Journal of Transport Geography 19 (2011) 200–211

Contents lists available at ScienceDirect

Journal of Transport Geography

journal homepage: www.elsevier.com/locate/jtrangeo

Urban rail systems investments: an analysis of the impacts on property values and residents' location

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ARTICLE INFO

Keywords:
Urban rail systems
Residents' location
Property value change

ABSTRACT

Light rail, metro and other urban rail transit systems can play a significant role in improving the attractiveness and quality of urban public transport. They can influence the attractiveness of locations near the stations and improve accessibility for these locations. Furthermore urban rail can improve a location's attractiveness by its image effect: it makes a station appear modern and dynamic, and thus raises the status of this location.

This paper summarises findings on the land-use and economic impacts of the urban rail system of the city of Naples over time and space. It examines changes in residential and non-residential (offices and retail) property prices around the newly built stations between 2001 and 2008 as well as the changes in the number of residents for the same station catchment areas. Ad hoc station control areas have been specified in order to compare the results of these changes. Results show that values in station control areas are lower than those of those of the stations catchment areas.

1. Introduction

Interaction phenomena between rail infrastructure and urban systems have been studied extensively using different approaches in both transport and urban studies disciplines, with the aim of defining theories and analysis methods in order to understand transport/land use system behaviour (Nijkamp and Blaas, 1994; Burmeister and Joignaux, 1998; Waddell, 2001). From a strictly transport definition, the transport system is an urban sub-system whose components generate transport demand between origins and destinations, and a supply system is conceived to satisfy this demand (Cascetta, 2009). Transportation planning has tended to be based on standard future land use patterns that are usually derived from market projections rather than a land use plan. Transport systems therefore generally tend to reinforce past development trends rather than respond to urban plan directions (Giuliano, 1999). Meanwhile, land use planners have typically taken into account the transport plan regardless of the decision process, with only mere acceptance of the proposed transport interventions rather than endeavour to coordinate the transport plan with future land use (Kaiser et al., 1995). In fact, the urban plan defines the densities and the location of activities without considering the future impacts of these choices on the transport system.

Both transport and urban planning disciplines uncover the need for a new holistic approach based on complex theory and support of a transport/land use system integration. In practice, approaches and methods have been developed to define strategies for a more coordinated and cooperative planning process between urban and transport policies (Cervero, 1998).

In order to support an integrated urban-transport planning decision process it is essential to examine the impacts of the introduction of a new transport infrastructure on the urban system. Experience of urban rail transit shows that it can play a significant role in increasing the quality and the attractiveness of urban areas, through value capturing phenomenon (Du and Mulley, 2007).

This paper considers how the introduction of new rail transit lines can lead to property value changes and reallocations of residents, taking into consideration the Naples Municipality as a case study. Using GIS techniques and time series data, land-use and economic impacts have been analysed in 16 stations areas of the urban rail system, opened between 2001 and 2008.

The rest of the paper is organised as follows. Section 2 outlines evidence from empirical studies of the land-use and economic impacts of urban rail investments. Section 3 describes Naples as a study case. Section 4 summarises the findings and highlights some further perspectives.

2. Impacts of rail transit on residents' reallocation and property values: results from empirical studies

Empirical studies on transit and land use system interactions have focussed mainly on measuring and interpreting transit

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doi:10.1016/j.jtrangeo.2010.02.006

impacts on urban features, including an analysis of different impact types and the use of various interpretative methods (Rietveld, 1994; Debrezion et al., 2004a,b; RICS, 2002; Vessalli, 1996). These impacts can be classified into land-use, economic, social, and environmental, but most of the empirical researches focus on land-use and economic effects. Most studies have been carried out in the US, where data quality and availability allows for the application of more sophisticated analysis methods, such as correlation analysis or hedonic price models (Haider and Miller, 2000). In Europe quantitative methods have only been applied relatively recently (Transplus, 2002; Transecon, 2003).

Rail transit system land-use impacts involve urban physical transformations such as land development or renewal interventions in the urban system (Newmann and Kenworthy, 1999; Cervero, 1997) and activity pattern changes, such as residents and jobs reallocation (Landis et al., 1995; Kim et al., 2004; Transecon, 2003). Most of the studies reviewed found some level of land use change resulting from transit improvements and an activity clustering effect close to urban rail stations. Since the Bay Area Rapid Transit (BART)'s 1973 opening, population has grown relatively faster away from BART than closer to BART (Cervero and Landis, 1997). Over the 1970–1990 period, population grew 35.2% in the 25 Bay Area superdistricts not served by BART compared to 17.1% in the 9 BART-served superdistricts. Only in San Francisco was the pattern different – population grew in the BART-served part of the city while the western half of the city lost some 4000 residents.

A similar behaviour is shown by the MTA New York City Transit where an increase of residents is registered in the peripheral stations' catchment areas. The same for the underground of Washington DC (Vinha, 2005) where an increase of residents equal to 10% is present in the more peripheral stations' catchment areas. In the case of Madrid (Transecon, 2003) a new transit line construction was accompanied by the shift of residents from the city centre to suburban areas.

On the other hand, property value studies show higher impact intensities than the land-use impact studies, but the results are even more variable. The economic transformations related to rail system evolution consist of microeconomic impacts, such as property and rent value changes for different land uses, and macroeconomic effects such as urban economic competition variation (Banister and Berechman, 2000), potential development increase, or economic viability of the central business districts (Arrington, 1995; Parson, 2001; Berechman and Paswell, 1983; APTA, 2002). A number of empirical studies show an increase in property values in the new station areas which is higher than the municipality average change value, as demonstrated in the Vienna and Athens case studies (Transecon, 2003; Golias, 2002; Roider and Klementschitz, 2002).

Studies in the US which have looked at the effect of new rail transit provision on house prices have generally found positive effects, showing significant statistical evidence of residential property price increases, of up to 25%, which have been attributed to the new rail transit provision (Cervero and Duncan, 2002). The study by Hess (2007) assesses the impact of proximity to light rail transit stations on residential property values in Buffalo, New York, where light rail has been in service for 20 years. Hedonic models are constructed of assessed value for residential properties within half a mile of 14 light rail stations. The model suggests that, for homes located in the study area, every foot closer to a light rail station increases average property values by $2.31 (using geographical straight-line distance) and $0.99 (using network distance). Consequently, a home located within one-quarter of a mile radius of a light rail station can earn a premium of $1300–3000, or 2–5% of the city's median home value.

In the UK, the increase in house prices in London as a result of new rail transit has been dramatic. Riley (2001), a south London property developer, estimated that land values around the stations of the Jubilee Line extension have increased by £13bn when the cost of the extension itself was only £3.5bn. These positive results were confirmed, in more modest terms, by a recent study on the impact of the London Jubilee Extension which found positive but variable results in residential property prices. A very early study about the impacts of London Victoria Line showed the value of properties in the catchment of the line increased between 1% and 5% as compared to properties outside the catchment areas (Du and Mulley, 2007).

Senior (2009) noted that Ovenall (2007) detected a positive price effect of Manchester's light rail Metrolink in 2004/2005 for houses located 0.5–1 km away from the Metrolink stations although initially in the mid 1990s Metrolink had no significant effect on house prices (Forrest et al., 1996).

How property values are affected by proximity to rail stations in various cities is in the following table reported (see Table 1).

3. The Naples case study

Campania region has about 5.7 million inhabitants within a 13,590 km^2 area and is the second largest region in Italy. It is divided into five administrative provinces and is characterised by a twofold distribution of population and activities. There is a very large central metropolitan area centred around Naples with 3.5 million inhabitants. Naples is a Large Urban Zone (LUZ), i.e. an area with a significant share of residents travelling to work within the city, with one of the highest residential densities of the whole of Europe (an average value of 2305 inh/km^2 and peaks of 13,323 of inh/km^2) (see Fig. 1).

During the second half of the last century, very limited investments were made to expand and/or upgrade the existing railway network. Furthermore, these efforts followed an un-coordinated process in which decisions were taken by individual transport companies, thereby limiting an integrated vision of the regional railway system. Moreover, expansion projects were not coordinated with land-use decisions; in fact, the latter were often made independently of, or even in open contrast with, the rail system (Cascetta and Pagliara, 2008). The new planning approach, started in 1996 in Naples and extended in 2001 to the whole region with the Regional Metro System (RMS) project, is based on the idea that only a highly integrated and extended railway system can provide sustainable mobility in an area with densities such as those of the central area of Campania.

Between 2001 and 2007 several interventions have been carried out on the urban rail network with the opening of new rail lines with the upgrading and opening of many stations both in central and peripheral areas of the city of Naples.

