Urban transformations and rail stations system - the study case of Naples

Papa, E.

Papa, Enrica

Conference Paper

Urban transformations and rail stations system - the study case of Naples

45th Congress of the European Regional Science Association: "Land Use and Water Management in a Sustainable Network Society", 23-27 August 2005, Amsterdam, The Netherlands

Provided in Cooperation with:
European Regional Science Association (ERSA)

45th Congress of the European Regional Science Association
23-27 August 2005, Vrije Universiteit Amsterdam
Land Use and Water Management in a Sustainable Network Society

Urban transformations and rail stations system: the study case of Naples

Enrica Papa[1]

1 Department of Spatial Planning DiPiST, Engineering Faculty, University of Naples Federico II, Piazzale Tecchio, 80, 80125 Naples, Italy
(e-mail: enpapa@unina.it)

Abstract: The aim of this study is to give an interpretation of the urban transformations connected to rail transit system investments; in particular the main research goal is to analyze and give a methodological support for the urban transformation phenomena government in the rail transit stations areas. The article proposes an empirical studies comparative analysis and an application in the Naples urban area, in which a new rail transit network has been developed. In particular the socio-economic transit impacts on the urban system are measured and interpretated with the support of a GIS; therefore an application of the *node-place* interpretative model (Bertolini 1999) is proposed in order to support transit–land use planning processes in the stations areas.

Key words: rail transit stations, urban transformations, impacts assessment, TOD

JEL classification: R14, R20, O22, R42

1 Introduction

System analysis techniques have been used to interpretate and understand the transport system behaviour and the performance of its components. More recently an increasing attention has been developed on the linkages and the relationships among the transport system and the other global system to which it belongs (Meyer and Miller 2001). The study of this relations are fundamental for the transportations analysis and policy decision and at the same time to understand which goals could be established for the transport system that could achieve desirable effects at the urban and community level.

This article, starting from this complex theoretical and practical framework on the transport and land-use interaction, proposes a reply to the following questions: which are the impacts of the transit system on the urban structure? How is possible to govern this interrelation phenomena between the transit network evolution and the stations area transformations? Which are the elements that have to be taken into account in the integrated transit-land use system planning process? The answers are articulated into three different parts: in the first section the theoretical literature framework on the transit and urban system links is defined; in the second part an empirical studies comparative analysis is presented, underlining the common points and the urban contests different factors that can influence the transit impacts on the urban structure; in the third section is proposed an application in the Naples urban area, in which a new rail transit network has been developed. In particular the socio-economic transit impacts on the urban system are measured and interpretated in the time period 1991-2004 and in the space with the support of a GIS. Finally an application of the node-place interpretative model (Bertolini 1998) is proposed in order to define the first steps towards a SDSS to govern the integrated transit–urban system transformations process according to TOD principles and in order to maximize the transit investments.

2 Transit and urban system interaction: theories and planning practices

Rail infrastructure impacts on urban system have always been studied with different approaches in both transport and urban studies disciplines, with the aim of defining theories and methods for the analysis and the interpretations of the transport-urban system interactions (Nijkamp and Blass1994; Burmeister 1998; Banister 1995). However, only in recent studies this topic is also faced with a more “planning perspective” and finalized to define common and integrated strategies for the transport-land use transformations management.

In fact, despite the evident interrelation between the two systems, land use and transportation planning have tended to be separated operations in practice. According to a strictly transport disciplines point of view, the transport system is defined as a urban sub-system, whose elements generate transport demand between origins and destinations, to which is related the transport supply construction (Cascetta 1995, 1998). Transportation planning has tended to assume the future land use pattern as given, usually based on market projections of land use rather than a land use plan. In this way generally transport system tends to reinforce past development trends and not the urban plan directions (Giuliano 1999). On the other hand, land use planning often consider the transport plan outside the decision process, and merely accepts the proposed transport interventions rather than a plan element to be coordinated with the future land use (Chapin 1995). In fact the urban plan defines the densities and the location of the activities, according to their capacities to generate transport demand, without considering the future impacts of these choices on the transport system. In other words, if the urban system is considered as a cinematic network, whose nodes are the urban activities and whose arcs are the transport fluxes, the transport plan acts on the arcs capacity and the urban plan acts on the nodes locations, but both approaches consider the elements given by the parallel planning process as hexogen variables coming outside from their government planning process.

Both transport and urban studies disciplines show the awareness of the necessity of a new holistic approach, which is based on the complex theory and that sustains a transport-land use system integrated interpretation. The mobility system should be conceived as a join and incorporated element of the land use spatial distribution and the accessibility opportunities supplied by the transport infrastructures (Wegener and Fürst 1999). According to this approach, the transport and the transit system should be conceived as a spatial integrated structure and the interrelations between the two sub-system are fundamental to understand and govern the complex system: from one side the urban activities structure determines the transport demand and from the other side, the accessibility supplied by the transport system conditions the localization choices and in this way the land-use pattern. Land-use and real estate availability can be influenced by the accessibility conditions and by the transport system: a transport system modification involves a residential and economic activities re-allocation and therefore the transport demand entity derived from this urban structure will be influenced not only by the transport supply, but also by the new spatial system.

Only relatively recently, with a system approach application at the socio-technical issues, the land use-transport system has been studied and modelled as a whole entity, taking into account all the structuring system elements and their internal and external interrelations. This trend also lead to large scale aggregate models use, that allow to simulate land-use transport interactions simulations (for a recent review, see Waddell 2001, Bates Oosterhaven, 1999; Wegener and Fürst 1999).

On the other hand, in the practice field, approaches and methods have been developed in order to define strategies and practices for a more coordinated and collaborative planning process between the urban and transport strategies (Cervero 1997 and 1998). This form of coordination aims at obtaining an equilibrium between the urban policies and transport interventions. This collaborative approach seeks to balance the use of land use policy as n input to transportation planning with a realization that transportation is a determinant in land use projection and land use plan (Chapin 1995). In planning practices is almost clear the necessity of the definition of a common strategy between transport and land-use planning and in particular and an increasing attention is being turned to the role that the transit system could have in the urban system evolution. The combined and integrated set of strategies involving transit infrastructure investments, urban development along transit lines and supportive integrated policies have been analysed by many expert of Transit Oriented Development (TOD) and Transit Join Development (TJD) (Boarnet and Crane 1998; Calthorpe 1993). However this approach often tends to overestimate the effectiveness of planning remedies, lacks of quantitative approaches and doesn't take into account the urban actor's behaviour as a determinant aspect of the urban evolution process (Dittman 2004).

3 Rail transit impacts on urban system

During the '70s physical impacts related to transportation infrastructures construction received an increasing attention, also for the growing awareness of the important contribution of the transport system performance on the urban system environmental quality (Meyer and Miller 2001). Later, with the increasing diffusion of "sustainable development" theories, transport impacts assessment methods and practices developed (Kreske 1996; Bregman 1999). Only in relatively recent years transport and land use system are considered as a spatial integrated structure. This holistic approach is based on a collaborative developed vision of desired future conditions that integrates ecological, economic and social factors (Garrett and Bank 1995). In the following paragraphs are defined all the different aspects of transport system effects, and in particular the transit infrastructures, on the urban structure. Those are articulated into spatial, economic, social and environmental impacts.

2.1 Spatial impacts

Rail transit system spatial impacts include urban physical transformations and activities pattern variations. Physical transformations consist of constructions or land development interventions and renewal interventions in the urban system as urban renewal or building restoration. Several studies have looked at the relationship among urban form and rail infrastructures development, with different approaches. In particular first researches on this topic have underlined the strong linkage among rail transit investments and the city rapid expansion and decentralization (Middleton 1967; Fogelson 1967). However such investments have also been shown to reinforce the economic viability of the central urban areas, where the new accessibility conditions have contribute to change central rail stations areas. In central urban areas new transit system investments have also caused physical renewal processes in the improved accessible areas (Cervero 1998), as also described in the table 2. Spatial impacts include also land-use variation related to accessibility provided by the transit infrastructures evolution. The urban activities re-allocation is related to the business and household decisions; the resulting combination of individual urban actor's choices causes a variation of the land-use pattern, as for example an activities clustering effect near many urban rail stations (Landis 1995).

