

# TeMA

Journal of  
Land Use, Mobility and Environment

The Special Issue collects six papers that use mobile phone data and spatial analysis techniques to study new urban critical features and social phenomena that arose with the Covid-19 pandemic. The applications of mobile phone data in the three study contexts investigated the potentialities of mobile phone data, as well as their limits. Compared to traditional methods of urban survey mobile phone data provide real-time maps of daily practices.

TeMA Journal offers papers with a unified approach to planning, mobility and environmental sustainability. With ANVUR resolution of April 2020, TeMA journal and the articles published from 2016 are included in the A category of scientific journals. From 2015, the articles published on TeMA are included in the Core Collection of Web of Science. It is included in Sparc Europe Seal of Open Access Journals, and the Directory of Open Access Journals.

*Special Issue 2.2022*

**Mobile phone data for exploring spatio-temporal transformations in contemporary territories**

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Journal of  
Land Use, Mobility and Environment

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## Mobile phone data for exploring spatio-temporal transformations in contemporary

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*Special Issue 2.2022*

## MOBILE PHONE DATA FOR EXPLORING SPATIO-TEMPORAL TRANSFORMATIONS IN CONTEMPORARY

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## EDITORIAL PREFACE

Special Issue 2.2022

### Mobile phone data for exploring spatio-temporal transformations in contemporary territories

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Over the last few years, TeMA Journal has published numerous in-depth scientific-disciplinary Special Issues on the topics of interest to the journal, most of which are closely related to the main purpose of this scientific initiative: to contribute to the construction of new scientific and professional skills on one of the topics of greatest interest to those who study and work in the fields of urban and territorial transformations. The integration between the disciplines which study urban transformations and those which deal with issues of mobility governance makes it possible to overcome the apparent fences between these disciplines, and to build a new body of theoretical-methodological knowledge which provides new solutions to the problems which we continue to face today with the old tools of last century's scientific culture.

These include: the volume 'Transit-Oriented Development in Iran: Challenges and Solutions', published in 2016, in which the experiences of TOD in Iran and Germany were examined, focusing both on the problems which have limited the positive effects, ease of use and good accessibility of public transport systems in Iran and on the state of the art in Germany; in 2018, the volume 'Elderly Mobility' addressed the issues of mobility of the elderly by exploring the supply and demand of Local Public Transport (LPT) in Italian urban areas; finally, in 2018, the volume 'New Scenarios for Safe Mobility in Urban Areas' was dedicated to the relationship between mobility and quality of life in urban areas, with a specific focus on the safety of vulnerable road users.

Other Special Issues, published over the years, have dealt with topics of pressing topical interest: the study, design and implementation of the 'smart city'; the role of new technologies in the organisation of the city of the future; urban resilience as a conceptual approach to urban design aimed at building new awareness among citizens, technicians and administrators to reduce the impacts of climate change and the consequences of natural and man-made disasters; improving the quality of life of the elderly and, finally, the recent implications of the issue of the pandemic which has affected the lives of citizens.

This latest TeMA Journal Special Issue 'Mobile phone data to explore spatio-temporal transformations in contemporary territories' takes up the focus of the journal in a stringent logical-temporal sequence. The volume, in fact, offers the scientific community an in-depth study on the increasingly relevant relationship between new communication technologies and the governance of urban and territorial transformations, and aims to develop a cognitive framework on the evolution of digital communications in the urban and territorial sphere and on their use for the knowledge of settlement phenomena.

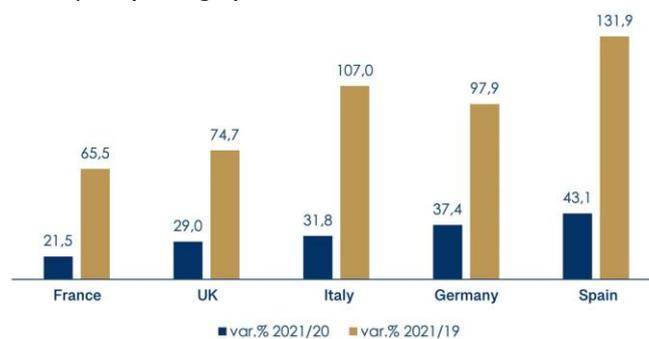
The research contained in this volume utilises - a practice which is not very common in our country - a panel of data provided by the use of mobile telephony to gain insight into aspects which are highly relevant to research on

urban phenomena such as metropolitan commuting, distance learning and multi-residentiality. They also testify to the relevance of the availability of mobile telephony data in the investigation of spatial dynamics.

