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Investigating the role of High Speed Rail in shaping metro-regions

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Investigating the role of High Speed Rail in shaping metro-regions

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Abstract

High Speed Rail systems have revolutionized users' life style together with their mobility behavior thanks to their power of shrinking spaces and shaping places. Indeed these systems are trying to solve the unbearable problem of urbanization, since metropolitan areas are now merging to form vast *megaregions*.

This contribution is based on the recognition that commuting flows are not enough to justify the formation of a megacity or a megaregion. Even if they can contribute to it, they don't justify the development of a *megapolis*.

A theoretical model is here proposed with the objective of explaining the mechanisms through which metro areas integrate into mega-regions and to understand what is the real role of High Speed Rail systems. This manuscript attempts to fill this gap, present in the literature, and identifies some European corridors having high potential for mega-region formation as supported by High Speed Rail.

Further perspectives should consider that this construct should be tested and synthesized in mathematical terms and then calibrated with the collection of real data.

Key words: *Megaregions, urbanization, High Speed Rail, commuting flows*

1. Introduction

Nowadays all over the world metropolitan areas are merging to form megaregions, stretching hundreds of kilometres across countries. According to a report by the United Nations, the *endless city* could be one of the most significant developments in the way people live and economies grow in the next 50 years (Ross, 2011).

In the literature many definitions are proposed (Urena et al., 2009; Pagliara et al., 2011). For example, Hall (2009) defines a mega city region as a “*series of cities physically separated but functionally networked clustered around one or more larger central cities and are connected with dense flows of people and information using important transport infrastructures*”.

But is the phenomenon lying behind? Cities are pushing beyond their limits and are merging into new conurbations called as megaregions, which are linked physically and economically. Their expansion fosters economic growth but also leads to urban sprawl, rising inequalities and urban unrest.

There are numerous large and wide cities all around the world. At the present time the urban population is estimated to around 3.5 billion of inhabitants and will probably be more than 5 billion by 2030.

The term “mega-cities” has been defined for metropolitan agglomerations concentrating more than 10 million of inhabitants (Kotter and Friesecke, 2008). In the report by Euramet (2013), megacities are considered as the 40 most populated cities, and they formed an association “C40” to propose some common projects, in order to share innovative solutions for a sustainable development. These 40 megacities represent a population of around 300 million of residents, generate 18 % of global GDP and 10 % of global carbon emissions. Some definitions of megacities also add the component or criteria of population density.

Many countries of the world are investing in High Speed Rail (HSR) systems which have many advantages compared to other alternative transport modes, since they represent an optimal solution to meet challenges of increasing mobility demand while simultaneously addressing the greater attention of citizens to sustainability issues. HSR offers performance, safety, service, high energy efficiency and environmental friendliness (Pagliara *et al.* 2011).

In this paper, the authors argue that HSR systems have, in some cases, the potential to induce megaregion formation and thereby promote economic development at a large scale. A theoretical model is here proposed with the aim of showing this impact.

This paper is organised as follows. Section 2 concerns the role of High Speed Rail in shrinking space. In section 3 the theoretical model is proposed; while section 4 reports some possible corridors where this methodology can be applied. Conclusions and further perspectives are reported in section 4.

2. High-Speed Rail: Shrinking Space, Shaping places

HSR can change the geography of a country, bringing regions and cities closer to each other by increasing accessibility. These benefits in turn can be the basis for promoting economic development, justifying the higher costs of HSR investments. According to Givoni and Banister (2013) two are the factors central to the planning of HSR lines: *"the first relates to the numbers and locations of stations on the HSR network, and the second to how these stations are integrated into the rest of the transport network"*.

The paper by Perl and Goetz (2015) identifies three models of HSR development: (1) exclusive corridors (e.g. Japan), (2) hybrid networks-both national (e.g. France and Germany) and international (e.g. European Union), and (3) comprehensive national networks (e.g. China and Spain).