2.2 Economic impacts

The economic transformations related to the rail transit system evolution consist of micro-economic impacts, as property and rent values variations for different uses, and macro-economic effects as the urban economic competition variation (Banister and Berechmann 2000), potential development increase or economic viability of the central business districts. (Arrington 1995, Parson 1996; Berechman and Paaswell 1983). Many factors contribute to these urban aspects transformations, as stated by several studies (Cambridge Systematics 1999) as the regional economic trend or properties physical characteristics. In literature, different methods to analyse these factors have been developed and in particular is widely applied the hedonic pricing approach, that define the property values variation as function of different properties physical or functional characteristics. Using a multiple regression, the property values are explained by different variables that underline the marginal values variations dependence from different attributed as the accessibility, the land-use, the urban quality (Cervero and Duncan 2001; Bowes 2000).

2.3 Social and environmental impacts

Rail transit system is not only an integral component of an urban area's economy and land-use system, but also a defining factor in community quality of life. For this reason is important to define also the social and "community" effects of the transit system as e different impact category. The construction of a rail network can also influence the accessibility condition distribution to the different social classes (Meyer and Miller 2001) and have potential negative effects on historical and cultural resources or disrupt a neighbourhood community. Therefore latter studies have introduced the concept of "environmental justice", in order to analyse the assessment of equitable distribution of benefits and costs within the population, related to the transport projects (Lucas et al. 2001; Department for Transport 2000).

Environmental impacts of the transport system include all the natural system component transformation. Several studies concern the environment variation related with the transport system, but only relatively new studies have introduced the concept of ecosystem management as an integral part of the transport planning process. Two environmental impacts are often found in transportation planning studies: air quality and noise. The urban transportation system is one of the major source of air pollution and noise production in urban areas and a new rail infrastructure construction is related to this effects both directly than indirectly, trough the modal split variation. These two environmental effects are the most apparent and have impacts on the general urban quality and also on the land values pattern (Nelson 1978).

Table 1. Rail transit system impacts in theoretical and empirical studies

Impacts	Description	Authors
Spatial impacts	Urban form variation and sprawl effect	Middleton 1967; Fogelson, 1967; Cervero 1997
	City decentralization and urban development near rail corridors	Newmann and Kenworthy 1999; Wegener,1995
	Activities clustering impacts near rail stations	Landis 1995; Cambridge Systematics 1999
	Household and jobs density variation in the station areas	Hall Marshall 2000; Huang 1994; Cervero 1997; Parson 1996;
	Urban renewal and land development in rail stations areas	Cervero 1998; Bertolini 1998; Dittman 2004
Social impacts	"Community impacts"	Lucas et al. 2001;TRANSECON Consortium 2003;
	"Enviromental justice" distribution	Department for Transport 2000
Economic impacts	CBD economic viability reinforcement	Davies 2004; Arrington 1995; Parson 1996; Cervero 2002
	Land values and land properties variation	Weinberger 2001; Rietveld 1994; Cervero 2001 and 2002; Landis 1995; Debrezion et al. 2004; Bowes 2000; Huang 1994; Parson 2001; RICS 2002
	Economic grown and competition development in the urban system	Banister and Berechmann 2000; Knight and Trygg 1977
Environmental impacts	Air pollution ad noise variation	Nelson 1978; Halig and Cohen 1996

4 Spatial and economic impacts of the transit system: evidence from empirical study cases

The impact of rail transit on urban system transformation has been studied from many perspectives, including analysis of different type of systems, different type of impacts and with various interpretative methods (Debrezion Pels Rietveld 2004a and 2004b; RICS 2002, Vande Walle et al 2004;Vessalli 1996). Some empirical studies results are contradictory and this can be caused by the different analytical techniques, data quality and regional differences. Most of the empirical studies focus on the spatial and economic impacts of the transit system on the lines corridors and stations areas, as these kinds of effects are the most evident in a shorter period and also because of the data availability.

In order to compare different application in a qualitative way, in table 3 is shown a summary of studies where spatial and economic impacts or rail transit investments have been analysed. Most of the studies have been applied in USA, where the data quality and availability allows more sophisticated analysis methods, as regression analysis or hedonic price models (Haider and Miller 2000). In Europe, within the latest European projects (Transplus 2002; Transecon 2003; Sesame 1998) only relatively recently have been applied quantitative methods for the land use and economic impacts assessments. The selected study cases have been chosen mainly in order to compare the Naples application, proposed in this work, with significant and recent studies that have similar characteristics with the Naples urban contest.

As regards spatial effects, most of the studies reviewed found some level of land use change resulting from transit improvements. However, the extent of the impacts varied from study to study and the results were often accompanied by a caveat: that the impacts were generally small and indirect, and that they required the presence of several complementary factors as the vacant land near new transit stations, positive regional economic trend, good physical quality of the urban texture, presence of proactive urban planning policies in the transit corridors, central location of the new stations. As stressed mainly in the European study cases, the spatial impacts regards also physical quality improvements in the central stations areas, as the Madrid and Athens study cases. As regards economic impacts, property value studies tend to show greater impacts than the land use impacts studies, though these results vary even more widely. In different urban and regional contests, cross sectional and time-series methods application show a general land value increase in the station area, that is higher that mean properties values variation in the rest of the urban area.

Table.2. Economic and spatial impacts of rail transit: international experiences

City	Rail transit type	Authors	Impacts typology	Results and comment
San Francisco	BART commuter rail	APTA, 2002 Landis, 1995 Cervero, 1996	Economic impacts	Home price average decline by $1.00 to $2.00 per meter of distance from a BART station. Rent values are 10%-15% greater in the arear within ¼ mile to a station. No effects found for commercial property values.
		Landis, 1995	Spatial impacts	Population and employment grow slower in the stations areas that in the other areas; small urban development in the metro corridors and commercial activities grown.
Boston	MBTA, Red Line suburbana	Armstrong, 1994	Economic impacts	Residential properties in the stations areas have a market value 6.7% greater than the other areas
		Quackenbush, 1987	Spatial impacts	Industrial areas transformation in the lines corridors. New parking, offices and retail activities in the stations areas.
San Diego	LTR: San Diego Trolley	Landis, 1995	Economic impacts	Typical home sold for 272$ more for every 100 meters closer to rail station. No effects found on retail property values.
		SANDAG, 1984	Spatial impacts	Urban development in the peripheral area served by the new lines.
San Jose	San Jose LTR	Landis, 1995	Economic impacts	Typical house sold for $663 more for every 10 feet nearer a light rail station
		Landis, 1995	Spatial impacts	Small land-use variation in the stations areas.
Helsinki	Metro Line 1	TRANSECON, 2003, Laasko, 1992; TRANSPLUS 2002	Economic impacts	Property and rent values grow faster in the station areas for residential and commercial activities. Higher increase in the CBD station areas
		TRANSECON, 2003, Laasko, S. 1992	Spatial impacts	Increased population and jobs density occurred in the new subway station as compared to the rest of the urban area. Housing and officies development in the new pheriperical stations.
Lyon	Metro Line D	TRANSECON, 2003	Economic impacts	Property and rent values grow faster in the station areas
		TRANSECON, 2003	Spatial impacts	Household number increase faster in the new central stations. Small jobs number increase in the rail transit corridors. Transit line have strongly support development of employment center and residential areas. Importance of supporting policies and urban project in the stations areas
Atens	Attico Metro	TRANSECON, 2003	Economic impacts	Residential anc retail property values from 12% to 26% in the new stations areas from 1999 to 2003
		TRANSECON, 2003; Golias 2002	Spatial impacts	No household and jobs number variation in the transit lines corridors. Small land-use variations in the metro stations areas; renewal interventions in the central stations areas.
Wien	Metro Line U3	TRANSECON, 2003	Economic impacts:	High increase in land values in the transit corridors for housing, offices and retails. Transit investments has reinforced the CBD.
		TRANSECON, 2003; TRANSPLUS 2002;Gielge, 2002	Spatial impacts	Household number increases in the station areas. Job number increase only in the CBD. Renewal intervention in the stations areas (136€/mq in the station areas, 41€/mq in no stations areas)
Madrid	Metro Line 6	TRANSECON, 2003	Economic impacts	High increase of property values and rent values in the station areas (+5-10% for residential use; +10-20% for retail)
		TRANSECON, 2003	Spatial impacts	Decrease of household number in the central subway areas and small increase in the peripherical subway areas. No land-use variation in the transit corridors; some renewal intervention in the central subway areas.