In other words, the articles contained in the volume are oriented towards investigating and interpreting, among others, some highly complex urban phenomena such as 'the variability in the distribution of presences in the neighbourhoods of a large city', 'the seasonality of the use of second homes in a tourist area', 'the use of remote working in sparsely populated areas'.

The availability and reliability of this information, in conjunction with the possibility of using powerful dedicated software, finally makes it possible to investigate issues of great relevance to the study of the city which could not be pursued until now and can be the starting point for various in-depth studies in different disciplines which, like urban planning, study user behaviour (Papa et al., 2016; Carpentieri et al., 2020).

The increasing availability and reliability of mobile data is mainly due to the proliferation of increasingly powerful devices and innovative mobile applications, the use of which recorded a significant spike between 2019 and 2021, straddling the outbreak of the Covid-19 pandemic (Mediobanca, 2022). In fact, mobile data traffic shows an extraordinary increase over this period, reaching 65.5% in France, 74.7% in the UK, 97.9% in Germany, 107.0% in Italy and, finally, 131.9% in Spain (see Fig.1).



**Fig.1 Percentage change in data traffic in European countries (Mediobanca, 2022)**

This tumultuous growth trend is self-perpetuating and sees considerable resources committed to the digitalisation sector in 2021 as well: in Spain and Italy, investments have reached EUR 7.6 billion each, in Germany EUR 10.8 billion and in France EUR 15.5 billion. In addition, in order to foster the development of this strategic sector, the EU authorities have invested EUR 49.8 billion of Recovery Fund resources in initiatives of EU countries ranging from the digitisation of public administration to the development of ultra-wide bandwidth, from 5G to satellite networks. In Italy, access to the mobile telephony network has been steadily increasing over the last decade, as the diagram in Fig.1 shows, with a positive change between 2013 and 2021 of 6.9 million accesses to the total telephone network, accompanied by a positive change of 22.5 million accesses for M2M Sim devices. This diversification in mobile telephony operators highlights a twofold aspect of great scientific relevance: on the one hand, the growing and balanced involvement of public and private companies, which guarantees greater extension and articulation of the available database, and on the other hand, the increasing reliability due to the large number of data sources from devices which allow the exchange of information between devices with limited or no human interaction (M2M Sim).



**Fig.2 Number of mobile network accesses (in millions) per human and M2M (machine-to-machine) sim (Mediobanca, 2022)**

This exponential increase in mobile telephony activities leads to an equally massive increase in the availability and reliability of data, which can be used in many areas of scientific research, from economics to social research to computer science.

This opens up a fruitful field of research in the knowledge of urban phenomena to which urban scholars do not yet seem to have been devoting the necessary attention. In other words, a 'new' field of research is opening up, of which this volume is intended to be an initial result, requiring innovative approaches, dedicated tools, specific skills and, above all, scientific curiosity.

Mobile phone traffic data have been employed in several applications in urban and territorial research over the last fifteen years. Their application primarily aims to analyse the space-time variability in population distribution in cities (Mobile Landscape Method in Ratti et al., 2006; Ahas & Mark, 2005; Sevtsuk & Ratti, 2010); classify different 'basic' profiles of city users and patterns of consumption (Reades et al., 2007; Soto & Frías-Martínez, 2011; Järv et al., 2014), study trip chaining (Ahas et al., 2010; Srinivasan & Raghavender, 2006; Steenbruggen et al. 2013), update origin/destination matrices and transport models (Noulas et al., 2012; Shoval & Ahas, 2016; Shoval et al., 2014; Yip et al., 2016), detect mobility behaviour for demand analysis (Bayir et al., 2010), and during the COVID-19 pandemic, assist with emergency management (Wang et al., 2020).

These applications make it possible to deal with opportunities and critical issues in the processing of mobile phone records and address the need to integrate these data with other available data sources to investigate complex urban phenomena (Pucci et al., 2015).