The focus of this paper is to analyse the land-use impacts, in terms of residents' location, and the economic impacts, in terms of property values change, due to the opening of new stations. The impacts of stations, renewed between 2001 and 2007, are not included in this analysis since the authors assume that the time period considered is too short for such an evaluation.

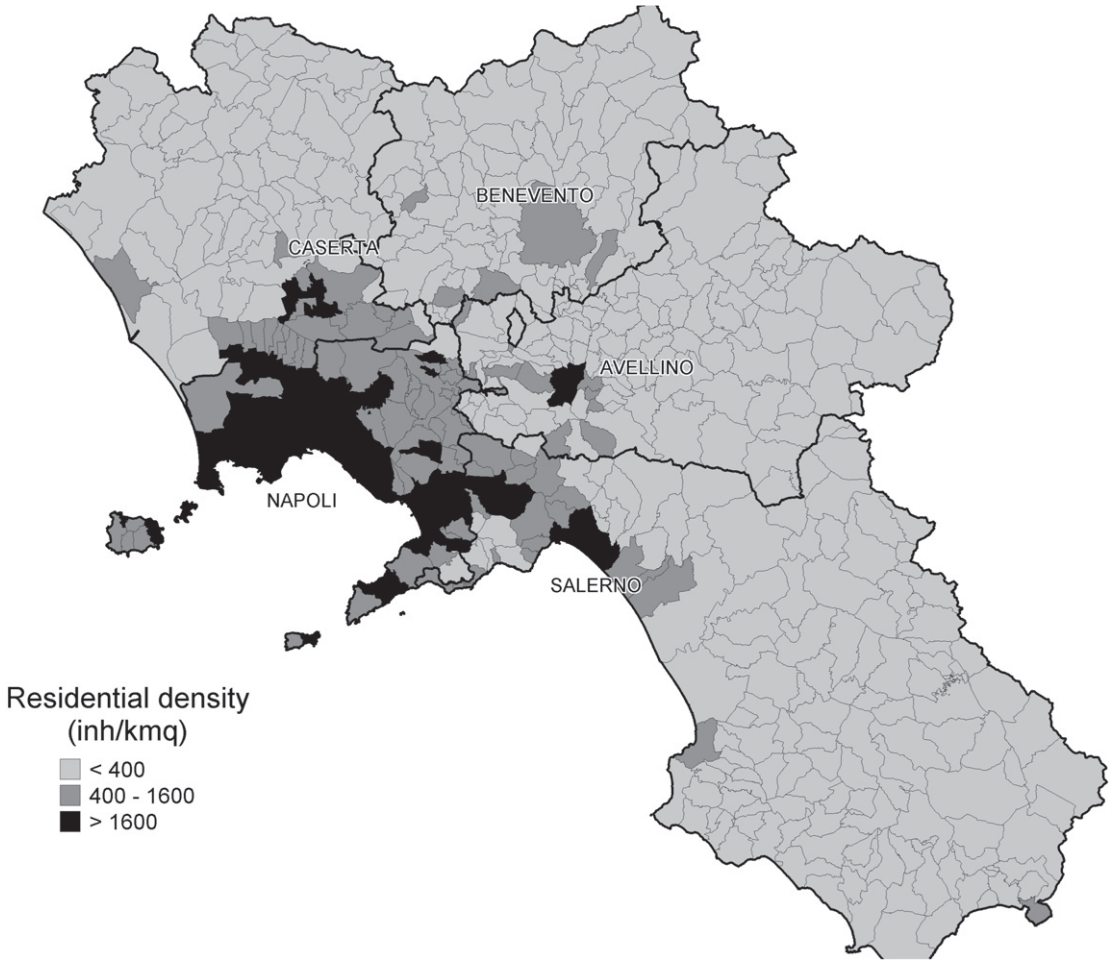
3.1. Methodology

Since the opening of new lines and stations has occurred in different years, this study considers two separate data sets one for the year 2001 when the extension of Line 1 (L1) was conceived and the other one for the year 2008, after the opening of Line 6 (L6).

Information on residents come from the Census (ISTAT, 2001), while data on property values have been collected from different sources (OMI, 2001, 2007; BIN, 2001; 2007). A comparison approach, previously used in the literature (Cervero and Landis,

Table 1
Property values impacts.

City (author, year of publication)	Rail system type	Property type analysed	Property values impacts
San Francisco Bay Area (Landis et al., 1995)	BART	Residential	Since 1990 a single-family property price has increased from 100$ to 200$ for every sqm far from BART stations
Dallas (Weinstein and Clower, 1999)	DART	Residential, Offices	For housing property values an increase of 32.1% has been registered; For offices the increase is of 24.7%
Buffalo (Lewis-Workman and Brod, 1997)	MTA	Residential	The average price decreases of 750$ for every 100 m far from the stations
Washington D.C. (FTA, 2000)	Underground	Commercial	Over 350 m far from station, property prices decline of 100$/m^2
United Kingdom	LRT	Residential and commercial	For housing property values an increase of 2.2% has been registered. For shops the increase is of 16.4%
Copenaghen (Naess, 2005).	Underground	Residential	A considerable increase has been registered
Strasbourg (LiRa, 2000)	Tram	Residential and commercial	An increase of 8.1–10% in central stations' areas while an increase of 5.2% in peripheral stations' areas have been registered
Lille (LIRA, 2000)	VAL	Offices	An increase of 10% has been registered in stations' areas
Netherlands (TI, 2006)	Underground	Residential	An increase of 32% has been registered in stations' areas



Provinces	*Inhabitants*	*Area (km sq)*	*Residential density (inh/km sq)*
Caserta	**852,872**	**2,639**	**323**
Benevento	**287,042**	**2,071**	**139**
Naples	**3,059,196**	**1,171**	**2,612**
Avellino	**429,178**	**2,792**	**154**
Salerno	**1,073,643**	**4,917**	**218**
Total Campania	**5,701,931**	**13,590**	**420**

Source: ISTAT 2001

Fig. 1. Campania region: residential densities.

1993; Davoudi et al., 1993; Du and Mulley, 2007), has been adopted in this study, i.e. changes in the catchment areas of a station are compared with changes in control areas.

The identification of different time frames may lead to different results of both land-use and property value changes. In this paper short and long term impacts of the interventions on the urban rail system have been considered assuming the time frames 2001–2005 and 2005–2008 respectively.

Sixteen catchment areas have been identified as areas within walking distance from the new station, where both land-use and economic impacts are expected from the introduction of a new rail line. There is evidence from the study on walking distances to and from light rail transit stations in the city of Calgary, Canada, that average walking distance to light rail stations is 326 m in the CBD area or 649 m in suburban areas. From this study, perception of walk time was found to vary over the walking environment of stations and 80 m/min was adopted to compare the calculated walking distances with the measured walking distances, which was an approximation to a normal distribution (O'Sullivan and Morrall, 1995). Nevertheless, according to RICS Policy Unit Report (RICS, 2002), the impact area for residential developments could extend to 1000 m from a station depending on the type of investment and the size of the urban area (Du and Mulley, 2007). In this study, areas of 500 m radius around the stations have been adopted as catchment areas (this would approximate to about a 7 min walk). Specifically catchment areas have been defined merging the census tracts that are within the radius of 500 m from the station exit.

In order to compare the changes in catchment areas, a set of control areas has been identified. The selection of control areas has been subject to two criteria. The first is that a control area should have similar characteristics to its paired catchment area. Second, the control area should not have benefited from other improvements or the presence of other metro stations.

For some stations that are located in a row or that have similar characteristics, one control area has been chosen for all of them. Thus, this study considers 16 catchment areas and eight control areas as shown in Fig. 2, while in Table 2 the location of each station and its urban and transportation characteristics are described.

Percentage changes (for different types of property) have been computed with GIS techniques as the average change of the values in census tracts belonging to station area (for residents change) or OMI zones (Osservatorio Mercato Immobiliare, Property Market Observatory) which fall within or coincide with the catchment areas (for property values change).

3.2. Results and analysis

In Table 3 the percentage changes in each catchment and control areas are reported. In general the property values are higher in catchment areas than in control areas.