5 The study case of Naples

Naples is the biggest city in southern Italy and it belongs to a conurbation (Province of Naples) of 3 million of inhabitants. The population almost reaches 1 million inhabitants on a surface of 117 square km. From 1993, a new transit line (Line 1) was developed and it goes from the city centre to the north Naples periphery. The first six stations of the new line were opened in July 1993 and in 1995, other three stations were released. From July 2001 to July 2002 four new stations started to work and now the line has 14 stations and is connected with the existing rail network by two interchange nodes (Vanvitelli and Museo stations).

The impacts assessment proposed in this application analyses the new transit line spatial and economic impacts on the urban system of Naples in two ways:

- in a temporal period (from 1991 to 2004), with the use of *longitudinal* (or time-series) data that allows before and-after comparisons of property values and land use patterns in the area surrounding the transit improvement;
- in the space, with the use of *cross-sectional* data that allows to compare the land use characteristics of transit-accessible urban areas to those without transit access.

The cross-sectional and longitudinal data comparison was possible by the use of GIS analysis techniques, that consents to organize, query and represent time-series spatial database. Georeferred time-sere data are related to each census parcels of the Naples municipality and transport network indicators are related to each station of the rail transport system. In this way, it is possible to make geographic correlations among the urban transformation indicators (household number variation or property values variation) and the accessibility indicators variation on the whole rail network. Furthermore, with the GIS support, stations influence areas have been defined as the union of the census parcels that are within a 500 m ray from the station exits. This measure is widely used as the mean walking distance to reach the station (Landis 1995).

In the next paragraphs are shown the mail results of the new transit network spatial and economic impacts analysis, focusing the attention of the Line 1 station areas transformation, where is higher the network accessibility index variations, as the table 3 and 4 illustrate. Figures 3 to 8 show some GIS layouts, in order to underline the interrelations among each station area transformations and the whole urban structure variation.

Fig.1. The Naples rail network, 1991

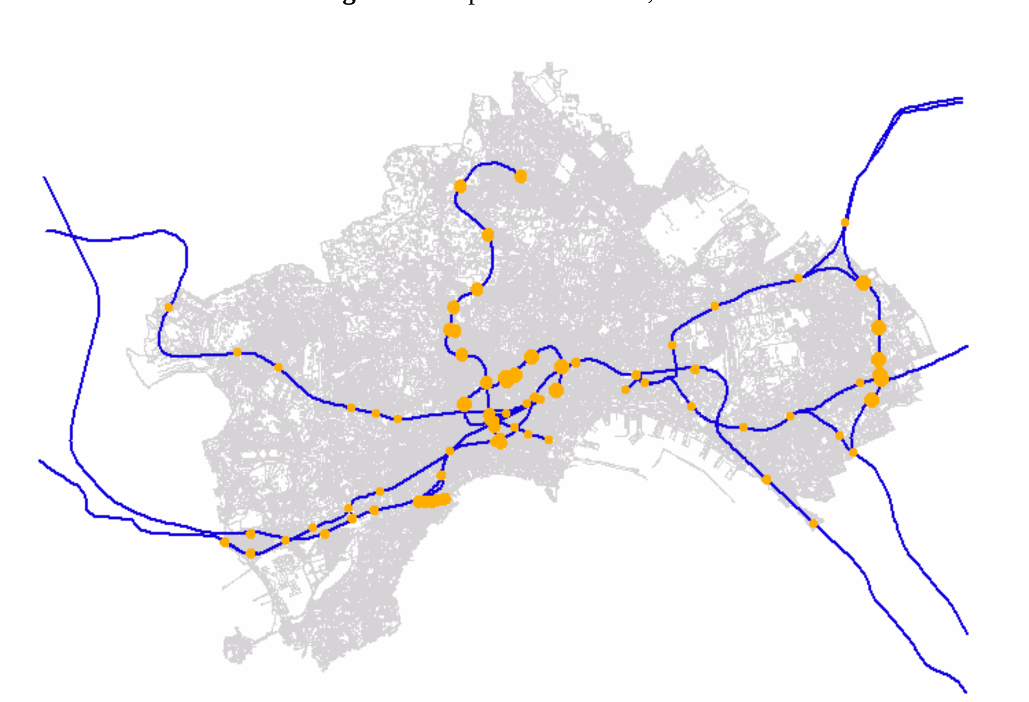

Fig.2. The Naples rail network, 2004

5.1 Transit spatial impacts in Naples

The main data source used for the transit spatial impacts assessment in the Naples area are the ISTAT data (National Institute of Statistic) in 1991 and 2001. Table 3 shows the household variation in the Line 1 station areas and other indicators, in order to underline the relation among the land-use transformations and other urban or transport features that could have influenced these phenomena. In particular the table illustrates the values of the following indicators:

- *location:* defines the station area location in the urban system. Three different areas are defined (central, semi central, suburban), depending on the CBD distance from the station.
- *functional mix*: is a measure of the presence and intensity of different activities (residential, retail, offices,…) in a station area *i*

$$mixfunz_i = \sum_{a=1}^{m} \frac{X_{ia}}{\max_a - \min_a} \cdot c_a \qquad (1)$$

X_{ia} = resident and job number (for economic activity *a*) in the station area *i*

$\max_a$ = maximum of residents of jobs for economic activity *a*

$\min_a$ = minimum of residents of jobs for economic activity *a*

c_a = number of economic activities in the station area *i*

m=total number of economic activities categories

- *network index*: is a measure of the network connectivity of the station area *i*:

$$indconn_i = \frac{\sum_{j=1}^{n} t_{ij}}{\sum_{ij} t_{ij}} \qquad (2)$$

t_{ij} = network access time[1] from station area *i* to station area *j* in 2001

n=total number of station areas in 2001

- Inhabitant number and inhabitants density variations are measured as mean variation of the census parcels *k* that belong to the station area:

$$\mathrm{var}\, res_i = \sum_{k=1}^{p} \frac{res_{2001k} - res_{1991k}}{S_k \cdot p} \qquad (3)$$

p=number of census parcel *k* that belong to the station area *i*

S_k = extension of the parcel census *k*

---

[1] The network times have been calculated with *Distance/Travel time Calculator* software written by dr. Evert Verkuijlen of the GIS-Centre of the Department of Geography and Planning of the University of Amsterdam

- Built area index is a measure of vacant land availability near station area and quantifies the concentration of built area; it is the ratio among the building covered surface and the influence area extension.
- Two different indicators measure the station use. The first one is the ratio between the station users and the total Line 1 users. The second one measures the station passenger variation from the opening year of the station to the 2001 year.

The results of the spatial new line impacts lead to some conclusions. First is shown a general resident density decrease in the whole Naples municipality, and a population decentralization trend; the new transit system seems to have supported the central area transformation, decreasing residential activities density and increasing functional mix in the central districts. In fact is strong the correlation among the network index variation and the population decrease. Therefore, the analysis shows a higher inhabitants decrease in the new central station areas, connected also to a strong residential property values grown, as shown in the next paragraph. In the suburban station areas, a small population decrease accompanied the new transit system evolution. However, both in central and suburban station areas, the population variation near new station area are found to be higher than in no station areas, and superior to the municipality average values. The station areas where the absolute value of indexes variation are stronger are the one in which the stations had a more intense transformation effect, connected with the variation of accessibility quality.

Is important to underline that each area has evolved in time in relation at the specific urban, historical and functional context. Moreover, different years of the stations opening can have influenced the impacts intensities.

