# Assessing Urban Transformations: A SDSS for the Master Plan of Castel Capuano, Naples

Maria Cerreta and Pasquale De Toro

Department of Conservation of Architectural and Environmental Heritage, University of Naples Federico II, via Roma 402, 80132 Naples, Italy
{cerreta,detoro}@unina.it

**Abstract.** The objective of this study is to present a spatial simulation modelling of real estate effects caused by urban transformations. The proposed approach extends the formalization of the "Monte Carlo" simulation methods in Geographical Information Systems (GIS), including spatial structure and temporal dynamics. The combined application can be useful in spatial decision making process for urban planning, supporting and modelling operations for urban land-use change. Analysing the new functions for the redevelopment of Castel Capuano, an historic building in Naples (Italy), the paper explores possible scenarios of transformations identifying the effects on the urban real estate market.

**Keywords:** Spatial Decision Support System, Monte Carlo simulation, Real estate market, Naples (Italy).

## 1 Introduction

In the recent years, spatially explicit simulation models of urban growth patterns have emerged. The economic versions of these models estimate land-use transition probabilities using discrete choice methods based on the behavior of agents making land-use decisions. Spatially explicit models use data from a Geographic Information System (GIS) to generate spatially disaggregated predictions of land-use change.

In recent works economic models of land-use change have been developed that are both spatially explicit and disaggregate, so that predicted outcomes may be to link ecological models of landscape changes. These modelling efforts require detailed parcel-level and GIS data that are often not widely available, limiting the possibility to apply the models to a broader region or transfer them to other areas altogether. Indeed, controlling for spatial effects in micro-level necessitates a range of analytical modifications varying from modest changes in data collection and the definition of variables to dramatic changes in the modelling of consumer and producer decision-making [1]. The main advantage of considering a micro-level is the opportunity to extend from using data at a scale that corresponds to the economic decision of interest; micro-level models can spatially aggregate up individual-level decisions to other relevant scales (e.g. city, labour market, agricultural market, real estate market,

B. Murgante et al. (Eds.): ICCSA 2012, Part II, LNCS 7334, pp. 168–180, 2012.

etc.) provide a unique means to assess the consequences of individual decisions and to analyse the impacts of policies directly. Then, because the unit of observation corresponds with the scale at which the underlying spatial process takes place, data measurement problems are minimised, which reduces a source of spatial error autocorrelation [1]. At the same time, the opportunity to overlay multiple layers of spatial data using GIS gives flexibility to describe the spatial aspects of economic, social and environmental problems, conceptualising spatial effects or patterns and showing the temporal and spatial distribution [2]. Visualising the results of policy analyses in map form may offer valuable information about the distributional impacts of specific policies or the potential cost savings from geographical targeting [3] [4]. The continuous changes in data collection, variable definition and communication of results have proved quite complementary to standard, empirical economic research methods. On the other side, relevant changes are evolving from the adoption of spatial econometric models and estimation approaches [5] [6].

In some cases, the changes coincide with modifications to traditional regression models: they reveal common approaches to the applied economics literature and empirical research, inspiring both different models and empirical methods (such as agent-based, Bayesian and geographically weighted regression models, etc.). Spatial and spatiotemporal econometric methods modify the representation of *consumer* and *producer* decision-making by bringing attention to spatial interactions among these decision-makers [1] [7].

In order to assess the potential effectiveness of urban policies, in this paper we examine correlations between real estate market and urban transformation, underlying the need to develop a Spatial Decision Support System (SDSS) in order to analyse the different impacts and represent their spatial implications. Through the empirical investigation in an operative case study related to the effects of the Master Plan of Castel Capuano, in the historic center of Naples, in the South of Italy, it has been possible to elaborate a dynamic map of impacts on the real estate market, result of the integration of Monte Carlo simulation and GIS. The SDSS emphasises the spatial distribution of the urban use/cover units, the real estate values and the spatio-temporal patterns, which were modelled by urban use/cover change trajectories over a series of observation years. Using the integrated GIS, several spatial variables were derived, including the proximity to historic monuments, major roads and public areas/piazzas, but also to economic and training activities. A simulation model was implemented to establish relationships between urban transformations and above spatial variables, capable of estimating the spatial probability of the Castel Capuano transformation effects on local real estate market.

