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Impact of the Madrid subway on population settlement and land use

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ABSTRACT

This paper studies the impact of the recent expansion of the subway system in Madrid (Spain). The population, land use and transit system evolution is described and relations between them are analyzed. It was found that residential developments and population growth in the vicinity of the new subway stations have been greater in the outer areas of Madrid than in the city center and Madrid's satellite towns. These effects have been even greater in the new suburbs that have sprung up simultaneously with the subway. Urbanization and population settlement is substantially more dynamic in areas affected by subway expansion than in similar areas elsewhere (whether or not they are served by urban rail). The impact of distance to the station can be seen in the areas around the new stations in the outer areas of Madrid and in the satellite towns, where population density diminishes as distance increases. This effect is more pronounced in the development of new urban areas spurred by new subway stations, where the speed and importance of the population settlement diminishes as distance increases. Therefore, these results demonstrate the benefits of an integrated land use and transit system planning.

Introduction

New urban developments tend to be accompanied by improvements on the transit system that encourages citizens to use their private vehicles less and promote sustainable mobility. Public transportation stations are also an additional incentive when looking for a location for residential areas and businesses. Therefore, the easier it is to access an area and the easier it is to travel to other parts of a territory, the more attractive a station will be. With this in mind, Madrid's subway system has considerably in recent years, from 121 km in 1995 to 293 km in 2010. In some cases, the subway system's expansion has been accompanied by important urban developments. Therefore, Madrid provides the perfect context for assessing the impact of subway on changes in land use and population settlement.

State of the art

A city's transit system is a subsystem that creates a demand for transportation and, at the same time, provides the resources (infrastructure and transportation services) to meet that demand (Cascetta, 2009). Overall, the grounds for transportation planning in the past have been market-based land use forecasts rather than land use plans as such. Typically, therefore, the transit system has expanded as an afterthought to meet the needs of urban developments that already existed (or that were in the process of being created), instead of responding to land use master plans (Giuliano, 1999).

However, it is worth bearing in mind that the place where population and employment are located use to be related to the transportation available. Changes in accessibility are likely to have an impact on the potential development of the study area by attracting population and businesses. Such factors should be taken into consideration during the planning process (Ortúzar and Willumsen, 2001). According to Pagliara and Papa (2010), implementing a rail system for public transportation in a city can have an impact on the population in several different ways:

- In San Francisco Bay area, the population diminished in the area served by a new rail service and grew in areas that were not served by the metropolitan railway. The contrary effect occurred only in the city of San Francisco, where the population grew around the new rail service and diminished in the neighbourhoods not served by the new metropolitan railway.
- In New York, the metropolitan railway saw a sharp rise in population growth around the stations located at the ends of the lines, compared to the stations in the city center.
- Washington also saw the population grow 10% at the end of the lines stations, as opposed to stagnation of the population in the city center.
- In Naples, the positive impact around new stations occurred only in a few cases.

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Du and Mulley (2007) also point out how experience shows that urban rail can play a key role in the ability to attract population and businesses to certain areas of a city by increasing their accessibility. Obviously, such effects do not depend on the transit system alone. Other aspects of a city are also decisive factors: the evolution of the real estate market and availability of building land, the emergence of new forms of urbanization; changes in vehicle fleets, urban decay in city centers and connections of the new line with the city center, for instance. In addition to enhanced accessibility, the rise in value of properties (residences, offices and shops) located in the zone of influence of a new mode of transportation is another factor that influences the establishment of the population around new public transportation lines.

There are a number of ways to measure the accessibility of a public transportation station, depending on the conceptualization and aims of the analysis (Pirie, 1979; Koening, 1980; Jones, 1981; Reggiani, 1998). One simple indicator is what it is known as accumulated opportunities, which consists in considering the population or number of businesses within a certain distance or time limit. When the indicator was used by Gutiérrez et al. (2000) to study the expansion of the Madrid subway in 1995–1999, the result was that the population had increased more in a radius of 0–300 m than in the ring 300–600 m. This indicates the population's tendency to concentrate in the area closest to the new public transportation stations.

