the tendency of the university-city system to develop greater attractiveness (index value tending to 1) or marginality (index value tending to 0). The results show that the university-city system is more cohesive and interdependent in the case of medium-sized cities such as Cagliari (0.91) and Trieste (0.86) while it is weaker in the case of Enna (0.56) and Aosta (0.75).

As its value increases, the index shows that universities and urban areas that host them are increasingly linked by a continuous exchange of resources, knowledge and human capital and therefore they are two ecosystems that cannot ignore a strong physical, economic and social interdependence. This happens above all when universities have no central campus, but rather university buildings are scattered around the city, as in the cases of Cagliari, Trieste and Aosta, which "permeate the city representing crucial hubs of a complex urban network" [53] by which, at the same time, they are influenced.

The characteristics selected for the construction of the set of indicators take into account simultaneously the intrinsic attractiveness of the university, determined by factors such as its ranking, the number of students, the cost of renting for university students, and the extrinsic one linked to the components of the city and in particular its socio-economic system, urban mobility and land use. The combination of these features highlights how the centrality of universities is configured not only in terms of innovation of the educational services offered but also in terms of actions and relationships that universities trigger and establish with their urban surroundings, generating socio-economic impacts, on the urban mobility system and on the land use of the city itself. Qualifying itself as a real urban space, the university is a system able to extend its area of influence to the surrounding context and at the same time to be influenced by the latter [54].

This relationship of mutual dependence relates in particular to the aspects of accessibility and urban mobility, since the attractiveness of universities also depends on the urban planning choices of the urban areas in which they are located, the organization of services related to mobility and therefore the degree of accessibility of the places.

The diffusion of universities and university buildings open to public use (libraries, cultural centers) or intended for mixed functions (residential, commercial) points out that a greater permeability allows the university to become a real piece of the city [55], which can help to compensate for the limited performance of an urban system or, conversely, can benefit from the positive results of its urban surroundings.

Enhancing the proximity between universities and the urban environment, today, seems fundamental both in the post-pandemic context and even more in the framework of a possible energy crisis, which inevitably requires a rethinking of urban space and its distribution with the aim of enhancing the construction of a network of central, accessible, and livable places.

5 Conclusions

The development and spatial distribution (concentrated and/or widespread) of universities over the years has increased the spread of services and activities in their vicinity. They have also led to a different demand for mobility characterized not only by residents but also by commuters with reference to university students. In particular, the attractiveness of universities depends not only on the educational offer for students but also on the characteristics of cities, in terms of connections, quality of life and cost of living. Specifically, urban planning of the areas and on the optimization of services and in particular on transport and therefore on the degree of accessibility of the places.

In recent years, universities and local administrations have focused on environmental, social and economic impacts and this must also be pursued in the post-pandemic phase to avoid the increase in the use of private vehicles and therefore the related road congestion phenomena.

Several intrinsic and extrinsic indicators were considered for a preliminary assessment of the universities with particular reference to the comparison between two medium-sized and two small university towns.

After selecting a set of extrinsic intrinsic indicators, the Simpon's index commonly used to measure biodiversity, i.e. the diversity of living beings in a given place -, allowed us to measure the diversity of anthropogenic elements such as schools, commerce, mobility and transport, etc. The future prospects of this research are to extend to the main University Italian cases.

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