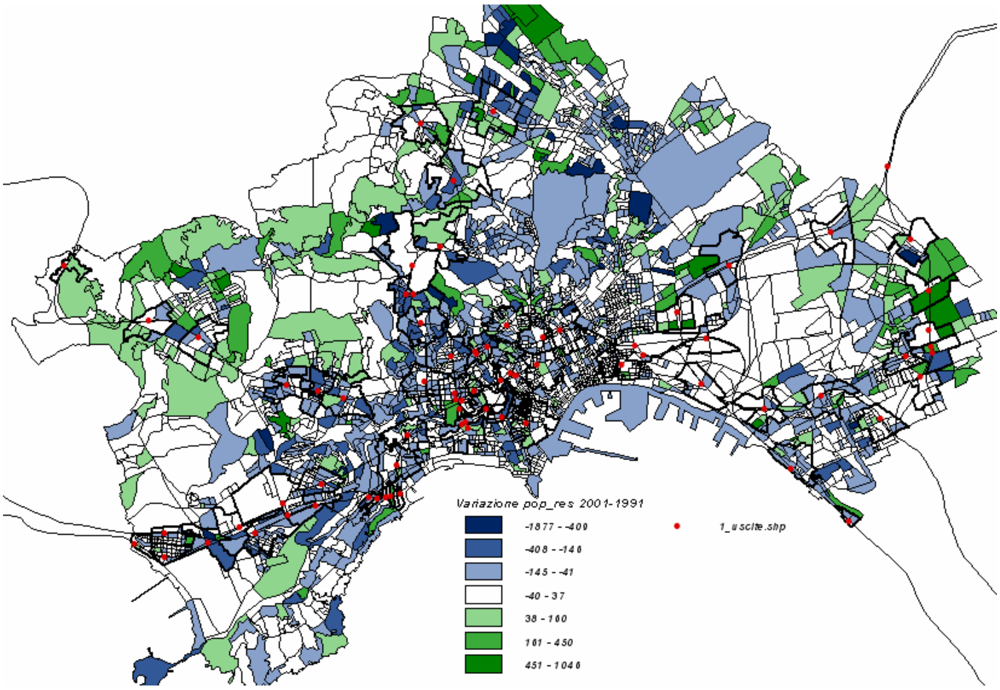

Fig.3. Resident variation in Naples, 1991-2001

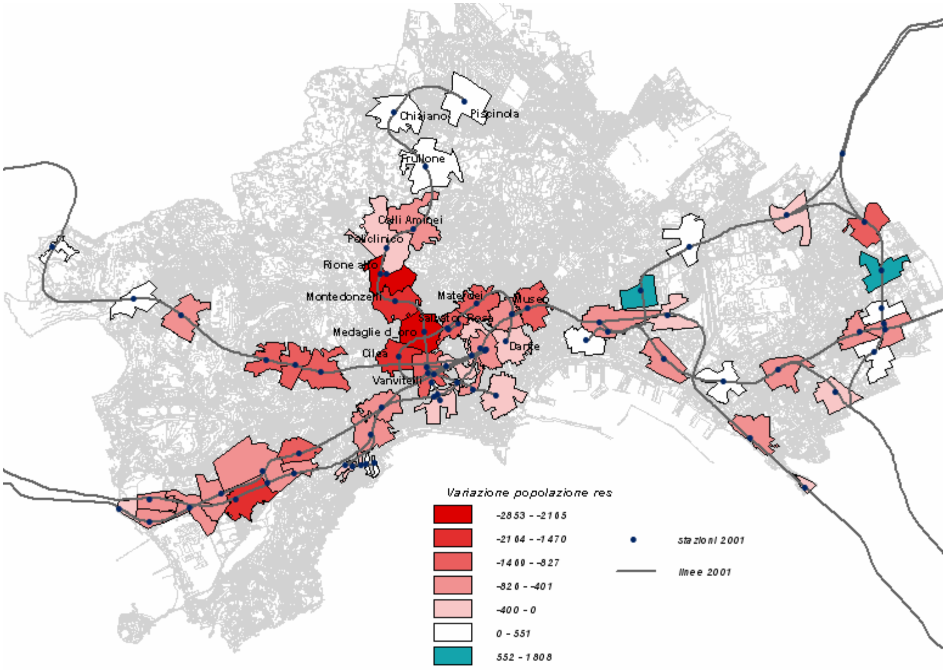

Fig.4. Resident variation in the rail station areas, 1991-2001

Table 3. Inhabitant's variations and context indicators in the Naples L1 station areas[2]: 1991-2001

Station areas	Station opening year	Location	Funzional mix 1991[3]	Network index 2001	Built area index 1991	Station users / line users 2001	Δ% station users 2001	Jobs 1991 (jobs)	Residents 1991	Residents 2001	Δ residents 1991-2001	Δ resident/ mean municipalty variation	Δ resident/ mean stations areas variation	Δ resident / mean L1 station areae variation	Δ residential density (res/ha)
Chiaiano	July 1995	suburban	10,561	54,649	0,219	**14,4**	**12,3**	401	5166	5215	0,9	3,063	0,121	0,059	-2,848
Cilea	April 2001	central	**77,866**	**100,030**	**0,401**	1,6	-	2948	**15594**	**14029**	**-10,0**	**-97,813**	**-3,872**	**-1,870**	**-46,579**
Colli Aminei	July 1993	semi-central	13,198	71,465	0,184	5,8	4,0	861	4058	3407	-16	-40,688	-1,611	-0,778	**-33,222**
Dante	April 2002	central	**114,344**	**96,460**	**0,620**	-	-	**7621**	7789	7470	-4,1	-19,938	-0,789	-0,381	-3,338
Frullone	July 1995	suburban	8,174	61,727	0,154	3,4	2,7	429	2876	3027	5,3	9,438	0,374	0,180	24,666
Materdei	July 2003	central	31,891	94,295	0,476	-	-	1905	**14471**	**13497**	-6,7	**-60,875**	**-2,410**	**-1,164**	**-35,457**
Medaglie d'Oro	July 1993	central	**77,044**	**104,248**	0,355	**17,0**	**16,9**	**4953**	**19592**	**17427**	**-11,1**	**-135,313**	**-5,357**	**-2,586**	**-35,665**
Montedonzelli	July 1993	semi-central	23,610	**91,414**	0,299	3,7	2,3	1729	**11281**	**9811**	**-9,3**	**-65,438**	**-2,591**	**-1,251**	**-44,681**
Museo	April 2001	central	**57,493**	**106,101**	**0,582**	3,8	-	**3886**	8279	7588	**-8,3**	-43,188	-1,710	-0,825	-23,352
Piscinola	July 1995	suburban	8,905	46,526	0,200	8,3	7,1	523	9759	**10144**	3,9	24,063	0,953	0,460	4,612
Policlinico	July 1993	semi-central	12,564	77,549	0,211	5,8	3,8	**9751**	742	690	-7	-3,250	-0,129	-0,062	-5,549
Rione Alto	July 1993	semi-central	**49,451**	81,053	**0,363**	**9,7**	5,5	1932	**19365**	**16512**	**-14,7**	**-178,313**	**-7,059**	**-3,408**	**-77,854**
Salvator Rosa	April 2001	central	23,811	**94,911**	**0,352**	6,0	-	1287	8768	7698	**-12,2**	**-66,875**	**-2,648**	**-1,278**	**-50,040**
Vanvitelli	July 1993	central	**78,195**	**116,437**	**0,487**	**26,0**	**19,5**	**4570**	9577	8660	**-9,6**	**-57,313**	**-2,269**	**-1,095**	**-43,538**
average			41,936	85,490	0,350	8,3	8,2	3057	9808	8941	-7,1	-52,317	-2,071	-1	-26,632
total			-	-	-	100	100	42796	137317	125175	-	-	-	-	-

2 Source: ISTAT 1991, 2001

3 Bold figures in the column represent higher mean in each group

5.2 Transit economic impacts in Naples

The main data source used for the transit economic impacts assessment in the Naples area are the “Agenzia del Territorio” data in 1994 and 2004, that concern property values for different property types (single family house, median house, offices, retails, industrial buildings). Each property value variation for a different type of property *t* is calculated as the mean variation of each census parcel *k* that belong to the station area and is measured in €/mq.

$$\mathrm{var}\,value_{it} = \sum_{k=1}^{p} \frac{value2004_{kt} - value1994_{kt}}{S_k \cdot p} \qquad (4)$$

p=number of census parcel *k* that belong to the station area *i*

S_k =extension of the parcel census *k*

t =property value type

The analysis show the property values to grown for different property types in the station areas faster than the urban municipality average. In the new and central subway stations, the prices increase faster and with higher intensity also because of other urban revitalization intervention localisations in these areas (urban renewal, new pedestrian areas, open spaces renewal), as for the new *Dante*, *Materdei*, and *Museo* “art stations”. In the suburban and semi central areas the property values grow less and slower than in other urban areas, and this can explain the decentralization phenomenon of the whole city of Naples.

As shown in the GIS layouts, these impacts are not uniform and occur with stronger intensity only where other economic conditions already favour these increases. For example in the GIS layout is clear the impact on new urban transformation in the property values grow in the Bagnoli area, in the west periphery, where a big ex-industrial area is being transformed into a new urban green area. .