In its original model, HSR systems were conceived to serve corridors of 480-560km connecting two megacities. The second model of HSR was introduced as a *"hybrid system that blended high speed travel across new dedicated trunk line infrastructure together with operation at conventional speeds along interconnected branch lines shared with regular trains"*. This hybrid strategy multiplied the number of origins and destinations that could be served by HSR. The third model of HSR linked major cities and mid-sized communities across countries such as China and Spain. In China, a four east-west and four north-south HSR lines connect many large cities, covering routes up to 1600 km long.

The paper by Ureña *et al.* (2009) proposes big intermediate cities along HSR lines, and examines HSR's capacity to change time distances and accessibility.

Indeed the role of HSR in promoting new opportunities for Cordoba and Zaragoza in Spain and Lille in France is highlighted. The introduction of regional HSR services transforms the connections and the time distances from some of the small cities to the metropolitan areas and to the big intermediate cities. HSR has the power to change balance and hierarchy of the established city system, by improving the regional centrality of big intermediate cities w.r.t given smaller regional cities. It can also diminishes it in relation to other smaller cities in favour of the metropolises, by fostering polarisation towards the metropolises alone.

Very interesting is the contribution by Verma *et al.* (2013), for the case study of India. Due to the trends of urbanization and motorization in India, an urgent need is present for integration, revitalization and renewal of the smaller towns and cities to make urban areas in India more sustainable. Indeed the urbanization process in India is unsustainable. Local government asserts that a solution can be found in providing opportunities for medium and smaller size cities through their integrations and it argued that HSR can play a significant role in achieving this. *"A more balanced and sustainable development of towns and cities, opening up opportunities for growth across a wider, interconnected, region, with the benefit of taking the pressure of the larger cities to absorb additional burgeoning populations"*.

The paper by (Zhenga and Kahn, 2013) supports the claim that China's bullet trains are playing a significant role in China facing the question of growing megacities suffering from different problems. Indeed high levels of traffic congestion, pollution, they are degrading the quality of life. Transportation technology, allowing individuals to access the megacity without living within its boundaries, provides large benefits, since people can enjoy the advantages of urban agglomeration, without paying megacity real estate rents and city's social costs.

Indeed since 2007, China has introduced bullet trains, which connect megacities such as Beijing, Shanghai, and Guangzhou with nearby cities. Through facilitating market integration, bullet trains can stimulate the development of second and third-tier cities and they can help protecting the quality of life of the growing urban population.

Another contribution on China (Yang *et al.*, 2011) presents the trends in mobility in China's three megaregions, i.e. the Capital Economic Zone, the Yangtze River Delta and the Pearl River Delta- and how megaregional development has led to solutions to the challenges of mobility.

This experience has been compared with trends in megaregions in USA and in Europe. This comparison has confirmed that China's investments into rail, and particularly HSR, has provided a better chance to reduce congestion and pollution.

The paper by Ross (2011), for the case study of the USA, suggests that HSR is an attractive transport alternative to consider in providing greater connectivity between and within megaregions. The latter *"offer an appropriate spatial scale for US rail planning"*.