In recent years, the availability of mobile phone traffic data in Italy, provided through business services targeted towards public administrations, large companies and research institutions by TIM, Vodafone and Windtre has made it possible to experiment with different uses. In urban research, these data have been increasingly exploited to detect urban practices and complex territorial processes, generating knowledge about their scientific reliability, their limits and the need for a structured integration with other data sources.

In this framework, the special issue aims to reflect on the usability and relevance of mobile phone traffic data for territorial research, on the challenges posed by its treatment in statistical terms and on possible integration with other available datasets, presenting the outcomes of specific empirical experiments on three territorial settings (Milan, Lecce and its coast and the Piacenza Apennines).

These settings represent relevant and challenging study contexts within research on territorial fragilities carried out by the Department of Architecture and Urban Studies, Politecnico di Milano, in the last few years. Processing mobile phone data in these three Italian cases, characterised by different socio-territorial conditions, settlement densities and mobility practices, allows testing the potentialities of mobile phone data and their limitations in exploring unobservable trends and dynamics that may be associated with existing fragility, or on the contrary, signal the presence of opportunities to be exploited to counteract such fragilities.

The data used in the research works presented in this special issue, provided by TIM and characterised by a very high spatial-temporal resolution (15 minutes for 12–16 months in 2019–2020 for three Italian territorial areas) describe two phenomena:

- Human presences: as an estimation of the number of presences detected at the Istat ACE (census areas) level, with socio-demographic details provided by the TIM registry (gender, age groups, foreigners, users' profiles as commuters, inhabitants, tourists, contract typology as business or consumer);
- Human mobility: in terms of displacement with details on origins and destinations at the ACE spatial level for the municipality of Milano.

These data on human presences and mobility, related both to a city's inhabitants and users profiled by age group, gender and nationality and collected over a wide timespan, including a pre-lockdown phase and the pandemic period, have been processed to analyse:

- Space-time variabilities in urban practices, providing information on temporary populations and city usage patterns on a daily, weekly and seasonal basis and considering the impact of holidays, weekdays or specific public events;

- Time variability in the use of urban spaces to detect their over/under-use in some periods of the day/month/season;
- Prevalent mobility flows and their intensity and variability to distinguish systematic from non-systematic mobility, as well as the recurrence of mobility practices at different scales (municipalities and provinces), considering gender issues and nationalities.

Due to the unique characteristics of the three study areas (Milan, Lecce and its coast, the Piacenza Apennines), mobile phone data have been used to investigate different and place-based dynamics, including the variability of presences in the neighbourhoods of Milano during the pandemic; the seasonality of use in coastal areas in the municipality of Lecce, characterised by the presence of second homes, partly unauthorised; and the analysis of practices such as remote working in sparsely populated and low connected territories (Piacenza Appennines), as well near-home tourism, during the pandemic.

Dealing with complex urban phenomena – otherwise difficult to study with conventional data sources – the three case studies led to testing whether and to what extent mobile phone traffic data allow more detailed interpretations of some spatial effects of the pandemic on urban behaviours such as changes in the timing of the use of the cities, rhythms of daily commuting, the impact of remote work and learning and multi-residentiality. Moreover, even though not always representative of the overall population of a territory, case studies illustrate the variability of practices and times of use of urban and rural spaces.

The differences in the study contexts and the related research questions represent a test case for investigating the heuristic potential role of mobile phone data in urban studies, highlighting that mobile phone data do not ‘speak for themselves’, but instead need interpretative models to guide their use and integration with other data sources. These conditions are relevant in affecting their usability in urban and spatial analysis that remains marginal, despite the availability of a large amount of (digital) data, due also to the level of complexity in the approaches finalised to process and integrate this data (Einav & Levin, 2013; Batini, 2018; Kitchin & Lauriault, 2018; Concilio & Pucci, 2021).

Within this general framework, the six papers of this special issue contribute to the general debate on the use of mobile phone data for urban research, addressing theoretical, methodological and technical issues and presenting three specific case studies. The first paper, ‘Mobile phone traffic data for territorial research: opportunities and challenges’, reconstructs state of the art in mobile phone research for urban studies in detail, highlighting the potentialities and limitations of mobile phone data. Moreover, the paper introduces the DASTU Department's research on territorial fragilities and the role of mobile phone data in addressing specific topics solicited by this approach. Thus, the paper is intended to guide the reader through theoretical and contextual aspects of urban research based on mobile phone data.