## 2 Castel Capuano Master Plan: Analysis of Urban Transformations

Castel Capuano is an ancient castle, located in the historic center of Naples and, in particular, in the area that, in 1995, was proclaimed by UNESCO “World Heritage”. In fact, the historical center of Naples has been listed as a UNESCO World Heritage

Site and the inscription refers to the extension of Old Town introduced with the approval of the General Plan of the city in 1972, and part of the historic city located in the new General Plan approved in 2004. The identification of new functions for Castel Capuano, not more a court since 2005, can be seen as part of a wider strategy for the redevelopment of the historic center, which could have a significant impact on the entire city, especially if interventions were to be activated with a high index of employment, to improve the socio-economic context (fig. 1).

In this perspective, the Management Plan of UNESCO sites, according to the Plan proposed by the Ministry of Heritage and Culture, explicitly provides for a phase of "integrated development", both cultural and economic, aims to promote the cultural value sites and emergencies affecting them, and to foster growth opportunities for enjoyment of all economic sectors and industries (tourism, hospitality, commercial, cultural, etc.).

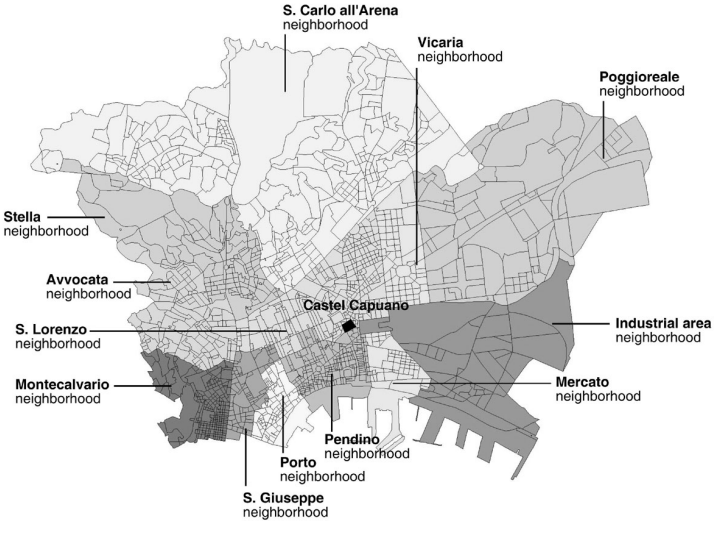


**Fig. 1.** Castel Capuano: localization in the historic centre of Naples

Protection and enhancement of historic and architectural heritage means, therefore, providing appropriate interventions to establish new functions that not only support the system of cultural heritage, but also the potential related to the existing socio-economic functions and/or future ones.

Taking into account the broader context of the city of Naples, the socio-economic framework and the proposed transformations, it was decided to evaluate the real estate impacts and the overall improvement of urban environment as a result of the settlement in the architectural complex of new functions.

In particular, the methodological process was articulated into the following phases:

1. *first phase*, in which it has been selected a preliminary set of socio-economic indicators, able to describe the characteristics of the urban environment in question, with reference to data already available from official sources. We

analyzed two main categories of indicators: the first category for the economic activities in the area of study, analyzing the dynamics starting from 2001 (year of the last Census Istat), the second category relating to real estate values recorded and available at Borsa Immobiliare of Naples, which define and characterize the study area, considering the trend over time too. The study area has been defined as a function of the characteristics and trends found in the course of the analysis of the data;

2. *second phase*, in which it has been constructed an adequate Geographic Information System (GIS), with the different types of data collected, useful to look at trends and possible relationships between the different variables considered, with reference to an area of influence within the perimeter of the selected study and significant for the determination of the impacts related to different activities. The GIS contains processed data available regarding the characteristics of the population and buildings, the presence of businesses and activities, with the number of employees, and the dynamics of the housing market, with reference to market values of transactions that took place. Specifically, data relating to real estate market consider the period between 2007 and 2010, divided into eight semesters, and refers both to houses (Market Value and Rental Value) and the shops (Market Value and Rental Value). The data on population, housing stock, businesses and activities refer to Istat Census 2001. All data are reported in detail for particles and are related to the census districts (or parts of neighborhoods) are considered significant for the study (fig. 2);
3. *third phase*, in which it has been examined the functions to be set up in terms of induced effects on the urban context, using tools of multidimensional assessments. By building simulation models of the impacts produced by the installation of the new features, we analyzed the likely consequences of urban change and tested the relevance of their implications. In particular, at this stage we have identified, described and assessed the significant effects of the intervention analyzing the context of reference through: a. the construction of suitable indicators, in order to describe the effects of the proposed transformations; b. the assessment of potential environmental, social, and economic functions of the proposals through the use of appropriate simulation models applied to the dynamics of real estate values.