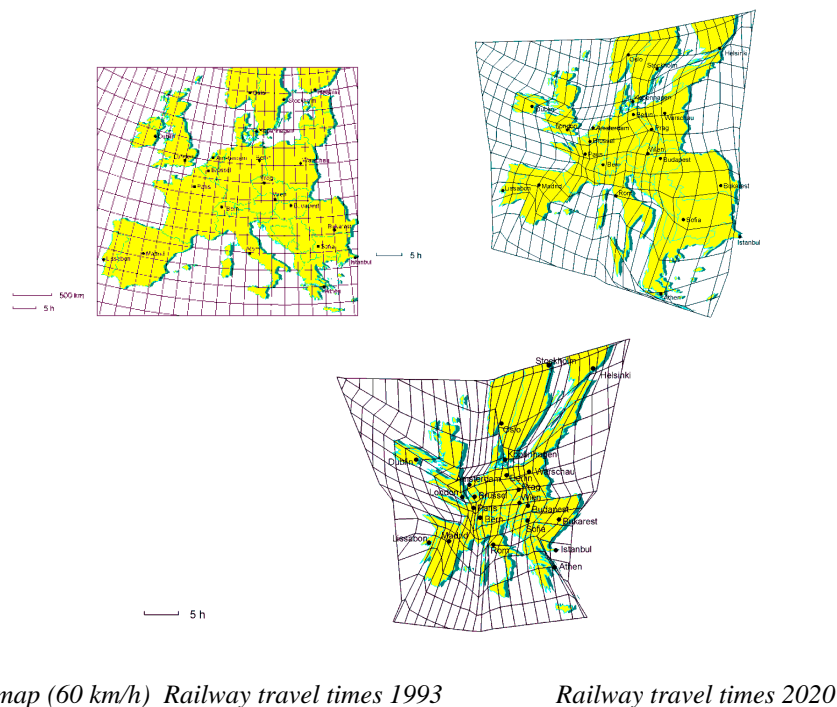
For the United Nations urbanisation is now becoming unbearable and therefore new challenges are requested to transportation systems. *"The role of technology, the demands for more sustainable mobility systems, the demand for clean energy sources more friendly to the environment, emerging megaregions and markets all suggest a need for new, improved and*

more efficient mobility systems". A number of states and regions and the federal government have promoted the development of a national HSR system in the United States. These projects foster the competitiveness of the megaregions in which they are placed (Ross, 2011).

3. The theoretical model

3.1 Time-space maps

Modern transport technologies are able to reduce the time to overcome space; measured in units of time. Time-space maps represent the interaction between space and time cartographically. In time-space maps the distance between two points is not proportional to their physical distance (as in physical maps) but proportional to the travel time between them. This change of map scale leads to distortions of the map compared with "familiar" physical maps. In Fig. 1 three maps show the "shrinking" of space due to the improvement of the European railway network between 1993 and 2020 compared with the base map with constant speed of 60 km/h (http://www.spiekermann-wegener.com/mod/time/time_e.htm).



Source: www.spiekermann-wegener.com/mod/time/time_e.htm

Figure 1 - European railway network between 1993 and 2020 compared with the base map with constant speed of 60 km/h.

The concept of time-space convergence was introduced to show that larger cities benefited more than smaller cities from the contraction of time-space by faster transport means (Janelle 1968; Janelle and Gillespie, 2004). For Janelle (1968) the modernisation of transport systems is seen as a factor of concentration in urban agglomerations and he demonstrated that the increase in speed deliver stronger effect on time-space contraction on long distances than on short distance (L'Hostis, 2009). The evolution of the system of speeds gives an advantage to the larger cities over smaller ones a conclusion which is in line with the literature on metropolisation.

In the paper by L'Hostis (2009) it is clearly stated that "*understanding distances between places is a fundamental task for the geographer, while the representation of distances constitutes one of the major functions of cartography*". A literature review is proposed as well to the readers concerning the different maps able to represent time-space. Among these, the anamorphoses were supplemented, constituting a innovation and giving the chance to build a representation of global time-space. The metaphors associated with the images proposed are then discussed evoking the shrinking, the crumpling and the shriveling of time-space. The shriveling metaphor takes into account the contraction/dilatation movement that high speeds provoke on space.

3.2 The model proposed

In this paper, a different approach is presented. Indeed a theoretical model is proposed with the aim of analyzing the impact of given variables on the formation of a megaregion. Regression models are powerful tools to be used for this objective. In this respect the dependent variable is the degree in which a series of cities belong to a megaregion. Normally commuting flows are used to measure the relations between different cities, in order to investigate if they could be grouped within a certain regions. We believe, that although important, commuting flows present a very narrow perspective and therefore should be complemented by other variables that measure economic integration, e.g. travel times, freight flows, other communication flows, to name a few. All of these variables should be merged into a single index with the help of data reduction techniques, like factor analysis. The independent variables are the result of several considerations, as discussed below.