Considering the time frame 2001–2005, the increase of property values in the station catchment areas is higher compared to that of the control areas for all types of property, while in the time frame 2005–2008 this is valid for houses and offices, but it seems that for shops the trend is different. In fact for shops, property values

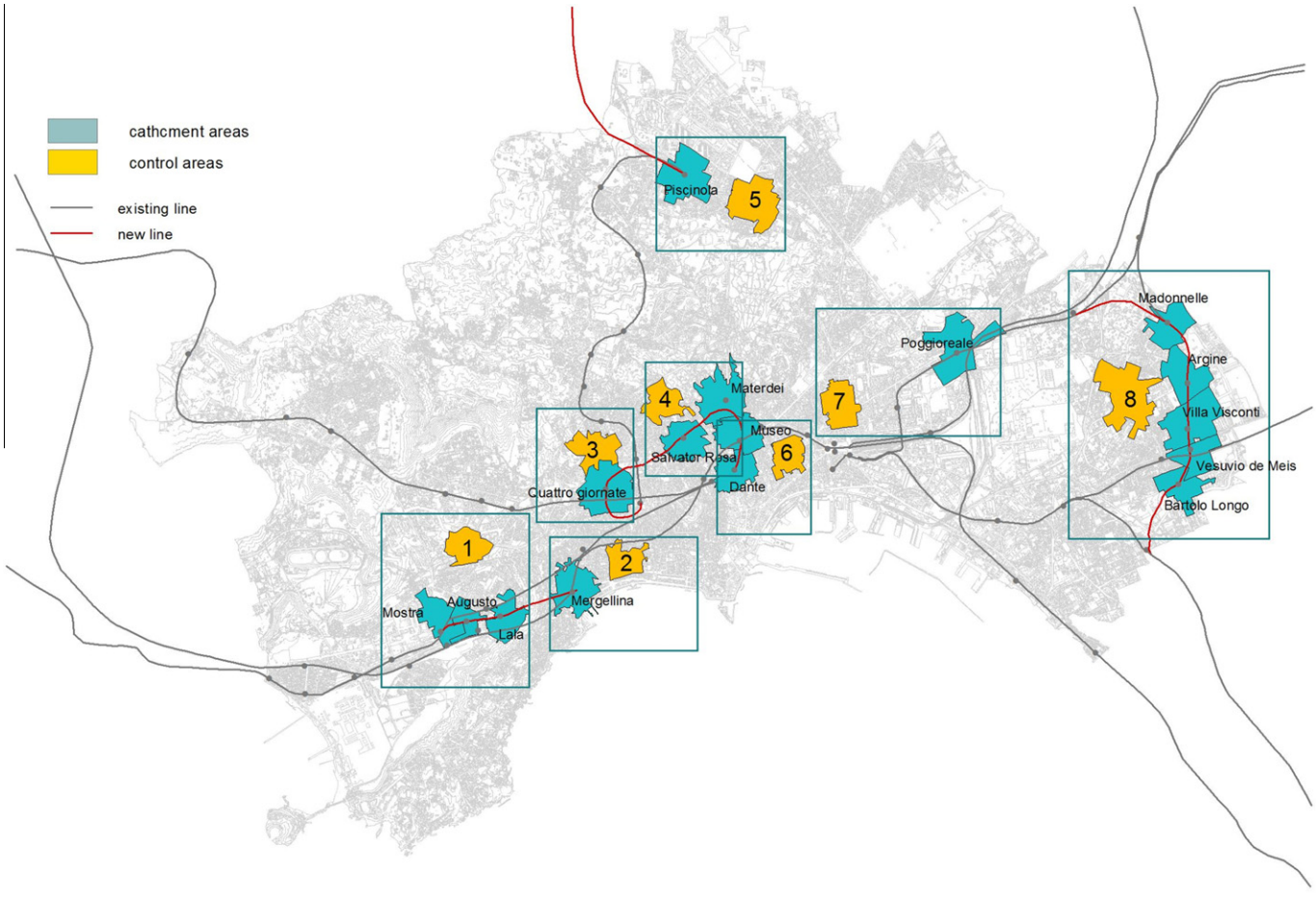


Fig. 2. Catchment and control areas considered in this study.

Table 2
Catchment and control areas used in this study.

Catchment area	Station location	Line	Opening year	Id control area	Control area	Urban and transport characteristics
Mostra	Semi-central	L6–L7	2007	1	Fuorigrotta	Semi-central residential areas in the western part of the Municipality with the presence of services (universities and the stadium). High accessibility to other urban, regional and national rail services in Mostra catchment area existing before 2007
Lala	Semi-central	L6	2007			
Augusto	Semi-central	L6	2007			
Mergellina	Central	L6–L2	2007	2	Mergellina	Central mixed use area, mainly residential with services as well. High accessibility to other urban, regional and national rail services, existing before 2007
Quattro Giornate	Central	L1	2001	3	Quattro Giornate	Central residential and commercial area. No metro accessibility before 2001
Materdei	Central	L1	2003	4	Materdei + Salvator Rosa	Central residential area. No metro accessibility before 2001
Salvator Rosa	Central	L1	2001			
Piscinola	Suburban	L1	2005	5	Piscinola	Suburban residential area. Good accessibility to the city centre before 2002
Dante	Central	L1	2002	6	Museo + Dante	Mixed use area (residential, commercial and services). Good accessibility before 2001
Museo	Central	L1-L2	2001			
Poggioreale	Suburban	L3	2003	7	Poggioreale	Suburban residential and industrial area
Argine	Suburban	L3	2002	8	East	Suburban residential area in the eastern part of the Naples municipality periphery. No accessibility before 2001
Bartolo Longo	Suburban	L3	2002			
Madonnelle	Suburban	L3	2002			
Vesuvio de Meis	Suburban	L3–L4	2001			
Villa Visconti	Suburban	L3	2002			

decrease considering the trend of the property market in the Municipality of Naples. Therefore the introduction of a new station has a positive impact on property values of all types (some exceptions are of course present). Specifically in the case of the increasing trend of property prices, their increase is higher in station catchment areas compared to those of control areas. In the case of a decreasing trend (this happens for shops in the time frame 2005–2008), the opening of a new station blocks the decrease of prices. In fact in control areas the decrease of property values is higher than in catchment areas.

Concerning the change in the number of residents, a general decrease within the Municipality of Naples is observed (Cascetta and Pagliara, 2008), and this happens in many European cities which are exploring gentrification phenomena. If on the one hand the opening of a metro line (both urban or suburban) has fostered this gentrification phenomenon making areas in the hinterland of Naples more accessible, on the other hand in the new station catchment areas under study the decrease in residents is lower compared to that of the control areas.

In order to compare results between catchment and control areas, property prices (Euro/m^2) have been normalised into a 0–100 numerical range, assuming the year 2001 = 100. Therefore property price indices have been defined for all property types (see Figs. 3-10 and Table 4).

In the following section a detailed analysis of each group of stations is carried out.

3.2.1. Stations of Line 6: control areas Fuorigrotta and Mergellina

Stations Mostra, Lala, Augusto and Mergellina have been opened recently in 2007, therefore considering the time frames chosen in this study, not many years have passed since they have become operational. This consideration can justify the small percentage changes which resulted in these areas, especially for the number of residents. Specifically, for Mostra, Lala and Augusto, located in a semi-central part of Naples, the average change of the number of residents is quite small both for the period 2001–2005 (0.03%) and 2005–2008 (0.02%), but it is higher compared to the decrease, although small, reported for the corresponding control area of Fuorigrotta (−2.85% for the period 2001–2005 and −1.90% for 2005–2008). Another important consideration to highlight is that this area already had good accessibility to other urban, regional and national rail services before 2007. In fact, the presence of Campi Flegrei station, an important rail node connecting Naples with Rome through InterCity trains and also a train stop on Line 2 of the urban rail network of Naples, can explain these small changes.

In the period 2001–2005, for all the station catchment areas and for all the property types, an increase can be observed which is higher than the corresponding values of the control area; 37.80% (27.81% for the control area) for housing property price; 31.06% (22.77% for the control area) for retail property price and 57.73% (48.13% for the control area) for office property price.

From the analysis of the percentage change of property prices between 2005 and 2008, it follows that there is an average increase in housing property price equal to 3% compared to a small decrease equal to −3.64% for the corresponding control area. In this borough of Naples, where there are many offices, percentage change in property prices has increased on average by 57.73%, which is higher compared to the corresponding value of the control area (48.13%) in the period 2005–2008. In the same period a general decrease in retail property prices occured in all the station catchment areas.

From the analysis of the housing property price index (see Fig. 3 and Table 4), it follows that in the period 2001–2005, before these stations were opened, Augusto station catchment area experiences a steeper positive slope ($\Delta H\_01–05 = 19$) than the trend for the

Table 3
Property values and residents changes in catchment and control areas.