In order to understand the dynamics of socio-economic context relating to Castel Capuano, has been defined the perimeter of the study area (fig. 2), selected from the available data.

The phases of the methodological path are summarized in the diagram of fig. 3, showing the relationships between the GIS and simulation models of the impacts, which are a prerequisite for the analysis of the two main scenarios: *Scenario 1*, which identifies the features of the environment after 2005, the year from discontinued original functions present in Castel Capuano; *Scenario 2*, which identifies the potential impacts on the environment analyzed in real estate dynamics, determined by the inclusion of new functions in Castel Capuano in synergy with some territorial changes already planned by the municipality.

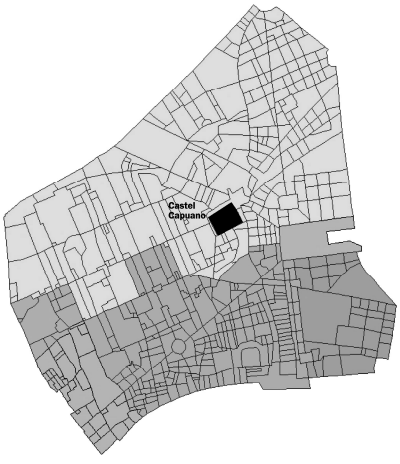


**Fig. 2.** Castel Capuano: perimeter of the study area

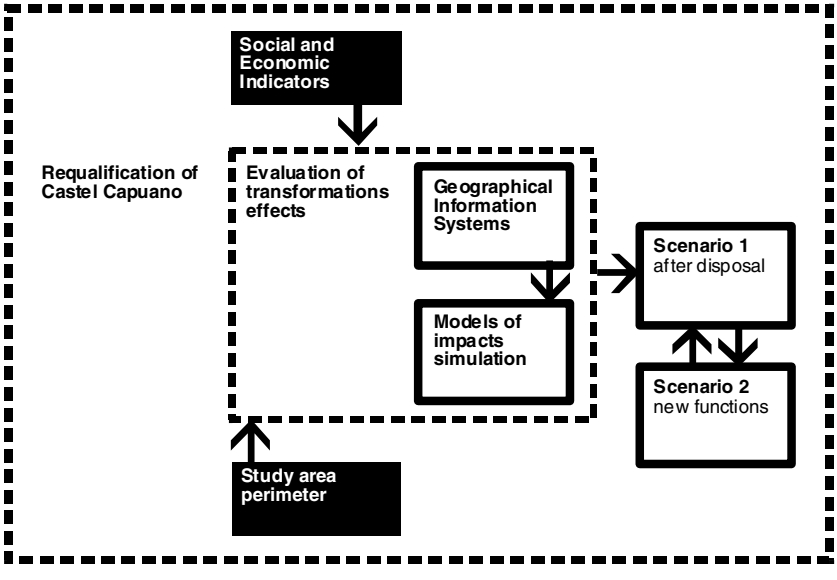


**Fig. 3.** The methodological phases

In particular, *Scenario 2* was projected to 2020, distinguishing between three possible developments: *2020 minimum scenario*, *2020 middle scenario* and *2020 maximum scenario*.

## 3 Evaluation of Transformations Effects: A Perspective to 2020

The cognitive framework, taking into account the socio-economic characteristics of the study area and the dynamics of the housing market, has identified the potential and the critical context affected by the changes envisaged for Castel Capuano, outlining the main features characterizing the Scenario 1 (see § 2), and refers to the period after 2005, the year of the original functions disposal.

In order to understand the impacts following the redevelopment, it has been analyzed the Scenario 2, which represents a projection in 2020 of three possible developments: a *low scenario*, an *intermediate scenario* and a *maximum scenario*. Therefore, Scenario 2 analyzes the features identified, considering the wider context of urban transformation.