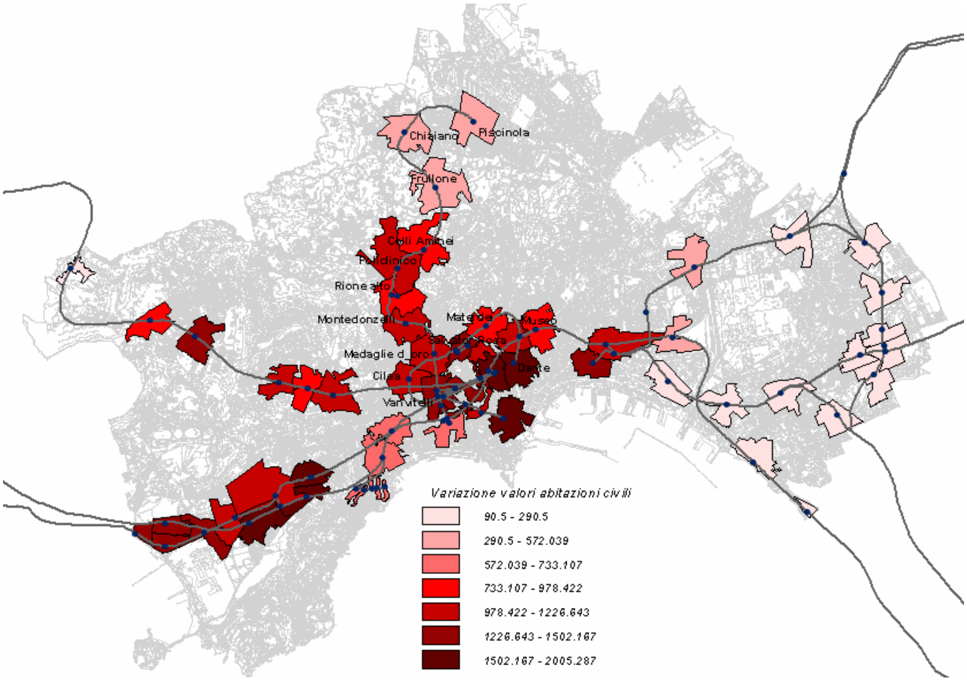

Fig. 5. *Property value variation of median house in the station areas 1994-2004*

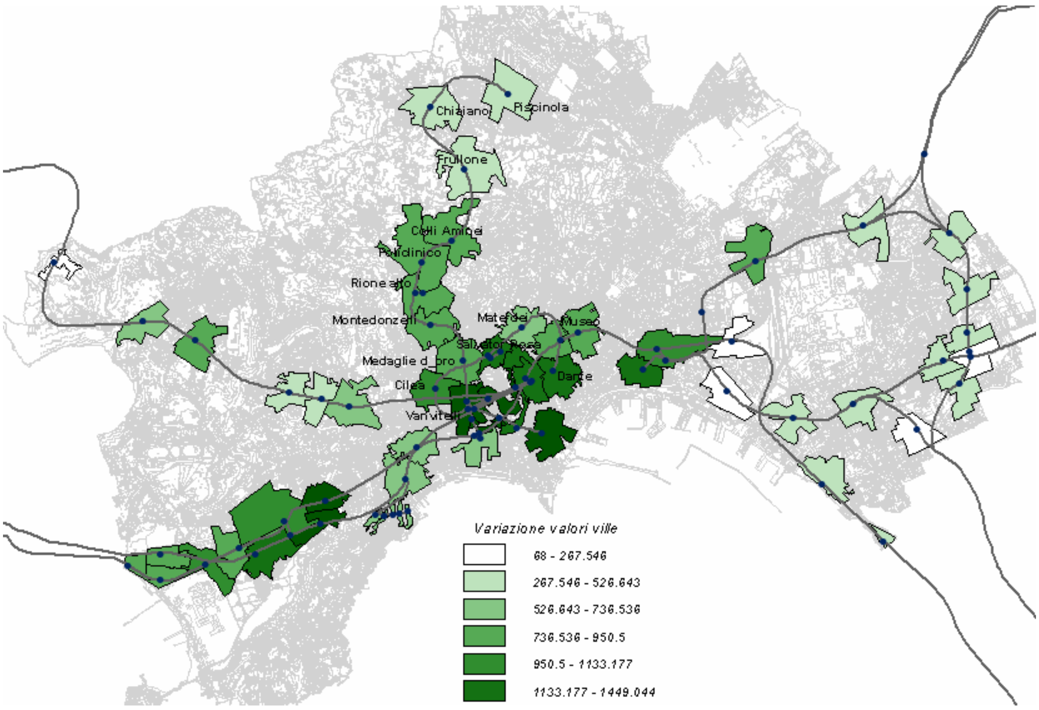

Fig. 6.*Single family house property value variation 1994-2004*

Table 4. Property values variation in the Naples L1 station areas: 1994-2004[4]

Station	Station opening year	location	Network index 2001[5]	Median house value 1994 (€/mq)	Δ % median house value	Δ median house value/ mean variation in the urban area	Apartment value 1994 (€/mq)	Δ % apartment value (€/mq)	Δ apartment value/ mean variation in the urban area	Parking space value 1994 (€/mq)	Δ % parking space value (€/mq)	Δ parking space value./ mean variation in the urban area	Single family value 1994 (€/mq)	Δ % single family value (€/mq)	Δ single family value/ mean variation in the urban area	Commercial space value 1994 (€/mq)	Δ% Commercila space value (€/mq)	Δ commercial space value/ mean variation in the urban area	Offices value 1994 (€/mq)	Δ% Offices value (€/mq)	Δ office value/ mean variation in the urban area	Industrial shed value1994 (€/mq)	Δ% Industrial shed value (€/mq)	Δ industrial shed value/ mean variation in the urban area
Chiaiano	July 1995	suburban	54,649	1084	50,6	0,65	1032	15,6	0,32	619	32,5	0,42	1472	28,3	0,57	2195	0,4	0,01	1162	40,5	0,64	439	20,0	0,91
Cilea	April 2001	central	**100,030**	**2324**	52,8	**1,45**	**2118**	39,1	**1,64**	**1601**	**46,4**	**1,55**	**3151**	31,3	**1,34**	**4028**	8,4	0,33	**2324**	**55,5**	**1,75**	-	-	-
Colli Aminei	July 1993	semi-central	71,465	1936	44,6	1,02	**1730**	35,3	**1,21**	**1549**	26,5	0,86	2195	40,3	**1,21**	**3744**	1,1	0,04	**2582**	13,9	0,49	387	**80,9**	**3,25**
Dante	April 2002	central	**96,460**	**2905**	58,3	**2,00**	**2647**	33,3	1,74	**2001**	23,8	0,99	**3938**	33,7	**1,81**	**5035**	**34,2**	**1,69**	**2905**	55,3	**2,18**	520	**50,2**	**2,71**
Frullone	July 1995	suburban	61,727	1084	52,8	0,68	1032	16,0	0,33	619	33,6	0,43	1472	29,3	0,59	2195	0,4	0,01	1162	42,6	0,67	439	19,8	0,90
Materdei	July 2003	central	94,295	1291	**69,8**	1,06	1162	48,4	1,11	955	**51,2**	1,02	1549	40,3	0,85	2840	10,0	0,28	1342	**65,7**	1,20	336	25,0	0,87
Medaglie d'Oro	July 1993	central	**104,248**	**2840**	43,0	**1,44**	**2582**	32,6	**1,67**	**1807**	40,9	**1,54**	**3486**	26,5	**1,26**	**4298**	7,3	0,31	**2711**	47,6	**1,75**	-	-	-
Montedonzelli	July 1993	semi-central	**91,414**	**2130**	54,5	**1,37**	**1903**	43,0	**1,62**	1704	40,2	**1,43**	**2415**	35,8	1,18	3119	7,9	0,24	**2841**	40,4	**1,56**	437	**71,6**	**3,25**
Museo	April 2001	central	**106,101**	1678	**63,6**	**1,26**	1511	38,0	1,13	1242	**69,3**	**1,80**	2014	**47,2**	**1,30**	**3693**	**26,6**	**0,96**	1745	**65,6**	**1,55**	437	**65,0**	**2,95**
Piscinola	July 1995	suburban	46,526	976	58,3	0,67	952	12,5	0,24	929	24,5	0,48	789	37,9	0,41	557	7,7	0,04	906	54,2	0,67	**1324**	4,4	0,60
Policlinico	July 1993	semi-central	77,549	981	**107,0**	**1,24**	878	**81,8**	**1,42**	619	**104,2**	**1,35**	1472	**59,2**	1,19	2582	10,2	0,26	1291	50,6	0,89	464	**63,1**	**3,04**
Rione Alto	July 1993	semi-central	81,053	2130	40,6	1,02	**1903**	32,1	1,21	**1704**	24,1	0,86	**2415**	36,6	**1,21**	3119	1,3	0,04	**2841**	12,6	0,49	426	**73,5**	**3,25**
Salvator Rosa	April 2001	central	**94,911**	1291	**97,1**	**1,48**	1162	**65,4**	**1,50**	955	**79,7**	**1,59**	1549	**82,6**	**1,74**	2840	**16,6**	**0,46**	1342	**95,6**	**1,74**	-	-	-
Vanvitelli	July 1993	central	**116,437**	**2969**	43,1	**1,51**	**2711**	25,4	**1,36**	**2195**	35,5	**1,63**	**4390**	36,3	**2,17**	**6972**	8,8	**0,60**	**3098**	41,2	**1,73**	-	-	-
media			85,490	1829,93	59,7	1,20	1665,93	37,0	1,18	1321,36	45,2	1,14	2307,64	40,4	1,20	3372,64	10,1	0,38	2018,00	48,7	1,23	520,90	47,4	2,18
totale				25619		-	23323			18499			32307			47217			28252			5209		