		HP_0105 (%)	RP_0105 (%)	OP_0105 (%)	HP_0508 (%)	RP_0508 (%)	OP_0508 (%)	RES_0105 (%)	RES_0508 (%)
1									
Mostra	Catchment area	35.03	46.61	34.41	9.81	−6.42	34.41	−2.75	−1.84
Lala	Catchment area	50.57	35.00	74.22	2.88	−7.14	74.22	4.51	3.00
Augusto	Catchment area	27.81	11.58	64.57	−3.64	−7.59	64.57	−1.66	−1.10
Fuorigrotta	Control area	27.81	22.77	48.13	−3.64	−7.59	48.13	−2.85	−1.90
2									
Mergellina	Catchment area	7.67	35.53	34.56	5.52	−12.86	34.56	−2.72	−1.82
Mergellina	Control area	8.58	21.06	35.01	14.40	−20.79	35.01	−2.86	−1.90
3									
Quattro Giornate	Catchment area	14.23	5.26	38.46	15.54	−17.22	38.46	−2.26	−1.50
Quattro Giornate	Control area	18.75	2.62	41.36	6.52	−3.95	41.36	−2.84	−1.90
4									
Materdei	Catchment area	40.66	4.81	53.72	6.96	−4.17	53.72	−1.03	−0.68
Salvator rosa	Catchment area	18.75	2.62	41.36	6.52	−3.95	41.36	−2.25	−1.50
Materdei + Salvator Rosa	Control area	11.14	−9.35	13.98	17.81	−3.52	13.98	−2.87	−1.91
5									
Piscinola	Catchment area	17.03	13.64	40.37	25.52	−1.25	40.37	17.22	11.48
Piscinola	Control area	33.07	20.78	29.72	14.18	−11.75	29.72	2.18	1.46
6									
Dante	Catchment area	45.91	17.24	48.67	4.67	−14.86	48.67	−1.75	−1.17
Museo	Catchment area	38.27	35.97	75.60	12.00	0.00	75.60	2.49	1.66
Museo + Dante	Control area	52.52	25.00	76.24	10.55	0.00	76.24	−2.26	−1.50
7									
Poggioreale	Catchment area	6.17	−5.83	19.72	−12.16	26.55	19.72	−2.81	−1.87
Poggioreale	Control area	5.80	−2.92	18.03	0.75	15.45	18.03	−0.94	−0.63
8									
Argine	Catchment area	5.05	0.00	15.14	15.75	4.72	15.14	14.34	9.56
Bartolo longo	Catchment area	14.03	4.70	11.33	16.52	−12.93	11.33	2.44	1.62
Madonnelle	Catchment area	5.36	0.00	16.17	16.67	5.00	16.17	11.68	7.78
Vesuvio de meis	Catchment area	25.28	8.21	6.49	16.36	−25.29	6.49	−0.06	-0.04
Villa visconti	Catchment area	35.48	8.21	2.61	29.52	−19.54	2.61	−2.86	−1.90
East	Control area	19.99	5.98	8.42	20.60	−15.38	8.42	0.44	0.30

%HP_0105: housing property value change between 2001 and 2005.
%RP_0105: retail property value change between 2001 and 2005.
%OP_0105: office property value change between 2001 and 2005.
%HP_0508: housing property value change between 2005 and 2008.
%RP_0508: retail property value change between 2005 and 2008.
%OP_0508: office property value change between 2005 and 2008.
%RES_0105: residents change between 2001 and 2005.
%RES_0508: residents change between 2005 and 2008.

corresponding control area (ΔH_01–05 = 14), while for Mostra and Lala catchment areas the trend is lower or the same. Augusto station's effect can be explained as property prices increased before the station was opened, after the decision to build the new rail facilities was announced. In the period 2005–2008 the trend changes, in particular a decrease in the housing property price index can be observed for both Augusto's catchment (−2) and control (−1) areas. This can be explained by the fact that there was no real urban renewal intervention in the station area when Augusto station opened. In fact house prices, in the same period, show a percentage decrease equal to −3.64% for both catchment and control areas.

A different "behaviour" seems to follow Mostra and Lala stations where the metro effect was felt both before their opening (2001–2005, ΔH_01–05 = 10 and 14 for Mostra and Lala stations respectively), and 2005–2008 (ΔH_05–08 = 4 and 1 for Mostra and Lala stations respectively). This can be explained by the urban renewal interventions carried out in both stations' areas. The whole square surrounding Lala station has become a place where people meet.

As far as the retail property price index trend is concerned, in the period 2001–2005, it can be observed that Mostra and Lala's catchment areas have steeper positive slopes (ΔR_01–05 = 12; 10) than in the control area (ΔR_01–05 = 7), while for Augusto's catchment area the slope is less steep (ΔR_01–05 = 4) than that of the control area. In the period 2005–2008 the trend changes in all the stations' catchment areas as a decrease is observed everywhere including the control area. This follows the general trend in the Municipality of Naples.

For office property prices, Lala and Augusto catchment areas have steeper positive slopes (ΔO_01–05 = 19; 19) than in the corresponding control area (ΔO_01–05 = 14) in the period 2001–2005. From 2005 to 2008 the slope is always steeper (14, 19, 18 for Mostra, Lala and Augusto stations) than in the corresponding control area (13). This can be compared with the trend in the housing property price index.

Mergellina station opened in 2007 and is located in a very central part of the town with easy access to transport rail services before that year. The general decrease in the number of residents during the periods 2001–2005 (−2.72%) and 2005–2008 (−1.90%) is in any case smaller or the same as for the corresponding control area (−2.86% and −1.90%).

From 2001 to 2005, positive percentage changes for all property types can be observed. They are almost equal to the values in the control area, except for retail properties, which increased by 35.53%, which is much higher than for the control area (21.06%).

From 2005 to 2008, housing property prices increased by 5.52%, less than the 14.40% increase in the corresponding control area;

Table 4
Property price indices.

Stations	*H*_01	*H*_05	Δ*H*_01–05	*H*_08	Δ*H*_05–08	Δ*H*_01–08	*R*_01	*R*_05	Δ*R*_01–05	*R*_08	Δ*R*_05–08	Δ*R*_01–08	*O*_01	*O*_05	Δ*O*_01–05	*O*_08	Δ*O*_05–08	Δ*O*_01–08
Mostra catchment area	28	38	10	42	4	14	26	38	12	35	−3	9	29	39	10	43	4	14
Lala catchment area	28	42	14	43	1	15	30	40	10	37	−3	7	26	45	19	45	0	19
Augusto catchment area	37	47	19	45	−2	8	37	41	4	38	−3	1	30	49	19	48	−1	18
Fuorigrotta control area	33	42	14	41	−1	8	30	37	7	34	−3	4	30	44	14	43	−1	13
Mergellina catchment area	55	60	32	63	3	8	74	100	26	87	−13	13	44	60	16	72	12	28
Mergellina control area	50	54	26	62	8	12	77	94	17	74	−20	−3	41	55	14	68	13	27
Quattro Giornate catchment area	44	51	23	58	7	14	81	85	4	71	−14	−10	37	51	14	61	10	24
Quattro Giornate control area	44	53	25	56	3	12	81	83	2	80	−3	−1	37	52	15	59	7	22
Materdei catchment area	32	45	17	48	3	16	57	60	3	57	−3	0	30	45	15	50	5	20
Salvator Rosa catchment area	44	53	25	56	3	12	81	83	2	80	−3	−1	37	52	15	59	7	22
Materdei + Salvator Rosa control area	27	30	2	35	5	8	40	37	−3	35	−2	−5	26	30	4	36	6	10
Piscinola catchment area	18	21	−7	26	5	8	20	23	3	23	0	3	15	21	6	27	6	12
Piscinola control area	14	19	−9	22	3	8	19	23	4	20	−3	1	15	19	4	22	3	7
Dante catchment areas	31	45	17	47	2	16	49	58	9	49	−9	0	32	48	16	49	1	17
Museo catchment areas	26	36	8	40	4	14	33	45	12	45	0	12	22	39	17	40	1	18
Museo + Dante control area	24	37	9	40	3	16	33	42	9	42	0	9	22	39	17	41	2	19
Poggioreale catchment area	20	21	−7	19	−2	−1	17	16	−1	20	4	3	16	19	3	19	0	3
Poggioreale control area	18	19	−9	19	0	1	17	17	0	19	2	2	15	18	3	19	1	4
Argine catchment area	17	18	−−10	21	3	4	18	19	1	19	0	1	16	18	2	21	3	5
Bartolo Longo catchment area	14	16	−12	19	3	5	20	21	1	18	−3	−2	15	16	1	19	3	4
Madonnelle catchment area	16	17	−11	20	3	4	17	17	0	18	1	1	15	17	2	20	3	5
Vesuvio de Meis catchment area	13	16	−12	18	2	5	23	25	2	19	−6	−4	15	16	1	18	2	3
Villa Visconti catchment area	11	15	−13	19	4	8	23	25	2	20	−−5	−3	15	15	0	19	4	4
East control area	13	16	−12	19	3	6	21	22	1	19	−3	−2	15	16	1	19	3	4

*H*_01 = housing property price index in 2001.
*H*_05 = housing property price index in 2005.
*H*_08 = housing property price index in 2008.
*R*_01 = retail property price index in 2001.
*R*_05 = retail property price index in 2005.
*R*_08 = retail property price index in 2008.
*O*_01 = office property price index in 2001.
*O*_05 = office property price index in 2005.
*O*_08 = office property price index in 2008.
Δ_ = property price change for the time frame considered.