Thus, the proposal to create a "Legal Culture Centre" evoking the previous functions, but hosting new activities full fitting the current needs of the community, together with the idea of turning part of the building into a museum and a training centre, has been examined referring to the possible impacts that the project could have on the surrounding urban context. In particular, the intervention strategy was focused on design alternatives that can balance the demands of functions for the Judiciary and Lawyers with those of a cultural tourism linked to a route developing along the Decumanus major, that recognizes Castel Capuano as a landmark for the eastern approach to the ancient centre of the city.

The functions identified by the Master Plan are related to the operations of transformation/valorisation provided at the municipal level. In particular, the "Plan of the 100 stations" aims to improve and redevelop the area served by the network of public transport, with interventions to get better the accessibility and quality of architecture and urban stations (such as the metro station of Porta Capuana), public areas and squares. Besides, places, car parks and bus stations are tourist "nodes" that form the modal interchange between the different transport services. Furthermore, the enhancement process suggested by the Master Plan fits consistently into the broader Integrated Program for the Historic Urban Center UNESCO Heritage that aims to enable development processes and significantly develop the environment and quality of life of residents.

Taking into account the different redevelopment strategies planned and in progress, it was possible to develop a scenario of future transformation of Castel Capuano and its context. The impacts assessment focused on the dynamics of real estate market projected to 2020, assuming the consequences that may occur following the implementation of the planned changes. In particular, using an appropriate simulation model of the impacts, which falls into the family of models of Monte Carlo simulation [8] [9] [10], integrated into the GIS platform, it was possible to analyze the dynamics of the rental value and market value, both of houses and shops, for three scenarios [11] [12] [13] [14] [15] [16] [17]:

1. *2020 minimum scenario*, where it is assumed that the transformations can have effects that do not significantly interact with the context;
2. *2020 middle scenario*, where it is assumed that the changes can get together with the context and result in significant effects;
3. *2020 maximum scenario*, where it is assumed that the transformations can be integrated with the social and economic context, resulting in a substantial improvement in quality of life and welfare conditions of the local community.

The three scenarios have been simulated referring to the average of the values found in 2010 and defining, within the study area, a radius of influence of 500 meters, useful to identify differences between the two main types of impact: *direct impacts* (within the radius of influence) and *indirect impacts* (outside the range of influence) (fig. 4). Indeed, it is believed that the planned changes can be more significant in the areas overlooking Castel Capuano less so in more distant areas. Clearly, the distance cannot be the only parameter to be taken into account, but it can help changing some dynamics closely related to economic and social uses.

Finding the area of influence has led to be take two different coefficients of simulation, two "risk coefficients" [18], one for the area inside the perimeter and another for the outdoor area, selected according to the socio-economic context and in analogy with other studies in structured contexts considered similar for both types of functions established and planned changes.

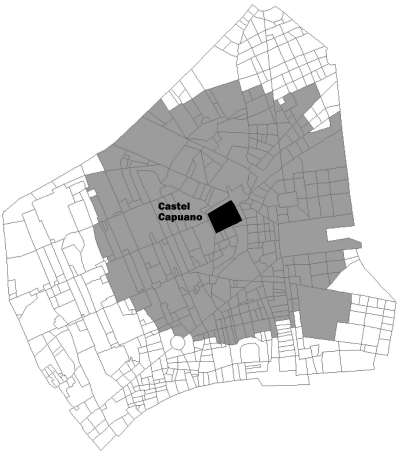


**Fig. 4.** The area of influence for the evaluation of direct impacts

Referring to the rental value of dwellings, for the three scenarios analyzed (fig. 5), it is possible to show how values have changed:

1. for the *2020 minimum scenario*, the rental values in the areas close to Castel Capuano are included within two main ranges, 4.98 to 5.67 euros/sqm and 5.68 to 6, 34 euros/sqm. The values do not differ greatly from those experienced in 2008 and 2009, but are lower than those recorded in 2010;