According to studies conducted in the United States, a new metropolitan rail can raise the value of property up to 25% (Cervero and Duncan, 2002). Again in the United States, Hess (2007) demonstrated that the value of a house located near a station can increase 5%, compared to the average value in the rest of the city. In London, there has been evidence (Du and Mulley, 2007) that the value of properties served by the new London Victoria Line has been raised 5% compared to areas not served by the line. In other cities, such as Strasbourg, Lille and cities in The Netherlands, the increase in property values in relation to the establishment of a new guided public transportation line was estimated at 10%, 10% and 32%, respectively. In any case, it should be pointed out that the impact can vary considerably when observing separately station by station, as Pagliara and Papa (2010) highlight for the case of Naples. With regards to Madrid, studies (Mejía-Dorantes et al., 2011) have shown that closeness to the new Metrosur line had a positive impact on real estate sales and that the value of properties decreased as their distance from public rail transportation stations increased.

To summarize, the above-mentioned studies show that the effects of attracting population and increasing property values diminishes as the distance from a station grows.

Scope of the study

The scope of this study is Madrid and its metropolitan area, which comprises 28 towns.

Zoning

The benchmark used is the official zoning plan used by the Madrid Region to manage the city's territory. This zoning partitions the Madrid Region into four concentric divisions (Fig. 1): the first two (called Madrid city center and Madrid outer areas) make up the municipality of Madrid, the third comprises the Madrid surrounding cities, and the fourth is the rest of the Madrid Region. Thus, the Madrid metropolitan area includes Madrid's city center, Madrid's outer areas and the surrounding cities. Moreover, each city is divided into districts (Departamento de Geografía Humana de la U.C.M., 2002).

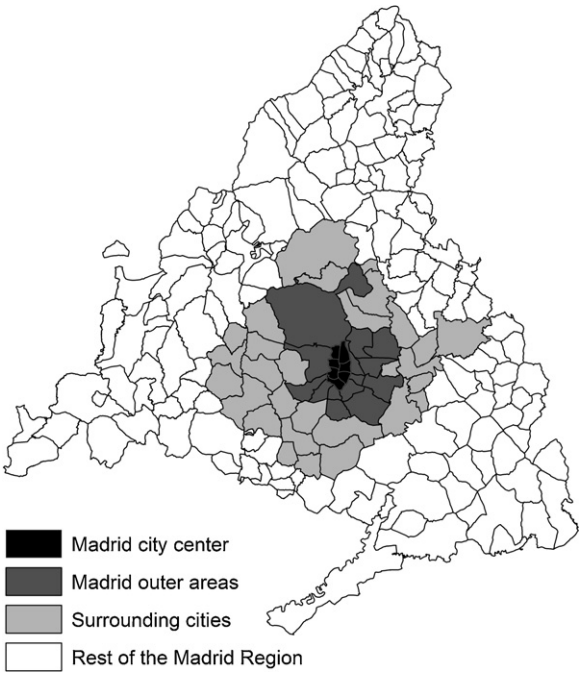

Fig. 1. Region of Madrid. Zoning of the scope of study.

Population

The Madrid metropolitan area is the most populated metropolitan area in Spain (3.3 million residents in the municipality of Madrid and 2.3 in the surrounding cities) and the third most populated metropolitan area in the European Union. From 2000 to 2010, the population in Madrid city center increased by an annual 0.9% (9.7% in all). Population growth was higher in Madrid's outer areas (15.4%) and much higher in the surrounding cities (27.3%) (Instituto de Estadística de la Comunidad de Madrid, 2011a). This is due to many factors, with the main one being that Madrid city center is a consolidated historical area, surrounded by areas with a higher growth potential and lower land prices. This, combined with the transit system expansion, causes differential growth.

Mobility

The number of daily trips in the Madrid's metropolitan area increased by more than four million from 1996 to 2004, with commuting to work being the main travel reason, followed by studies (García and Gutiérrez, 2007).

With regards to modal distribution, public transportation is the most used mode in the city of Madrid. In 2004 public transportation captured 43% of the demand, while private vehicles captured 28% and travel by foot came to 29%. This modal distribution has remained relatively stable since 1996. Therefore, considering that the average growth of motorized travel in the city of Madrid during the period concerned was an annual 4.2% (Mesa de Movilidad, 2006), it is evident that public transportation has captured a large number of trips, thereby contributing to the sustainability of the transportation system.

Fig. 2 shows the distribution of travel between public transportation and private transportation, taking into consideration the Madrid's metropolitan area and considering only motorized travel. It can be seen how the percentage of travel in public transportation diminishes as it moves away from Madrid city center. On the other hand, according to the Mesa de Movilidad (2006), the highest average growth in motorized travel occurred in the surrounding cities (7.1% annually). These results show how motorized mobility has