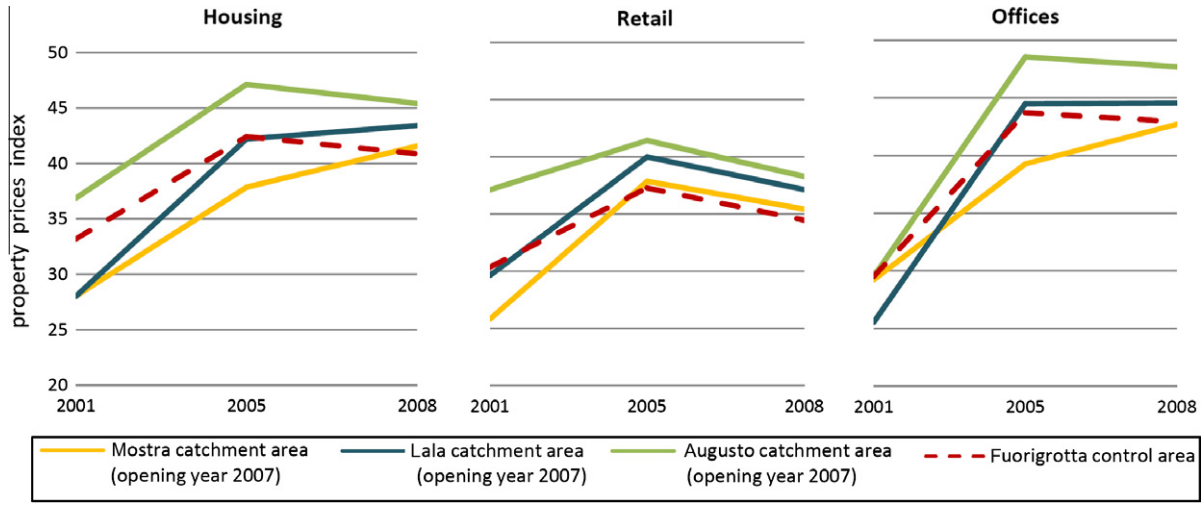


Fig. 3. Property price index for housing, retail and offices in Mostra, Lala, Augusto catchment areas and Fuorigrotta control area – Index 100 = 2001.

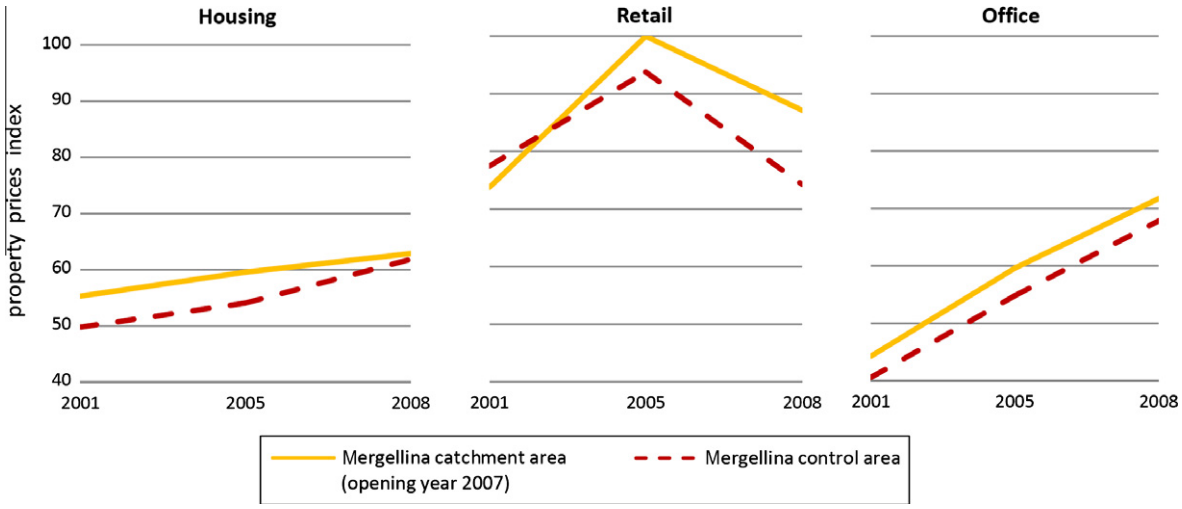


Fig. 4. Property price index for housing, retail and offices in Mergellina catchment and control area – Index 100 = 2001.

office property prices increased by 34.56% which is almost equal to that of the control area (35.01%), whilst retail property prices decreased by −12.86%, less than in the control area (−20.79%).

As far as the housing, retail and office property price indices are concerned (see Fig. 4 and Table 4), from 2001 to 2005, before the station opened, the impact of the forthcoming railway station was strong The housing property price index actually shows a steeper positive slope ($\Delta H\_01–05 = 32$) than the trend in the control area ($\Delta H\_01–05 = 26$). The same phenomenon can be observed for retail and office property price indices. From 2005 to 2008 the housing and office property price indices still show positive trends ($\Delta H\_05–08 = 3$ for houses and $\Delta O\_05–08 = 12$ for offices), however less steep than the corresponding values in the control area (8 and 13 respectively). This means that the "metro effect" was also evident after its opening. The retail property price index in contrast decreases from 2005 to 2008, ($\Delta R\_05–08 = -13$), like the stations for the Fuorigrotta area. However, the decrease is less steep than in the control area ($\Delta H\_05–08 = -20$).

3.2.2. Stations of Line 1: control areas Quattro Giornate, Materdei + Salvator Rosa, Museo + Dante, Piscinola

The stations of Quattro Giornate (opened in 2001), Materdei (opened in 2003), Salvator Rosa (opened in 2001), Museo (opened in 2001) and Dante (opened in 2002) are located in a central part of the city of Naples, where a decrease of residents in the catchment areas is notable confirming the general migration phenomenon toward more peripheral parts of the municipality. However, these decreases are always less than in the corresponding control areas. For the Quattro Giornate catchment area the decrease in the number of residents is −2.26% (2001–2005) and −1.50% (2005–2008) which is less than in the corresponding control area (−2.84% and −1.90% respectively). Similarly, the stations of Salvator Rosa and Materdei, lost fewer residents (−1.64% in 2001–2005 and 1.09% in 2005–2008), than in their control areas (−2.87% and −1.91% respectively). The same trend occurred in the catchment area of Dante station.

An exception is represented by Museo's catchment area, where an increase of residents is registered both for 2001–2005 (+2.49%) and 2005–2008 (+1.66%).

Piscinola station catchment area already experienced good accessibility to the railway before the station opened in 2005. and the number of residents increased both between 2001–2005 (+2.18%) and 2005–2008 (1.46%), more than in the control area. This is due to gentrification what is happening in the city of Naples is migration from the city centre towards the more peripheral parts of the town. Piscinola benefits from this migration because of its

suburban station and because it is mainly a residential area with good accessibility to the city centre.

In Quattro Giornate station catchment area housing property prices increased by 14.23% from 2001 to 2005, less than in the control area (18.75%), to 15.54% from 2005 to 2008. more than in the control area (6.52%), showing the impact of this new station over time. For office property prices the trend remains almost unchanged in the periods 2001–2005 and 2005–2008. For retail property prices the percentage change (5.26%) is higher than in the control area (2.62%) from 2001 to 2005, whilst from 2005 to 2008 a decrease is observed in both catchment (−17.22%) and control (−3.95%) areas.

From 2001 to 2005 (see Fig. 5 and Table 4), the housing property prices increased less ($\Delta H\_01–05 = 23$) than in the control area ($\Delta H\_01–05 = 25$). However from 2005 to 2008, the house prices increased faster ($\Delta H\_05–08 = 7$) than in the control area ($\Delta H\_05–08 = 3$). The same phenomenon is observed for office property price indices. The opening of the station in 2001 had its main impacts on property values in subsequent years.