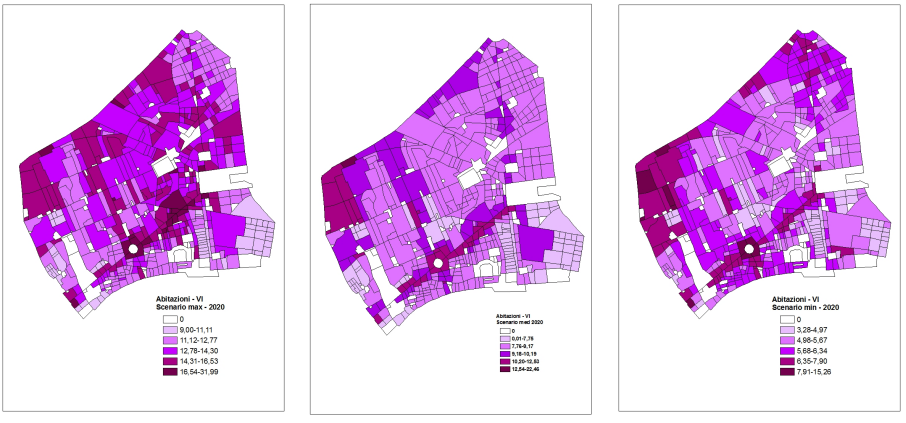


**Fig. 5.** Rental values of dwelling: three scenarios

2. for the *2020 middle scenario*, the rental values in the areas close to Castel Capuano are in the range 7.76 to 9.17 euros/sqm, with values slightly higher than those recorded in 2010. This result allows to emphasize that the ongoing changes have resulted in a steady improvement in economic and social environment and a slight recovery from the general state of crisis;
3. for the *2020 maximum scenario*, the rental values in the areas close to Castel Capuano vary more, identifying three possible ranges of variation (12.78 to 14.30 euros/sqm, 14.31 to 16, 53 euro/sqm, 16.54 to 31.99), the highest of which for a single particle census corresponds to the highest value expected in Piazza Nicola Amore. The maximum scenario, therefore, outlines a more dynamic perspective with effects that can make the areas near Castel Capuano more attractive.

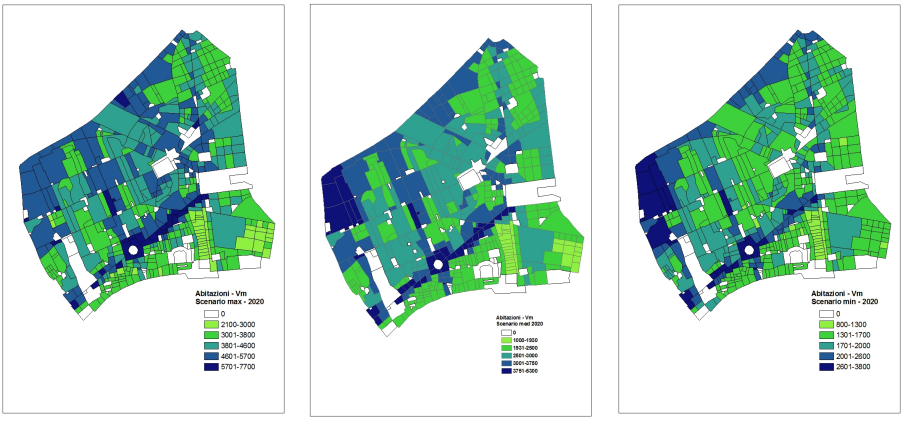


**Fig. 6.** Market values of dwelling: three scenarios

Referring to the market value of houses, analyzed for the three scenarios (fig. 6), it is possible to show that the values have changed as follows:

1. for the *2020 minimum scenario*, the market values in areas close to Castel Capuano are characterized by three main ranges of variation (1300-1700 euros/sqm, 1700-2000 euros/sqm, 2000-2600 euros/sqm). The estimated values are consistent with surveys conducted from 2007 to 2009, even if they present the lowest average;
2. for the *2020 middle scenario*, the market values in areas close to Castel Capuano are included in two main ranges of variation (2500-3000 euros/sqm and 3000-3750 euros/sqm), with values that are below the maximum values observed in 2010 (4000 euros/sqm);
3. for the 2020 maximum scenario, the market values in areas close to Castel Capuano appear divided into two main ranges of variation (3800-4600 euros/sqm and 4600-5700 euros/sqm). In this case, the values significantly increase in consistency with the implementation of strategies of transformation able to activate positive dynamics of development for the context.