The paper titled ‘A glimpse into mobile phone data: characteristics, organization and tools’ provides a detailed description of the characteristics of mobile phone data to support their uses and deploy their potential in urban studies. By presenting mobile phone data provided by TIM and its spatial and temporal disaggregation and information related to age groups, gender and classification of behaviours, the paper proposes a baseline for the comparison of the data trends, as well as integration with traditional sources and ad hoc surveys to show how they can facilitate the interpretation of mobile phone data, its validation and its use. Finally, a reference to the operational tools used for data processing and visualisation highlights the need to integrate skills, methodologies and tools for the maximum exploitation of this wealth of information.

The third paper explores ‘Exploring the “15-Minute City” and near working in Milan using mobile phone data’ and focuses on changes in the attractiveness of Milan neighbourhoods during the COVID-19 pandemic (2020) compared to the year before (2019). The aims of this paper are twofold: it measures the presence of remote workers at the neighbourhood scale and explores which neighbourhoods meet the requirements of the ‘15 minutes’ city paradigm, with specific attention to nearby working. Analysing the change of the city users’ presence in the Milan neighbourhoods in 2019–2020 using TIM mobile phone data, the paper performs a correlation of the residents working typologies (e.g. knowledge workers vs. other typologies) and the presence of users at the neighbourhood scale during the day as a proxy of remote working, and it investigates the supply of main services at the neighbourhood scale, including coworking spaces, to understand which Milan neighbourhoods better meet the

requirements of the 15 minutes city, as described in the policy measures promoted by the municipality of Milan (2020) favouring the '15 minutes city'.

Shifting from a central urban area like Milan to the coastal territory of Lecce, the paper titled 'Permanent and seasonal human presence in the coastal settlements of Lecce', tests the effectiveness of mobile phone data in providing an assessment of the permanent and seasonal residents in a coastal area (Marine) characterised by seasonal use and informality. Starting from challenging conditions related to the presence of coastal settlements mainly composed of unauthorised second homes, which are difficult to detect in traditional census and registry statistics, the paper compares TIM mobile phone datasets referring to different slot-times from September 2019 to September 2020 to reveal dissimilarities between the southern *marine* and northern ones, where the former are characterised by the more stable presence of a resident population and fewer environmental risks. In its concluding section, the paper questions, from an urban planning perspective, the usefulness of analysis based on mobile phone data with a high spatial-temporal resolution, with particular attention paid to the many illegal buildings which cannot be legalised and therefore must be demolished.

The third investigation conducted experimentation in the context of a sparsely populated, low-connected and poorly accessible mountain area located in the province of Piacenza (Val Trebbia and Val Nure) characterised by a general process of marginalisation due to the ageing of its population, low occupational rate, low income and a progressive deprivation of local know-how and shrinking of essential services. In this area, the paper titled 'Impacts of the COVID-19 pandemic in inland areas' investigates through the use of mobile phone data if and how, during the Pandemic, remote working and near-home tourism contributed to modifying the marginal conditions of these territories. Comparing the baseline trends of mobile phone data (September 2019) with two weeks in the lockdown (March 2020) and post lockdown (September 2020), the paper highlights the variability of presences at different hours of the day, contributing to profiling the municipalities based on their propensity to be 'stable', 'attractors' or 'generators' of daily presences. By combining mobile phone and socio-spatial data, differentiated trends emerge, and are linked to the intrinsic features of the study area (orography, accessibility, provision of services), supporting the idea that an increase in human presence is often a temporary trend unable to trigger new economies, especially for the most marginal municipalities. Moreover, providing a picture of the changes that have occurred in these marginal areas, the outcomes have shown the great potentiality of mobile phone data, along with some limits which may prejudice their usability, particularly for territorial research in low-density areas.