Materdei and Salvator Rosa are two boroughs of Naples where the opening of the metro stations had a very significant impact on property prices. Estate agencies declared that this was a really noticeable phenomenon as housing and office property prices soared everywhere. For Materdei station's catchment area, house prices increased by 40.66% from 2001 to 2005, higher than in the control area (11.14%). The same happened with office property prices, increasing from 2001 to 2005 by 53.72% compared to 13.98% in the control area. For retail property prices for 2001–2005, the increase of 4.81% is higher than in the control area, where a decrease (−9.35%) was registered.

The same trend characterises Salvator Rosa's catchment area, where from 2001 to 2005 the housing, retail and office property prices increased by 18.75%, 2.62% and 41.36% respectively, higher in each case than in the control area.

From 2005 to 2008, for both Materdei and Savator Rosa's catchment areas, housing and office property prices showed an average increase of 6.74% and 47.54% respectively, which is higher than in the control area (13.98%) in the case of offices, but lower in the case of housing property values (17.81%). A general decrease for retail property prices is reported for both station catchment areas (−4.06%) and the corresponding control area (−3.52%).

For both Materdei and Salvator Rosa catchment areas the analysis of the property price indices for houses, shops and offices (see Fig. 6 and Table 4) shows a steeper positive slope compared to the trend of the corresponding control area. This impact is immediately evident in the time frame 2001–2005, in fact the values

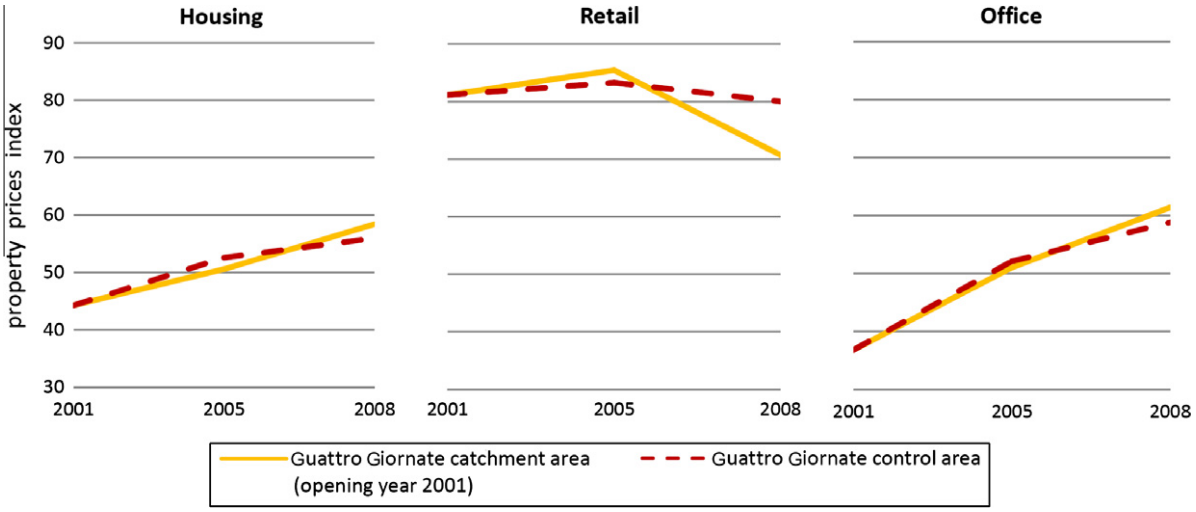


Fig. 5. Property price index for housing, retail and offices in Quattro Giornate catchment and control area – Index 100 = 2001.

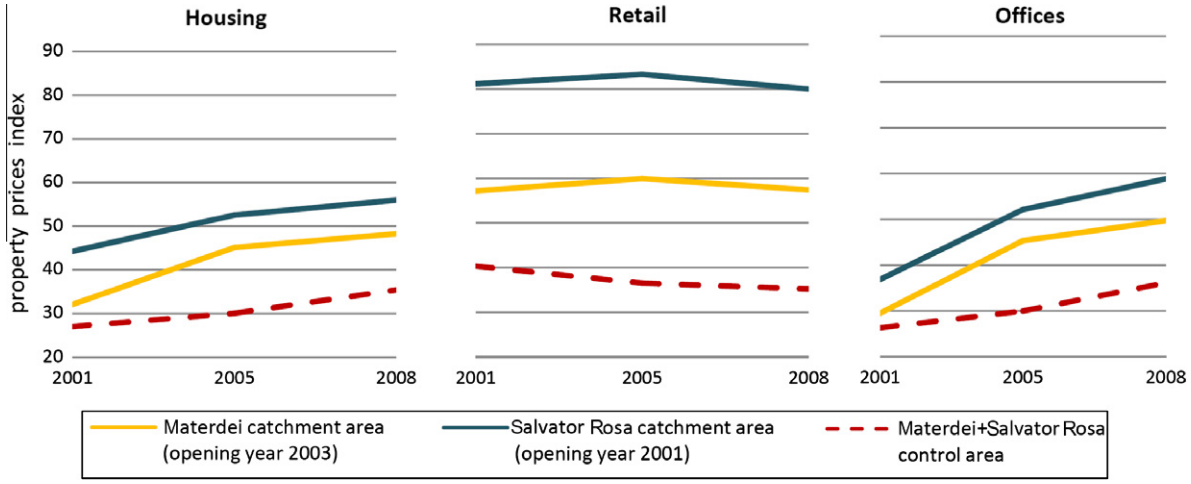


Fig. 6. Property price index for housing, retail and offices in Materdei and Salvator Rosa catchment areas and Materdei + Salvator Rosa control area – Index 100 = 2001.

registered for housing are 17 for Materdei and 25 for Salvator Rosa, while for the control area it is only 2; for shops the values registered are 3 for Materdei and 2 for Salvator Rosa, but −2 for the control area; the values for offices are 15 for both Materdei and Salvator Rosa catchment areas but only 4 for the corresponding control area. From 2005 to 2008 the housing and office property price indices still increased for both Materdei and Salvator Rosa catchment areas and their slopes are almost equal to those in the control area. Specifically $\Delta H\_05–08 = 3$ for both Materdei and Salvator Rosa catchment areas and $\Delta H\_05–08 = 5$ for the corresponding control area. While $\Delta O\_05–08$ is equal to 5 for Materdei and to 7 for Salvator Rosa at the same time it is 6 for the corresponding control area. While there is a general increase for these properties, in the same time frame the retail property price index decreases everywhere ($\Delta R\_05–08 = -3$ and −2 for the corresponding control area). Shops do not seem to have been affected by the metro in the subsequent years after the stations' opened.

For Museo and Dante station catchment areas an average increase of prices is observed for all property types. From 2001 to 2005, an average increase of 42.09%, 26.60% and 62.13% for housing, retail and property prices respectively is recorded; however these values are slightly lower than in the control area (52.52%, 25% and 76.24%, respectively).

Concerning the analysis of the property price index (see Fig. 7 and Table 4), in Museo's catchment area property prices present almost the same positive trend as in the corresponding control area, both for housing and offices. The pattern for Dante catchment area is different because for 2001–2005 the housing property price index increases more steeply (17) than in the control area (9). This is because the "metro effect" was almost immediate. From 2005 to 2008 the same effects occurred around Materdei and Salvator Rosa stations because this group of stations are located in the same part of the Municipality of Naples and the trend in property prices are similar.

For Piscinola's catchment area a general increase in property prices is observed in both periods; however these values are always lower than in the control area apart from for offices, where the increase is 40.37% in both periods and higher than in the control area (29.72%).

Fig. 8 and Table 4 show that all types of property prices increased faster than in the control area from 2005 to 2008, after the opening of the station. In the previous period (2001–2005) the opening of the metro mainly affected prices of shops and offices.

3.2.3. Stations of Line 3: control areas Poggioreale and East

The catchment areas of these stations show an increase in the number of residents of 5.11% and 3.40% in 2001–2005 and 2005–2008 respectively, higher than in the control area (0.44% and 0.30% respectively). Again this increase is because of gentrification which has led to migration to more peripheral parts of the town.

Fig. 7. Property price index for housing, retail and offices in Dante, Museo catchment areas and Museo + Dante control area – Index 100 = 2001.