In the paper by Kotter and Friesecke (2008), a system of urban indicators to monitor and steer the development of the megacities is proposed. Based on the main characteristics of megacities, the most important indicators are here integrated with the ones proposed by the authors (see Table 1).

Table 1 - Indicators for Megacities

Social indicators

- Population growth rate
- Population density
- Life expectancy rate
- Migration rate (migration from rural areas and immigration)
- At-risk-of-poverty rate
- Social polarization rate
- Inequality rate of income distribution
- Crime rate
- Dimension of housing shortages; ghettos, slums, squatters
- Unemployment rate
- Rate of people with unhealthy living conditions

Economic indicators

- Development of the local economy/economic structure
- Real GDP growth rate
- Unemployment rate
- Risk of economic loss in case of a disaster

Transport indicators

For Car, Plane, Train, HS Train, Bus:

- Travel time
- Travel cost
- Comfort
- Frequency of public transportation services
- Quality of the service;
- Accessibility indicators which could be built using a gravity approach (Chen and de Abreu e Silva, 2013)

Ecological indicators

- Air pollution from vehicle emissions, industry etc.; smog
- Groundwater and drinking water pollution
- Quality of sewage treatment
- Capacities of waste collection and disposal services
- Land sealing rate
- Suburbanization (urban sprawl) rate, which could be measured by density or other sprawl indicators characterizing other dimensions like fragmentation or dispersion
- Number and dimension of brown fields
- Destruction of original vegetation; deforestation; damage to flora, fauna, biodiversity per year
- Risks to natural disasters or industrial accidents

Source: Authors'elaboration adapeted from Kotter and Friesecke (2008)

4. The chosen corridors

The proposed model should be tested empirically against some existing HSR corridors. To undertake this task, at least one corridor should be chosen. The choice of the corridors to be analyzed has to balance issues related with both pertinence and data availability (considering both temporal and spatial dimensions), since a model like the one will be very data hungry.

Also, although there are relevant HSR related megaregions in Asia e.g. Tokyo-Osaka (Melibaeva et al., 2011), it would be relevant to focus more on European corridors, because of aspects related with data availability and deeper understanding of the contextual socio-economic climate.

Thus, 5 potential corridors emerge, Paris –Lyon in France, Frankfurt – Cologne in Germany, Madrid – Seville in Spain, Paris-Lille-Brussels between France and Belgium and London-Paris and London - Brussels between the UK, France and Belgian.

Paris – Lyon is the first European HSR line having started its operation in 1981, and it is considered as a success in terms of operational profits (Melibaeva et al., 2011). Cologne – Frankfurt opened in 2002 and Madrid-Seville which was considered also a success opened in 1992 (Shen et al., 2015). The other two corridors differ from these first three, because they all across national borders, nevertheless they are all located in Europe´s most densely populated areas. HSR was introduced in the Paris – Brussels railway connection in the end of 1997 and the Eurostar, linking London to Paris and Brussels started to operate at the end of 1994.

These corridors have all been operating long enough to allow enough observations and both they and the regions they serve have been the object of several studies and research published both in policy documents and scientific journals, providing an array of rich contextual data to complement transport, economic and demographic statistics. Finally, they represent different situations, ranging from highly dense and rich regions, to connections between the capital of a country and the second city, to cross border connections.

5. Conclusions and further perspectives

This work looked at High Speed Rail effects of shriveling of time-space and consequently to change mobility patterns and shaping regions. In particularly it looked at the potential effects of High Speed Rail in the emergence of megaregions. To study megaregions, the commonly used approach of using commuting flows as an indicator of economic integration is not enough and more and more detailed indicators are needed, covering dimensions that range from social

aspects, economic aspects, transportation and ecological aspects. This paper concludes with the identification of 5 corridors that could be used as empirical case studies to model the effects of HSR in the creation of Megaregions.

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