4 Source: Agenzia del Territorio 1994, 2004

5 Bold figures in the column represent higher mean in each group

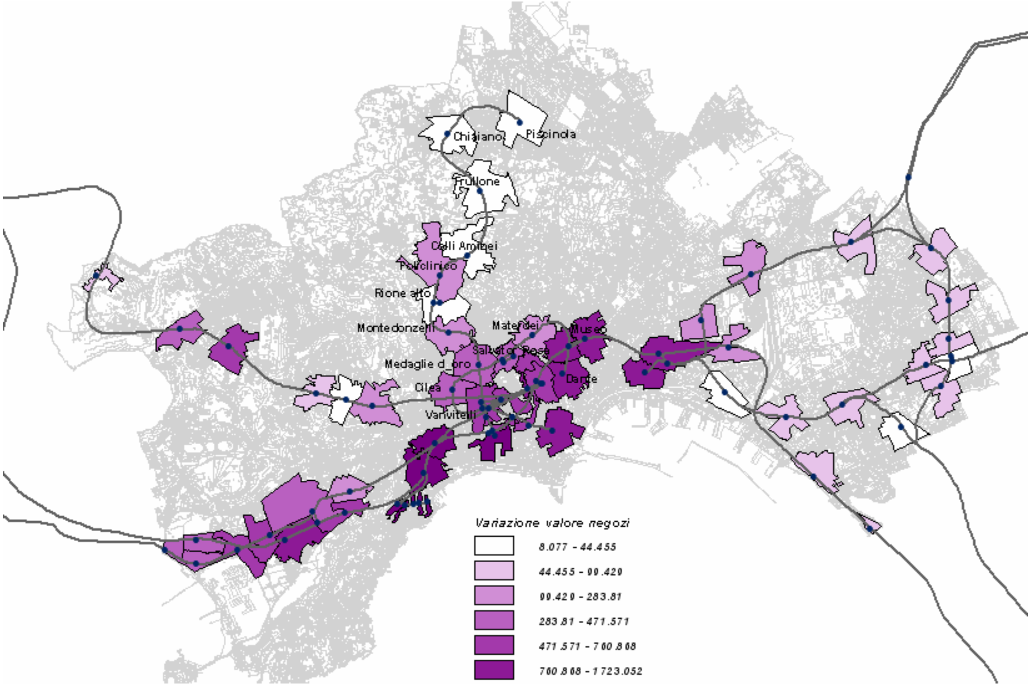

Fig.7. *Commercial space value variation 1994-2004*

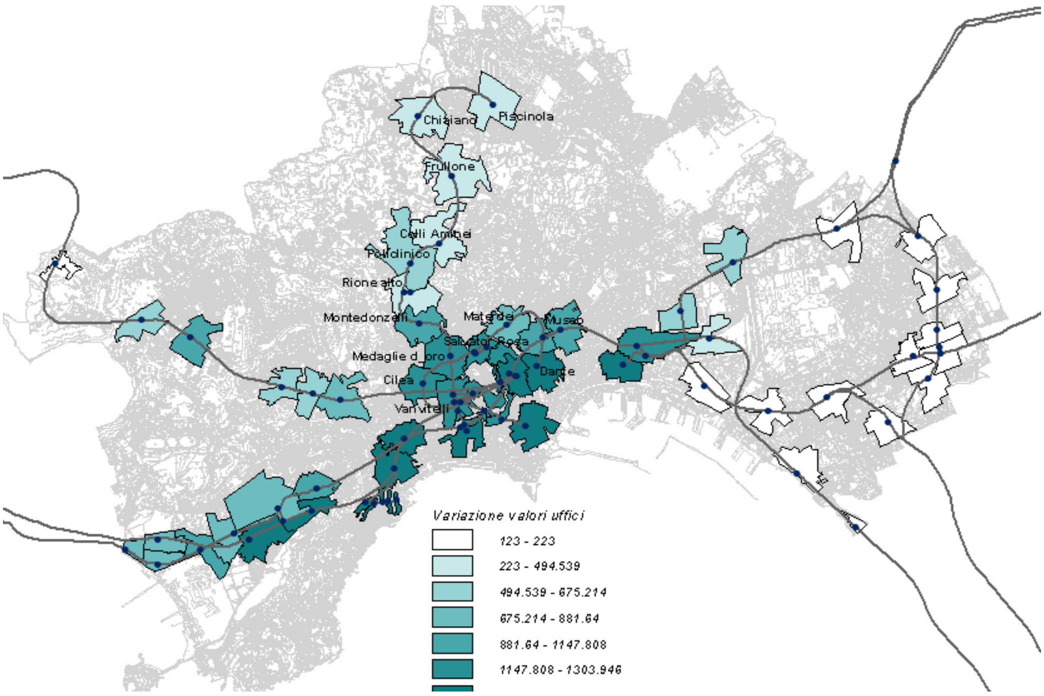

Fig.8. *Offices value variation 1994-2004*

5 Node-place model applications

The time-series and longitudinal data, with the support of GIS and simple statistical methods allow to underlines some particular aspect of the urban transformations connected with the transit network evolution. In particular in this section is applied the *node-place model* (Bertolini 1999) that provides an analytical framework to understand and measure the relations between two different aspects of the rail station. Each subway station can be considered both as a node of the rail transport network and as a place of the urban system. In order to study these different features of the station element, the node-place model allows representing two station indexes on a simple *xy* diagram. One axis value corresponds to a node index, which is a measure of the network accessibility of the station; the other axis value corresponds to a place index, which is a measure of the intensity and diversity of activities in the station area. In this study the model is applied not only to analyse the present `unsustained nodes' or `unsustained places' (Bertolini 1999 and 2003) in the actual urban situation, but also to analyse the stations area transformation in a time period and in relations to the whole station areas system.

In fig.10 is represented the scatterplot of the stations areas in a *xy* diagram, where the x value is the variation of resident number in each station area or the variation of the housing property values and the y value is the network connectivity index. The points inside the green-dotted eclipses are the new suburban station, that have a high variation o the connectivity index and at the same time a small positive variation of the population density in the station influence area. The points inside the blue eclipses are the new CBD stations, where the new stations opening went together with a land-use variation, with a decrease of the household density, a high increase of property values and a potential development of retails and offices areas.

These diagrams, which can be implemented also with other indicators, supply communicative and powerful decision support tools for the decision-making process in order to define integrated land-use transport interventions in the new and existing stations areas.

Another application of this model is the one proposed in the diagrams in fig. 10 and fig.11, where the *y* value is the network index as defined in (2) and the *x* value is a general place index measured as defined in (5). The three diagrams show the transit network evolution in the 1991-2001 time period and show the potential transformation of the urban station areas in the accessibility scenario in 2011, when the network will have 114 stations in total.