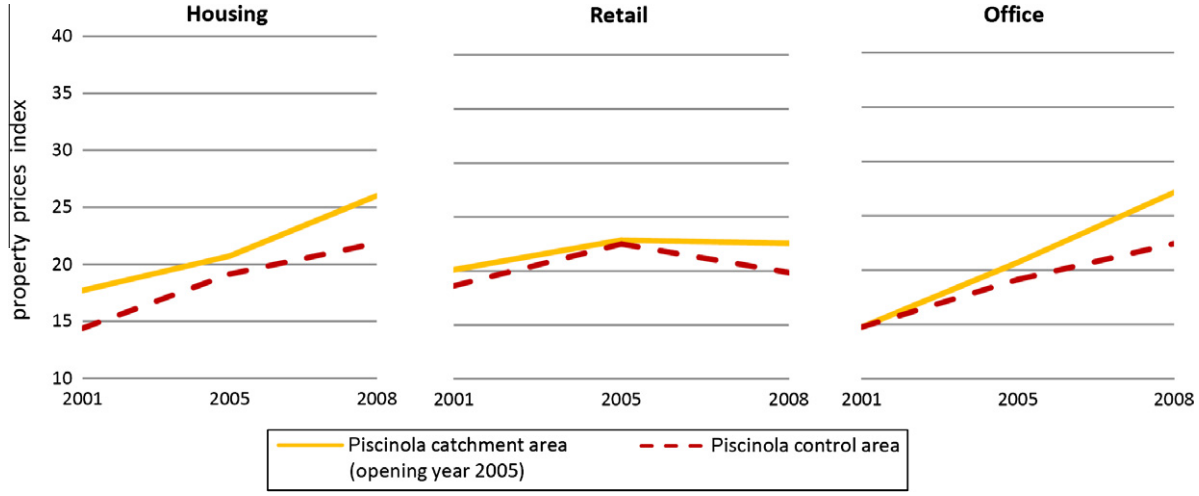


Fig. 8. Property price index for housing, retail and offices in Piscinola catchment and control area – Index 100 = 2001.

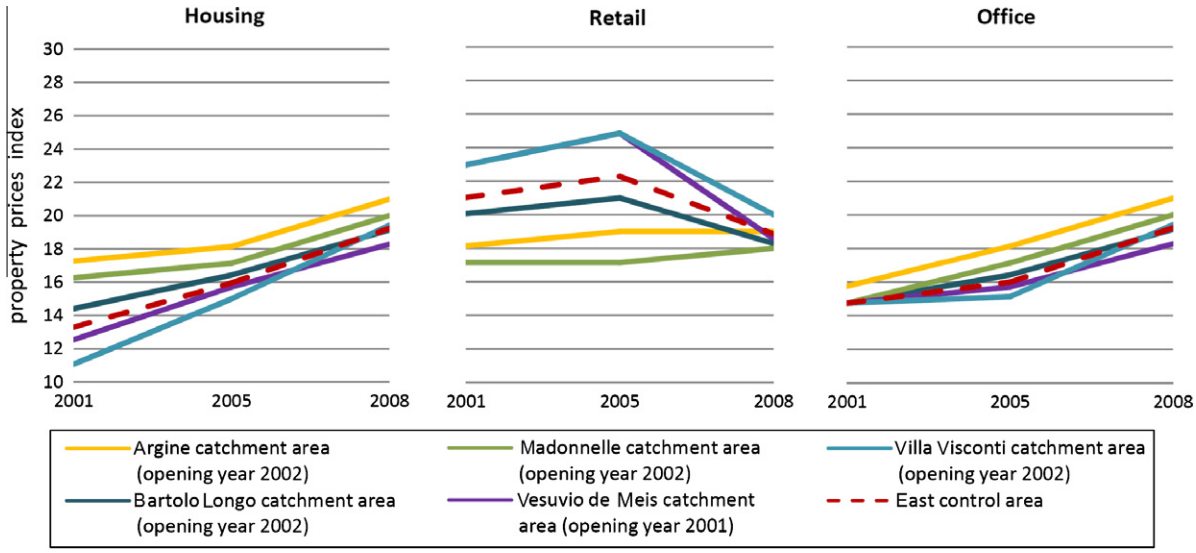


Fig. 9. Property price index for housing, retail and offices in Argine, Bartolo Longo, Madonnelle, Vesuvio De Meis, Villa Visconti catchment areas and East control area – Index 100 = 2001.

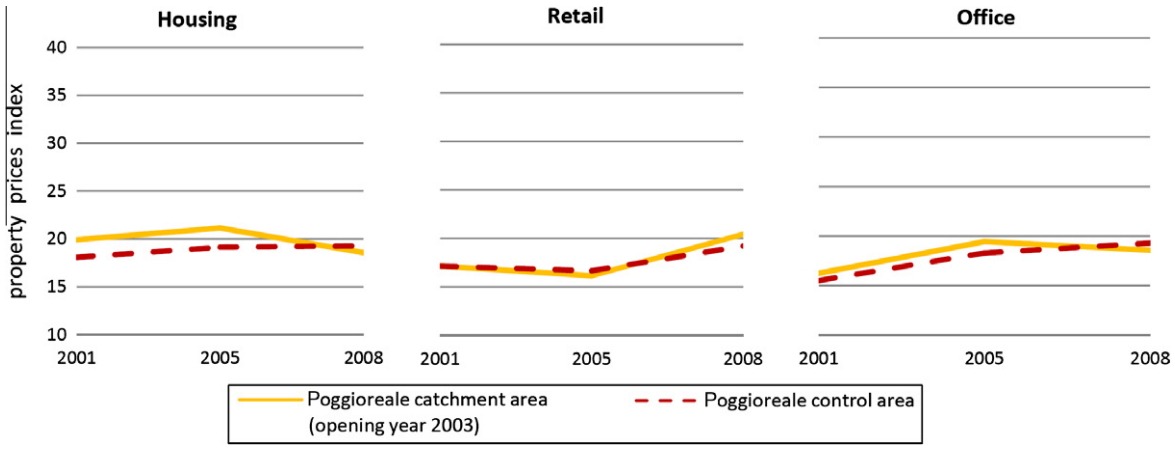


Fig. 10. Property price index for housing, retail and offices in Poggioreale catchment and control area – Index 100 = 2001.

The pattern in Poggioreale's station catchment area (opened in 2003) is different because it experienced a population decrease, albeit less than in the control area.

For both 2001–2005 and 2005–2008 in the East suburban area, all property types increased in value. Values are slightly lower compared than in the control area, except for office prices where the average increase is equal to 10.35% in both periods, higher than in the control area (8.42%).

Analysis of the property price index from 2005 to 2008 (see Fig. 9 and Table 4), shows that for all the stations (Argine, Bartolo Longo, Maddonelle and Villa Visconti stations opened in 2002 and Vesuvio de Meis station opened in 2001) a positive increase in housing property prices is equal to or less steep than the trend in the control area. In the case of offices, the slope is positive but less steep than in the control area. In this case the "metro effect" will probably be notable in subsequent years.

For Poggioreale's catchment area (station opened in 2003), between 2001 and 2005, housing and office property prices increased by 6.17% and 19.72% respectively; more than in the control area (5.80% and 18.03% respectively). In the same period, retail property prices show a sharper decrease (−5.83%) than in the control area (−2.92%). From 2005 to 2008, housing property prices decreased. For office property prices increased similarly to 2001–2005 while retail property prices increased by 26.55%, which is higher than in the control area (15.45%).

Analysis of the property price index (see Fig. 10 and Table 4), it is interesting to note that from 2001 to 2005 the metro opening had more influence on office property prices ($\Delta H\_01–05 = -7$ and −9 for catchment and control areas respectively; $\Delta R\_01–05 = -1$ and 0 for catchment and control areas respectively and $\Delta O\_01–05 = 3$ for both catchment and control areas). While from 2005 to 2008, a steeper positive slope of the retail property price index (R_05–08 = 4) is observed compared to that of the corresponding control area (R_05–08 = 2). This shows that the "metro effect" becomes evident in time for retail properties.

4. Conclusions

The introduction of a rail transit investment brings benefits to the transportation system and to the accessibility of the population to employment, retail, and recreational activities. Rail transit investments also introduce a variety of impacts to the area around the rail alignment. One of the most significant effects of a rail transit project is the impact on property values. Numerous

accounts of recent experiences with the impact of rail transit on property values have surfaced within the past two decades with varied results and general conclusions based on the local conditions of the rail transit systems studied.

This paper has summarised the land-use and economic impacts of the urban rail system of the Municipality of Naples over time and space (i.e. definition of catchment and control areas), using GIS techniques. Specifically the changes of property values and of the number of residents have been computed around the 16 stations which opened between 2001 and 2007. These changes have been reported for station catchment areas and they have been compared with the corresponding values for specified control areas. The main outcome of this analysis is that values are shown to be higher in station catchment areas than in control areas only in specific cases, depending on several factors such as location, local property market trend and connectivity given by the new metro line to the city centre, justifying the impact of rail on property values and residents' location. This phenomenon is more evident in inner city stations' catchment areas, which did not have good accessibility to other urban, regional and national rail services before the opening of the metro line. In suburban areas, the new stations have positive impacts on property values only in Piscinola's catchment area due to the "acquired closeness" to the city centre through L1. Furthermore the analysis shows more significant results for long term impacts, i.e. for the stations opened in 2001, for which the authors have the time series data for the seven years following their opening.