In the conclusion, 'Mobile phone data: Challenges for spatial research', two perspectives emerge from the experimentation carried out in the three different contexts: on one hand, the relevance of dealing with the features of mobile phone data as a condition for understanding its uses, potentials and limits is considered. On the other, their potentialities as well as their limits are addressed. These data are not always representative of the population of a territory, and above all, interpretative models are needed to guide their use, in combination with the integration with other data sources. These contributions to the Special Issue have addressed specific issues, such as the epistemological value of big data and its necessary interactions with other forms of knowledge, as confirmed by a well-known academic debate (Batty, 2013; Graham & Shelton, 2013; Kitchin, 2014, 2021; Kwan, 2016; Poorthuis & Zook, 2017; Rabari & Storper, 2015; Schwanen, 2015).

## References

- Ahas, R., Mark, U. (2005). Location based services: new challenges for planning and public administrations? *Futures* 37, 547–561. <https://doi.org/10.1016/j.futures.2004.10.012>
- Ahas, R., Aasa, A., Silm, S., Tiru, M. (2010). Daily rhythms of suburban commuters' movements in the Tallinn metropolitan area: Case study with mobile positioning data. *Transportation Research Part C: Emerging Technologies*, 18(1), 45–54. <https://doi.org/10.1016/j.trc.2009.04.011>
- Batini, C. (2018) Datacy, perché una scienza per studiare l'impatto dei dati sulla società in "Agenda Digitale". Retrieved from: <https://agendadigitale.eu/cittadinanza-digitale/datacy-percheuna-scienza-per-studiare-limpatto-dei-dati-sulla-societa/>.
- Batty, M. (2013). Big data, smart cities and city planning. *Dialogues in Human Geography* 3 (3), 274–279. <https://doi.org/10.1177/2043820613513390>
- Carpentieri, G., Guida, C., Fevola, O., & Sgambati, S. (2020). The Covid-19 pandemic from the elderly perspective in urban areas: An evaluation of urban green areas in 10 European capitals. *TeMA-Journal of Land Use, Mobility and Environment*, 13 (3), 389–408. <https://doi.org/10.6092/1970-9870/7007>