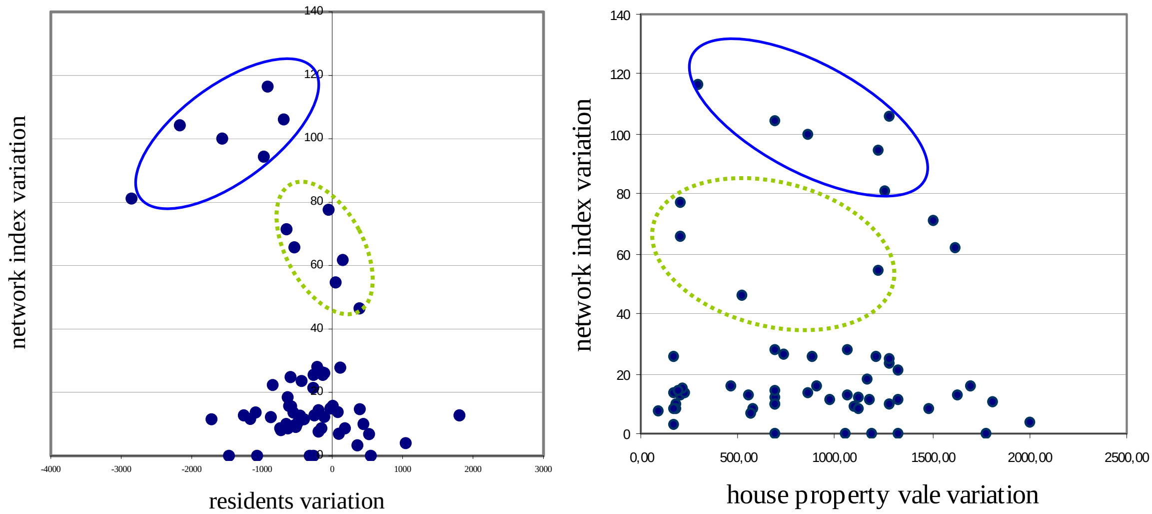

Fig.9. *population, property value and network index variation in the station areas*

$$placeindex_i = \sum_{k=1}^{p} mq_k(res) + mq_k(jobs) \tag{5}$$

$mq_k(res) =$ surface used for residential activity

$mq_k(jobs) =$ surface used for economic activities

From the future scenario representation, in fig.11, it is possible to define different station clusters; for example, the points inside the blue circle are the one that have a great transformation potentiality and the one that could attract private investments. From a more planning perspective, the diagram can also give some directions for different urban planning interventions and strategies in the new and existing station areas. The points inside the green-dotted lines are the one that have a high increase of accessibility, but are not used intensely in the present scenario; this means that the stations areas would need some proactive planning polices to be developed, according to TOD principles.

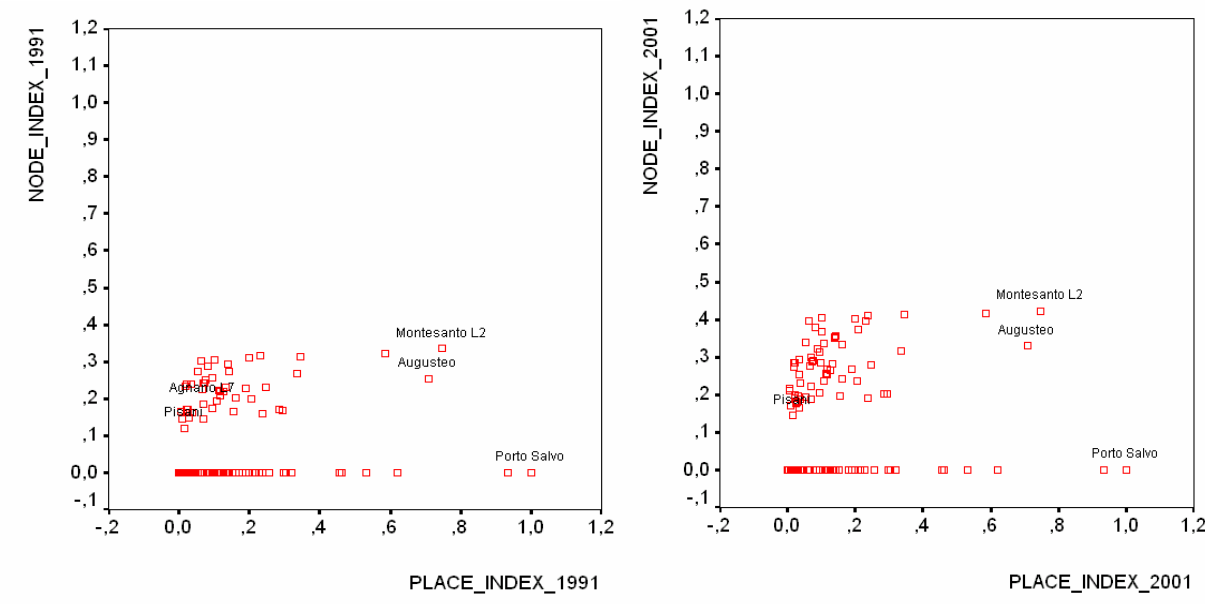

Fig.10. *network index and place index in 1991 e 2001*

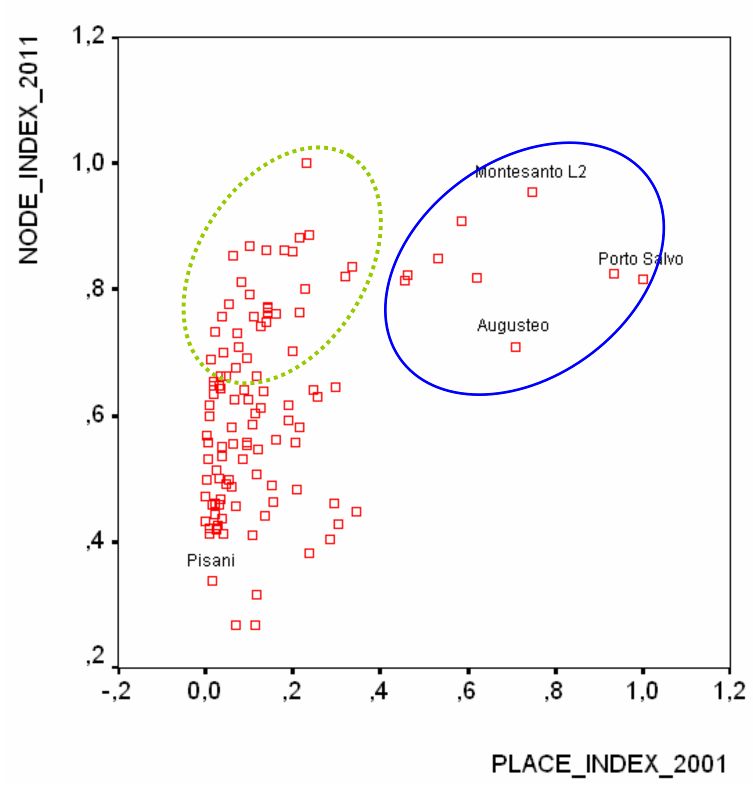

Fig.11. *network index in the 2011 scenario and place index at 2001*

6 Conclusion

The work has proposed a literature framework analysis on the transport and land-use interaction, with a particular attention to the transit role in the urban transformation process. With the aim of underlining some common aspects of these interrelation phenomena between urban transformation and transit system evolution, the paper has also proposed a comparative analysis of different relevant international experiences.

Therefore, with a GIS impacts assessments application, the study has analysed the Naples study case and some evidences on the transit land-use system have been verified in a quantitative way. Finally, the study has proposed some applications of the Bertolini node-place model in order to stress some impacts analysis elements and to provide a tool for the integrated transit-land-use interventions and strategies proposal. The results shown in the previous paragraphs give some interesting conclusions. In the Naples context, the new transit line had some negative impacts of the urban decentralization, increasing the general trend of sprawling (Belli, Russo 2005), reinforcing the urban central structure for offices and retails activities and shifting resident population in the suburban areas. It is clear that urban planning strategies have to take into account these transit effects and promote integrated land-use policies in the existing and future stations areas. Only a proactive land-use policy combined with transit investment decision can provide a more "desiderable" urban form. Promoting transit use and coordinating these policies with land-use planning is a sine qua non condition for permanent avoidance of aggravated urban transportation problems and for the creation of a liveable city (Vuchic, 1999).

The research agenda that follows these findings is as follow. To define a more sophisticated hedonic price model with the time-series and longitudinal GIS database. On the other hand to develop a more complete methodology for the urban planning interventions definition in the station areas and transit corridors, in order to define a SDSS for the transit-land use integrated planning and transformations management.