Referring to the rental value of the shops, analyzed for the three scenarios (fig. 7), it is possible to show how values have changed:

1. for the *2020 minimum scenario*, the rental values in the areas close to Castel Capuano vary in two major ranges (11.29 to 14.7 euros/sqm and from 14.76 to 19.46 euros/sqm). The estimated values are consistent with the average values in the period 2007-2010 and that they are not affected by the possible positive effects of the planned changes;
2. for the *2020 middle scenario*, the rental values in the areas close to Castel Capuano are characterized by a single range of variation between the values from 17.82 to 27.08 euros/sqm; these values are very similar to those of 2010, which outline a pattern that does not significantly increase;
3. for the *2020 maximum scenario*, the rental values in the areas close to Castel Capuano are characterized by two main ranges of variation (26.60 to 35.65 euros/sqm and from 35.66 to 46.03 euros/sqm) which are definitely higher than the maximum values (25.30 euros/sqm) reported in the same area in 2010. In this scenario, the dynamics of the redevelopment can make the area more attractive for retailers.

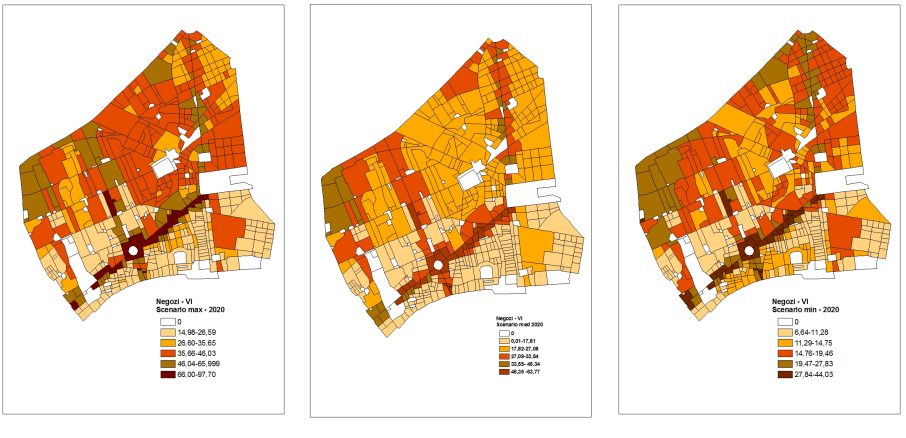


**Fig. 7.** Rental values of stores: three scenarios

Referring to the market value of the shops, analyzed for the three scenarios (fig. 8), it is possible to show that the values have changed as follows:

4. for the *2020 minimum scenario*, the market values in areas close to Castel Capuano vary between 2250-3130 euros/sqm, with a few examples of the lower interval (1100-2250 euros/sqm) and the higher (3130-4450 euros/sqm);
5. for the *2020 middle scenario*, the market values in areas close to Castel Capuano are characterized mainly by two intervals of significant changes to the values reported 3251-4100 euros/sqm and 4100-5450 euros/sqm, higher than values observed in 2010 and able to detect a slight recovery of the dynamic properties in the area in question;
6. for the *2020 maximum scenario*, the market values in areas close to Castel Capuano are characterized by a predominance of the value range 5400-7600 euros/sqm, with a few appearances in the range of lower values (3300-5400 euros/sqm) and the one with the highest values (7600 to 10900 euros/sqm). The highest values are, however, below the maximum ones in the same area in 2010, and indicate a significant difficulty in investing in businesses, as it emerges from the comparison with the maximum values found in Piazza Nicola Amore and that are in the range 16200-20900 euros/sqm.