- Concilio G., Pucci P. (2021). The Data Shake: An Opportunity for Experiment-Driven Policy Making. In: Concilio G., Pucci P., Raes L., Mareels G. (eds) *The Data Shake*. SpringerBriefs in Applied Sciences and Technology. Springer, Cham. [https://doi.org/10.1007/978-3-030-63693-7\\_1](https://doi.org/10.1007/978-3-030-63693-7_1)
- Graham, M., & Shelton, T. (2013). Geography and the future of big data, big data and the future of geography. *Dialogues in Human Geography* 3 (3), 255-261. <https://doi.org/10.1177/204382061351312>
- Einav, L., Levin, J. D. (2013). *The Data Revolution and Economic Analysis (NBER Working Paper Series No. 19035)*. Cambridge.
- Halevy, A., Rajaraman, A., & Ordille, J. (2006) Data Integration: The Teenage Years. *Proceedings of the 32nd International Conference on Very Large Data Bases (VLDB '06)*, 9-16.
- Jarv, O., Ahas, R., Witlox, F. (2014). Understanding monthly variability in human activity spaces: a twelve-month study using mobile phone call detail records. *Transportation Research Part C* 38, 122-135. <http://dx.doi.org/10.1016/j.trc.2013.11.003>
- Kitchin, R. (2014). The real-time city? Big data and smart urbanism. *GeoJournal* 79, 1-14. <https://doi.org/10.1007/s10708-013-9516-8>
- Kitchin, R. (2021). *The Data Revolution: A critical analysis of big data, open data and data infrastructures*. Sage.
- Kitchin, R., & Lauriault, T. P. (2018). Toward critical data studies. *Thinking big data in geography*, 320.
- Kwan, M. P. (2016). Algorithmic geographies: Big data, algorithmic uncertainty, and the production of geographic knowledge. *Annals of the American Association of Geographers* 106 (2), 274-282. <http://dx.doi.org/10.1080/00045608.2015.1117937>
- Kwan, M.P., Dijst, M., Schwanen, T. (2007). The interaction between ICT and human activity-travel behaviour. *Transp Res Part A: Policy Pract* 41 (2), 121–124. <http://linkinghub.elsevier.com/retrieve/pii/S0965856406000255>.
- Mediobanca (2022). Le maggiori telco mondiali (2017-2021). Retrieved from: <https://www.areastudimediobanca.com>
- Noulas, A., Scellato, S., Lambiotte, R., Pontil, M., Mascolo, C. (2012). A Tale of Many Cities: Universal Patterns in Human Urban Mobility. *PLoS ONE*, 7(5), e37027. <https://doi.org/10.1371/journal.pone.0037027>
- Papa, R., Gargiulo, C., & Battarra, R. (2016). *Città Metropolitane e Smart Governance: Iniziative di successo e nodi critici verso la Smart City* (Vol. 1). FedOA-Federico II University Press. <https://doi.org/10.6093/978-88-6887-005-8>
- Poorthuis, A., & Zook, M. (2017). Making big data small: strategies to expand urban and geographical research using social media. *Journal of Urban Technology* 24 (4), 115-135. <https://doi.org/10.1080/10630732.2017.1335153>
- Pucci, P., Manfredini, F., Tagliolato, P. (2015). *Mapping urban practices through mobile phone data*. Berlin: Springer. ISBN: 978-3-319-14833-5. <https://doi.org/10.1007/978-3-319-14833-5>
- Rabari, C., and Storper, M. (2015). The digital skin of cities: urban theory and research in the age of the sensed and metered city, ubiquitous computing and big data. *Cambridge Journal of Regions, Economy and Society* 8 (1), 27–42. <https://doi.org/10.1093/cjres/rsu021>
- Ratti, C., Frenchman, D., Pulselli, R. M., Williams, S. (2006). Mobile Land-scapes: Using Location Data from Cell Phones for Urban Analysis. *Environment and Planning B: Planning and Design* 33 (5), 727–748. <https://doi.org/10.1068/b32047>
- Reades, J., Calabrese, F., Sevtsuk, A., Ratti, C. (2007). Cellular Census: Explorations in Urban Data Collection. *IEEE Pervasive Computing* 6 (3), 30–38. <https://doi.org/10.1109/MPRV.2007.53>
- Shoval, N., & Ahas, R. (2016). The use of tracking technologies in tourism research: the first decade. *Tourism Geographies*, 18 (5), 587–606. <https://doi.org/10.1080/14616688.2016.1214977>
- Shoval, N., Kwan, M.-P., Reinau, K. H., & Harder, H. (2014). The shoemaker's son always goes barefoot: Implementations of GPS and other tracking technologies for geographic research. *Geoforum*, 51, 1–5. <https://doi.org/10.1016/j.geoforum.2013.09.0>
- Schwanen, T. (2015). Beyond instrument: Smartphone app and sustainable mobility. *European Journal of Transport and Infrastructure Research*, 15(4), 675–690.
- Sevtsuk, A., Ratti, C. (2010). Does Urban Mobility Have a Daily Routine? Learning from the Aggregate Data of Mobile Networks. *Journal of Urban Technology* 17 (1), 41–60. <https://doi.org/10.1080/10630731003597322>
- Soto, V., Frías-Martínez, E. (2011). Automated land use identification using cell-phone records. *Proceedings of the 3rd ACM international workshop on MobiArch*. <https://doi.org/10.1145/2000172.2000179>
- Srinivasan, K. K., & Raghavender, P. N. (2006). Impact of mobile phones on travel: Empirical analysis of activity chaining, ridesharing, and virtual shopping. *Transportation Research Record*, 1977 (1), 258-267. <https://doi.org/10.1177/0361198106197700130>
- Steenbruggen, J., Borzacchiello, M. T., Nijkamp, P., & Scholten, H. (2013). Mobile phone data from GSM networks for traffic parameter and urban spatial pattern assessment: a review of applications and opportunities. *GeoJournal* 78 (2), 223-243. <https://doi.org/10.1007/s10708-011-9413-y>
- Yip, N. M., Forrest, R., & Xian, S. (2016). Exploring segregation and mobilities: Application of an activity tracking app on mobile phone. *Cities*, 59, 156–163. <https://doi.org/10.1016/j.cities.2016.02.003>
- Wang, Y., Li, J., Zhao, X., Feng, G., & Luo, X. R. (2020). Using mobile phone data for emergency management: a systematic literature review. *Information Systems Frontiers*, 1-21. <https://doi.org/10.1007/s10796-020-10057-w>