References

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

Arrington GB (1995) *Beyond the fields of dreams: Light Rail and grow in Portland* Portland OR Tri-met

Armstrong R (1994) Impacts of Commuter Rail Service as Relected in Single-Family Residential Property Values Transportation Research Board, 73rd Annual Meeting

Banister D (1995*) Transport and Urban Development* London Chapman &Hall

Banister D (2002) *Transport Planning* 2nd edition SPON Press

Banister D, Berechman (2000) *Transport Investment and economic development* London UCL Press

Bates J, Oosterhaven J (1999) *Review of Land Use/Transport Interaction Models*, DETR

Belli A, Russo M (2005) *L'area metropolitana nel contesto della pianificazione regionale*, in Indovina F, Fregolet L, Savino M (eds) *L'esplosione della città*, Editrice Compositori, Bologna

Berechmann J, Paaswell R (1983) Rail Rapid Transit Investment and CBD Revitalization: methodology and results *Urban Studies* 20: 471-486

Bertolini L, Spit T (1998) *Cities on Rail: the redevelopment of Railway Station Areas*, E&FN Spon, London

Bertolini L (1999) Spatial Development Patterns and Public Transport: the Application of an Analytical Model in the Netherlands *Planning Practice and Research*, 14, 2: 199-210

Bertolini L, Dijst M (2003) Mobility environments and network cities, *Journal of Urban Design*, 8, 1:23-43

Bertolini, L. & F.le Clercq (2003) Urban growth without more mobility by car? Learning from Amsterdam, multimodal urban region. *Environment and Planning A*, 35, 4, pp. 575-589.

Boarnet M, Crane R (1998) Public Finance and Transit Oriented Planning: New Evidence from Southern California *Journal of Planning Education and Research* 17:206-219

Bowes DR Ihlanfeldt K (2000) Identifying the Impacts of Rail Transit Stations on Residential Property Values, *Journal of Urban Economics*, 50:1-25

Burmeister A Jouignaux G (eds) (1998) *Infrastructures de Transport at Territoires approaches de quelques grand projets*, L'Harmattan, Paris

Calthorpe P (1993) *The Next American Metropolis: Ecology, Community and American Dreams* New York: Princeton Architectural Press

Cambridge Systematics Inc. (1999) *Quantifying the Impacts of a Light Rail Transit Station on Adjacent Property Values*

Cascetta E (1998) *Teoria e metodi dell'ingegneria dei sistemi di trasporto* UTET, Torino

Cascetta E (1995) *Metodi quantitativi per la pianificazione dei sistemi di trasporto* CEDAM, Padova

Chapin F, Kaiser E, Godschalk T (1995) *Urban Land Use Planning* Urbana IL: University of Illinois Press

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 (2001) Rail Transit's Value added: effect of proximity to Light and Commuter Rail Transit on Commercial Land Values in Santa Clara County California, Paper prepared for National Assosiacion of Realtors Urban Land Institute

Cervero R, Duncan M. (2002) Benefits of Proximity to Rail on Housing Markets, *Journal of Public Transportation*, vol. 5,1: 1-18.

Crampton GR (2003) Economic Development Impacts of Urban Rail Transport *ERSA2003* Paper 295

Davies L, Banister D, Hall P (2004) Transport and City Competitiveness - Literature Review Dft London

Diaz RB (1999) Impacts of Rail Transit on Property Values. *APTA 1999* Rapid Transit Conference Proceedings Paper

Gielge J (2002) Metro Extension and Urban Development in Vienna *TRANSPLUS Workshop*, ILS Dortmund

Giuliano G (1999) Land use impacts of transportation investments: highway and transit, in Hanson S (ed) *The Geography of Urban Transportation* 2nd ed. New York Guilford Press

Debrezion G, Pels E, Rietveld P (2004a) The Impact of Railway Stations on Residential and Commercial property Value, *Tinbengen Institute Discussion Paper* TI2004-023/3, Amsterdam

Debrezion G, Pels E, Rietveld P (2004b) *The* Effects of Railway Investments in a Policentric City, *Tinbengen Institute Discussion Paper* TI2004-089/3, Amsterdam

Department for Transport (2000) Social exclusion and the provision and availability of public transport. *Report from DfT Mobility Unit*.

Dittmar H, Ohland G (eds) (2004) *The new transit town. Best practices in transit-oriented development* Island Press, Washington

Fogelson R (1967) *The fragmented metropolis: Los Angeles from 1850 to 1930* Cambridge MA Harvard Univesity Press
Haider M, Miller E J (2000) Effects of transportation infrastructure and location on residential land values: Application of spatial-autoregressive techniques *Transportation Research Record*, 1722, pp. 1-8
Hall P, Marshall S (2000) *Report on Transport and Land Use/Development for Independent Transport Commission* London: University College London.
Huang W (1994) *The effects of transportation infrastructure on nearby property values: a review of literature* Institute of Urban and Regional Development, University of California Berkeley, CA.
Knight R, Trygg L (1977) Urban mass transit and land use impacts. *Transportation* 5, 1:12-24.
Laasko S (1992) Public transport investment and residential property values in Helsinki, *Scandinavian Housing & Planning Research* 9(2): 217-229
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 Systems. *Monograph 48*, Institute of Urban and Regional Studies, University of California at Berkeley.
Lucas K, Grosvenor T Simpson R (2001) *Transport, the environment and social exclusion* Joseph Rowntree Foundation.
Meyer M, Miller E (2001) *Urban Transportation Planning: a decision-oriented approach*-2nd ed, Mc Graw Hill, New York, NY
Middleton W (1967) *The time of the trolley* Milwaukee WI Kalmbach Publishing
Nelson P (1978) *Economic analysis of transportation noise abatement* Cambridge MA Ballinger
NEORail II (2001) *The effects of Rail Transit on Property Values: a summary of studies*
Newman PWG, Kenworthy JR (1999) *Sustainability and cities: overcoming automobile dependence* Washington DC: Island Press
Nijkamp P, Blaas E (1994) *Impacts Assessment and Evaluation in Transportation Planning*, Kluwer Academics Publisher
Parson Brinckerhoff Quade and Douglas (1996) *Transit and Urban Form* vols 1 and 2 TCRP Report 16 Washington D.C. National Academy Press
Parson Brinkerhoff (2001) *The effect of rail transit on property values: a summary of studies,* NEORail II, Cleveland, Ohio Research carried out for Project 21439S, Task 7 (Draft)
Rerearch Results Digest *(*2002) Transit-Oriented Development and Joint Development in the United States: A Literature Review *RRD* 52
RICS Policy Unit (2002) Land Values and Public Transport: stage 1- summary of findings
Rietveld P (1994) Spatial economic impacts of Transport Infrastructure supply, *Transportation Research A* vol. 28 4: 329-341
Roider O, Klementschitz R (2002) The socio-economic effects of the metro line “U3” in Vienna Institute for Transport Studies University of Bodenkultur
Sesame project (1998) Urban Form and Mobility D4: Report on analysis of relationship
TranSEcon Consortium (2003) *Urban transport and local socio-economic development*, Deliverables 4 and 5, (http://www.transecon.org)
Transplus Project (2002) *Land Use and Transportation Planning: experiences in European Cities*, TNO Report 2002-67
Vande Walle S, Steenberghen T, Paulley N, Pedler A, Martens M (2004) The role of Indicators in the Assessment of Integrated Land-Use and Transport Policies in European Cities *International Planning Studies* 9 2-3:173-196
Vessalli KV (1996) Land Use Impacts of Rapid Transit: a Review of Empirical Studies, *Berkeley Planning Journal* 11: 71-105
Vuchic V (1999) *Transportation for liveable cities* New Brunswick NJ CURP Press
Waddel P (2001) *Review of the Literature and Operational Models*, Cambridge Systematics, Inc
Wegener M (1995) Accessibility and Development Impacts, in Banister, D. (1995) Transport and Urban Development. London: E & FN Spon.
Wegener M, Fürst F (1999) Land-Use Transport Interaction: State of the Art. *Transland. Integration of Transport and Land Use Planning*. Work Package 2, Deliverable D2a. Institute of Spatial Planning, University of Dortmund, Dortmund.
Weinberger R (2001) Light Rail Proximity: Benefit or Detriment?: The Case of Santa Clara County, California. Presented at *Transportation Research Board 80th Annual Meeting*, Washington, D.C. January pp. 7-11.