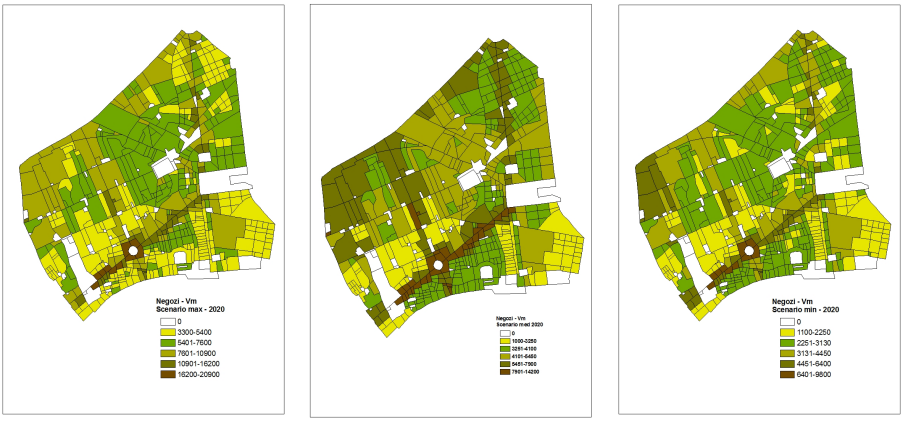


**Fig. 8.** Market values of stores: three scenarios

The *2020 maximum scenario* identify a perspective of development of the area cautiously optimistic, recognizing the opportunity that Castel Capuano becomes a catalyst in an area that currently suffers from various negative influences, due to the disposal of property, and a more general state of crisis and decay that characterizes the environment and the city. It is likely that the *2020 middle scenario* will outline a more realistic perspective of exploitation, that sees economic activities as leverages able to structure a system of synergies and mutual support.

In order to explore the potential of the intermediate scenario, two other simulations have been developed to compare the results of the *2020 middle scenario* with the average scenario of 2010, for both the rental value and for the market value of the stores (fig. 9).

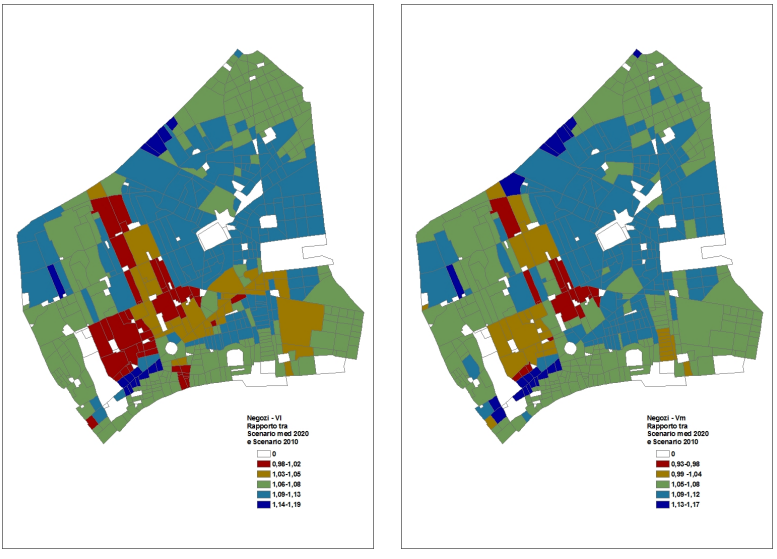


**Fig. 9.** Rental value of stores (€/mq) and market value of stores (€/mq): comparison between *2020 middle scenario* and average scenario of 2010

It was considered appropriate to carry out the analysis only on the values for the shops, because they are able to better reflect the impacts of urban change determined by the new functions located in Castel Capuano. The analysis of the maps shows that the change in value of location is in the range 1.09 to 1.13, and the change in market value considered interval 1.09 to 1.12. Basically the values are similar, allowing to define a common trend in increasing values, expression of the consequences envisaged after the implementation of planned interventions.

## 4 Conclusions

The results of the study highlight that the changes envisaged in the Master Plan for Castel Capuano are able to promote a process of active exploitation of the surrounding context, but need to relate to a broader and complex urban renewal strategy, capable to influence the social and economic fabric.

The application of Monte Carlo simulations of the variables, which are based on statistical measures and probability distributions, make it possible to incorporate the uncertainty of valuation parameters, in particular of future real estate values, using empirical data to extract information about the probability distributions of the related parameters and suggest a simple model to analyse the Castel Capuano transformation effects. Our empirical results suggest that simulations are expression of the distribution of values able to improve long-term decisions in real estate, but above all in urban transformation [18] [19] [20] [21].

From the analysis of impacts on the dynamics of real estate market, it seems clear that they can consolidate and increase according to the relevant values that characterize urban areas already considered as landmarks, such as Piazza Nicola Amore and Corso Umberto I. Therefore, it may be significant to establish relationships, tangible and intangible ones, including areas already known to lead the local economy and that are object of requalification, in order to define the common synergistic relationships aiming to get a total redevelopment of the city.