Moreover gentrification is observed in the urban area of Naples. The authors maintain that transit access can be considered a spur to gentrification; in fact changes in property values and in residents' location highlight a widespread phenomenon of migration from the central part of the town, where property prices are higher, toward peripheral areas, which are well served by the urban rail system, with lower property prices growing slowly.

Further perspectives will consider a more detailed analysis of such phenomenon for the whole metropolitan area of Naples, as positive land value impacts of urban rail are the basis for land value capture providing finance for the development of new rail systems in other areas of the Province.

References

APTA, 2002. Rail Transit and Property Values. <http://www.apta.com> (Information Centre Briefing 1).

Arrington, G.B., 1995. Beyond the Field of Dreams: Light Rail and Growth in Portland. Tri-Met, Portland, Oregon.

Banister, D., Berechman, J., 2000. Transport Investment and Economic Development. UCL Press, London.

Berechman, J., Paswell, R.E., 1983. Rail rapid transit investment and CBD revitalization: methodology and results. Urban Studies 20, 471–486.

BIN – Borsa Immobiliare di Napoli, 2001. Listino ufficiale dei valori correnti del mercato immobiliare I semestre 2001. <http://www.binapoli.it/>.

BIN – Borsa Immobiliare di Napoli, 2007. Listino ufficiale dei valori correnti del mercato immobiliare I semestre 2007. <http://www.binapoli.it/>.

Burmeister, A., Joignaux, G. (Eds.), 1998. Infrastructures de Transport at Territoires Approches de Quelques Grand Projets. L'Harmattan, Paris.

Cascetta, E., Pagliara, F., 2008. Integrated railways-based policies: the regional metro system (RMS) project of Naples and Campania. Transport Policy 15, 81–93.

Cascetta, E. (Ed.), 2009. Transportation Systems Analysis: Models and Applications. Springer, New York.

Cervero, R., 1997. Light rail transit and urban development. Journal of American Planning Association 50, 133–147.

Cervero, R., 1998. The Transit Metropolis: A Global Inquiry. Island Press, Washington D.C., California.

Cervero, R., Duncan, M., 2002. Benefits of proximity to rail on housing markets. Journal of Public Transportation 5, 1–18.

Cervero, R., Landis, J., 1993. Assessing the impacts of urban rail transit on local real estate markets using quasi-experimental comparisons. Transportation Research A 27, 13–22.

Cervero, R., Landis, J., 1997. Twenty years of the bay area rapid transit system: land use and development impacts. Transportation Research A 31, 309–333.

Davoudi, S., Gillard, A., Healey, P., Pullen, B., Raybould, S., Robinson, F., Silcock, D., Usher, D., Wymer, C., 1993. The Longer Term Effects of the Tyne and Wear Metro, TRRL. CR 357.

Debrezion, G., Pels, E., Rietveld, P., 2004a. The Impact of Railway Stations on Residential and Commercial Property Value. Tinbergen Institute Discussion Paper TI2004-023/3, Amsterdam.

Debrezion, G., Pels, E., Rietveld, P., 2004b. The Effects of Railway Investments in a Polycentric City. Tinbergen Institute Discussion Paper TI2004-089/3, Amsterdam.

Du, H., Mulley, C., 2007. The short-term land value impacts of urban rail transit: quantitative evidence from Sunderland, UK. Land Use Policy 24, 223–233.

Federal Transit Administration (FTA), 2000. Transit Benefits 2000 Working Papers: A Public Choice Policy Analysis. Federal Transit Administration, Office of Policy Development, Washington, DC.

Forrest, D., Glen, J., Ward, R., 1996. The impact of a light rail system on the structure of house prices: a hedonic longitudinal study. Journal of Transport Economics and Policy 30, 15–29.

Giuliano, G., 1999. Land use impacts of transportation investments: highway and transit. In: Hanson, S. (Ed.), The Geography of Urban Transportation, second ed. Guilford Press, New York.

Golias, J.C., 2002. Analysis of traffic corridor impacts from the introduction of the new athens metro system. Journal of Transport Geography 10, 91–97.

Haider, M., Miller, E.J., 2000. Effects of transportation infrastructure and location on residential land values: application of spatial-autoregressive technique. Transportation Research Record 1722, 1–8.

Hess, D.B., 2007. Impact of proximity to light rail rapid transit on station-area property values in Buffalo, New York. Urban Studies 5 (6), 1041–1068.

ISTAT, 2001. 14° Censimento della Popolazione e della Abitazione. Instituto Nazionale di Statistics, Rome.

Kaiser, E.K., Godschalk, D.R., Chapin Jr., S., 1995. Urban Land Use Planning. University of Illinois Press, Urbana IL.

Kim, J.H., Pagliara, F., Preston, J., 2004. Transport policy impact on residential location. International Review of Public Administration 9, 71–87.

Landis, J., Cervero, R., Guhathukurta, S., Loutzenheiser, D., Zhang, M., 1995. Rail Transit Investments, Real Estate Values, and Land Use Change: A Comparative Analysis of Five California Rail Transit System. Monograph 48, Institute of Urban and Regional Studies, University of California, Berkeley.

Lewis Workman, S., Brod, D., 1997. Measuring the neighbourhood benefits of rail transit accessibility. Transportation Research Record 1576, 147–153.

LiRa Pilot3, 2000. Light Rail, Economic Impact and Real Estate Development. <http://www.lira-2.com/docs/lira1/Pilot%203.pdf>.

Naess, P., 2005. Residential location affects travel behavior—but how and why? The case of Copenhagen metropolitan area. Progress in Planning 63, 165–175.

Newman, P., Kenworthy, J., 1999. Sustainability and Cities: Overcoming Automobile Dependence. Island Press, Washington DC.

Nijkamp, P., Blaas, E., 1994. Impacts Assessment and Evaluation in Transportation Planning. Kluwer Academic Publishers, Boston.

Ovenell, N., 2007. A Second Hedonic Longitudinal Study on the Effect on House Prices of Proximity to the Metrolink Light Rail system in Greater Manchester. Unpublished MSc Transport Engineering and Planning Dissertation, University of Salford.

O'Sullivan, S., Morrall, J., 1995. Walking distances to and from light-rail transit stations. Transportation Research Record 1538, 19–26.

Osservatorio Mercato Immobiliare OMI – Agenzia del Territorio, 2001. Quotazioni immobiliari OMI. <http://www.agenziaterritorio.it/>.

Osservatorio Mercato Immobiliare OMI – Agenzia del Territorio, 2007. Quotazioni immobiliari OMI. <http://www.agenziaterritorio.it/>.

Parson, B., 2001. The Effect of Rail Transit on Property Values: A Summary of Studies. Research Carried Out for Project 21439S, Task 7 (Draft). NEORail II, Ohio, Cleveland.

RICS, 2002. Transport Development Areas: A Study into Achieving Higher Density Development around Public Transport Nodes. The Royal Institution of Chartered Surveyors, London.

Rietveld, P., 1994. Spatial economic impacts of transport infrastructure supply. Transportation Research A 28, 329–341.

Riley, D., 2001. Taken for a Ride. The Centre for London Policy Studies, London.

Roider, O., Klementschitz, R., 2002. The Socio-Economic Effects of the Metro Line 'U3' in Vienna. Institute for Transport Studies, University of Bodenkultur.

Senior, M.L., 2009. Impacts on travel behaviour of Greater Manchester's light rail investment (Metrolink Phase 1): evidence from household surveys and census data. Journal of Transport Geography 17, 187–197.

Tinbergen Institute, 2006. The Impact of Rail Transport on Real Estate Prices: An Empirical Analysis of the Dutch Housing Markets. Tinbergen Institute Discussion Paper TI 2006-031/3.

Transecon Consortium, 2003. Urban Transport and Local Socio-Economic Development. <http://www.transecon.org> (Deliverables 4 and 5).

Transplus Project, 2002. Land Use and Transportation Planning: Experiences in European Cities. TNO Report 2002-67, Delft.

Vessalli, K.V., 1996. Land use impacts of rapid transit: a review of empirical studies. Berkeley Planning Journal 11, 71–105.

Vinha, K.P., 2005. The Impact of the Washington Metro on Development Patterns. PhD Dissertation. <http://www.lib.umd.edu/drum/bitstream/1903/3175/1/umi-umd-2997.pdf>.

Waddell, P., 2001. Review of the Literature and Operational Models. Systematics Inc., Cambridge.

Weinstein, B.L, Clower, T.L., 1999. The Initial Economic Impacts of the DART LRT, Report.