The results of elaborations emphasize the need to promote strategies and interventions that can be implemented at different scales, by acting on the monumental building, on minor building, on urban spaces and the system of connections, thereby establishing a relationship of constant interaction between the various interventions in order to implement a concrete process of development and enhancement of a relevant area of the city of Naples. Indeed, future studies will further investigate the impacts and interplay of different spatial variables on urban transformation patterns in order to analyse the interaction among use values, no-use values and intrinsic values that may also play important roles in Castel Capuano valorisation process.

## References

1. Bell, K.P., Timothy, J.D.: Spatial Economic Analysis in Data-Rich Environments. Journal of Agricultural Economics 58(3), 487–501 (2007)
2. Zhang, Z., Fan, S., Cai, X.: The path of technology diffusion: Which neighbors to learn from. Contemporary Economic Policy 20, 470–478 (2002)
3. Yang, W., Khanna, M., Farnsworth, R., Onal, H.: Is geographical targeting cost-effective? The case of the conservation reserve enhancement program in Illinois. Review of Agricultural Economics 27, 70–88 (2005)
4. Newburn, D.A., Berck, P., Merenlender, A.M.: Habitat and open space at risk of land use conversion: Targeting strategies for land conservation. American Journal of Agricultural Economics 88, 28–42 (2006)
5. Anselin, L., Florax, R.J.G.M., Rey, S.J.: Econometrics for spatial models: Recent advances. In: Anselin, L., Florax, R.J.G.M., Rey, S.J. (eds.) Advances in Spatial Econometrics. Methodology, Tools and Application, pp. 1–25. Springer, Berlin (2004)
6. LeSage, J.P., Pace, R.K. (eds.): Spatial and Spatiotemporal Econometrics, Advances in Econometrics, vol. 18. Elsevier Publishing, Oxford (2004)
7. Liu, H., Zhou, Q.: Developing urban growth predictions from spatial indicators based on multi-temporal images. Computers, Environment and Urban Systems 29, 580–594 (2005)
8. Kalos, M.H., Whitlock, P.A.: Monte Carlo Methods. John Wiley and Sons, New York (1986)
9. Kelliher, C.F., Mahoney, L.S.: Using Monte Carlo simulation to improve long term investment decisions. The Appraisal Journal 68(1), 44–56 (2000)
10. Kroese, D.P., Taimre, T., Botev, Z.I.: Handbook of Monte Carlo Methods. John Wiley and Sons, New York (2011)
11. Webster, C., Wu, F.: Coase, spatial pricing and self-organising cities. Urban Studies 38, 2037–2054 (2001)

12. White, R., Engelen, G.: High resolution integrated modelling of the spatial dynamics of urban and regional systems. Computers, Environment and Urban Systems 24, 383–400 (2000)
13. Appleton, K., Lovett, A.: GIS-based visualisation of development proposals: reactions from planning and related professionals. Computers, Environment and Urban Systems 29, 321–339 (2005)
14. El Yacoubi, S., El Jai, A., Jacewicz, P., Pausas, J.G.: LUCAS: an original tool for landscape modelling. Environmental Modelling and Software 18, 429–437 (2003)
15. Moreno, N., Ablan, M., Tonella, G.: SpaSim: a software to simulate cellular automata models. In: Proceedings of Integrated Assessment and Decision Support, First Biennial Meeting of the International Environmental Modelling and Software Society, Lugano, Switzerland, June 24-27 (2002)
16. Wu, F.: Simulating temporal fluctuations of real estate development in a cellular automata city. Transactions in GIS 7, 193–210 (2003)
17. Pang, M.Y.C., Shi, W.Z.: Development of a process-based model for dynamic interaction in spatio-temporal GIS. Geoinformatica 6, 323–344 (2002)
18. Hoesli, M., Elion Jani, E., Bender, A.: Monte Carlo Simulations for Real Estate Valuation. Research Paper 148. FAME, International Center for Financial Asset Management and Engineering, Université de Genève (2005)
19. Kelliher, C.F., Mahoney, L.S.: Using Monte Carlo simulation to improve long term investment decisions. The Appraisal Journal 68(1), 44–56 (2000)
20. Tucker, W.F.: A real estate portfolio optimizer utilizing spreadsheet modelling with Markowitz mean-variance optimization and Monte-Carlo simulation. Working paper. John Hopkins University Maryland (2001)
21. French, N., Gabrielli, L.: The uncertainty of valuation. Journal of Property Investment and Finance 22(6), 484–500 (2004)