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A model to define a real estate investment risk index for the administrative municipalities of Naples

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Abstract

Real estate redevelopment processes represent an important avenue for achieving sustainable development goals, but at the same time, they pose complex and opaque decision-making problems. Most existing risk assessment tools involve aggregate-scale analysis or require knowledge of extensive project financial data, which is often not yet available under ex-ante evaluation conditions. The aim of the work is to define a specific index through a spatial decision support system based on an innovative model that enables public and private entities to conduct effective ex-ante risk assessment at a sub-municipal territorial scale for public-private partnership risks. The proposed model adopts the flexibility of the Analytic Hierarchy Process (AHP) technique and the GIS system's ability to clearly display the spatial distribution of real estate risk.

Keywords: Real estate redevelopment processes; Risk assessment; AHP; GIS; Decsion-making processes.

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1. Introduction

The work pertains to the analysis of investment risk in real estate through the implementation of a synthetic indicator, named ISRR (Spatial Real Estate Risk Index), aimed at segmenting, at a municipal scale, the areas of Naples with the highest economic and financial risk based on the integration of the informative content of three criteria (Cacciamani, 2003): market, context, insolvency. The units of analysis consist of the ten territorial zones delineated within the City of Naples as administrative municipalities. In the digital age, where infodemics and big data pose significant risks in terms of information asymmetry and emphasize the importance of careful management of the available data, it is essential to assign the right priorities to the available information, condensing it into suitable dashboards of indicators that balance the trade-off between data synthesis and degree of approximation, also taking into account the adaptability and customization capability of the indicators specifically to the set investment objective. The dissemination and availability of information, together with the typical competitiveness of real estate markets, require investors to have adequate long-term strategic planning tools that accurately translate the investment objective into a coherent set of measures of the "commercial attractiveness" of urban territorial zones. For the aforementioned reasons, the proposed synthetic indicator not only allows for ex-ante analysis of the risk that would result from the investment undertaken but also provides a readily viewable rating on a georeferenced risk map of the areas under investigation, potentially accessible to private or institutional investors. Regarding the latter aspect, the level of generality of the model is such as to avoid arbitrary and *a priori* choices, providing the user with a decision-making tool adaptable to their investment objectives: from property leasing to the implementation of urban redevelopment projects. Furthermore, in the forms of public-private partnership, a precise definition of risk management connected to the projects becomes necessary during the tendering process, as a *conditio sine qua non* for their implementation, demonstrating the relevance of risk analysis and definition in the project phase (Abdelfattah, 2022; Anelli and Tajani, 2023; Saaty and De Paola, 2017).

2. Materials and Methods

The evidence from international literature shows that the determination of risk, understood as the estimation of the probability that a negative event, such as damage or loss, may occur at a given step of an investment project, is complex and without the possibility of establishing a unique level of risk outright. Therefore, the types of risk considered in the proposed model reflect the peculiarities of the urban area under investigation and the evolution of the economic situation that characterizes a quite broad retrospective period (2015 - 2023). This occurs without loss of generality, given the procedural protocol underlying the proposed risk analysis model (see Figure 1 and Table 1):

- Definition of the risk concept based on territorial specificities;
- Selection of the territorial scale;
- Identification of a set of indicators representative of the dynamics of phenomena affecting the metropolitan city of Naples, taking into account three distinct hierarchical levels, with their respective subsets of indicators describing each criterion, and where for each indicator, classes of variations defining the variability of each indicator (intensity-range) are defined;
- Data collection from informative sources (e.g., ISTAT; Municipality of Naples; Urbistat; Il Sole 24 Ore; Idealista; Immobiliare.it; TomTom Move; data acquisition from the "Sentinel" 2 and 5P network of the "Copernicus" satellite constellation; interviews with private and institutional subjects, etc.);
- Own elaboration of the collected data based on the explanatory variables of the model referred to in point 3, with specification of the criterion, the scale of measurement, and any interdependencies;
- Normalization of indicators with discordant units of measurement;
- Correlation analysis to identify and subsequently eliminate indicators that provide redundant information at the expense of the model's robustness;
- Determination of the number of variation classes for each indicator of the model that is representative of their variability; the composition of the classes is defined with the aid of percentiles and/or technical considerations derived from existing literature and an expert panel;

- Implementation of the Analytic Hierarchy Process for the computation of local weights (priorities) of the i-th considered variable, by creating 18 pairwise matrices respectively of order 6 for market risk indicators, 4 for insolvency risk, and finally 8 for those related to context risk (see Figure 2 and Table 1);
- Computation of the synthetic risk index for the administrative municipalities investigated based on the following equation, defined as the factorial product of the weighted sum of the local weights of the indicators and their respective variation classes for the i-th value assumed by the administrative municipalities, for each of which the calculation of the ISRR must be reiterated.

$$I_{SRR} = p_m(\sum_{n=1}^{n} v_{n,m} \cdot w_{n,m} \cdot i_{n,m}) + p_c(\sum_{n=1}^{n} v_{n,c} \cdot w_{n,c} \cdot i_{n,c}) + p_i(\sum_{n=1}^{n} v_{n,i} \cdot w_{n,i} \cdot i_{n,i})$$

$p_m = p_c = p_i = 1$ = local weights of the three criteria;
$v_{n,m}$, $v_{n,c}$, and $v_{n,i}$ = local weights of the n indicators related to market, context, and insolvency risks;
$w_{n,m}$, $w_{n,c}$, and $w_{n,i}$ = local weights of the m variation classes related to the *n* indicators considered;
$i_{n,m}$, $i_{n,c}$, and $i_{n,i}$ = values assumed by the *n* indicators for each administrative municipality investigated in Naples;

- Normalization of ISRR values using the min-max technique to bring them into the interval [0,1];
- Sensitivity analysis to test the robustness of the model;
- Ranking of ISRR values and graphical representation of the results in a georeferenced risk map using the Google MyMaps GIS system to improve the readability of the results.

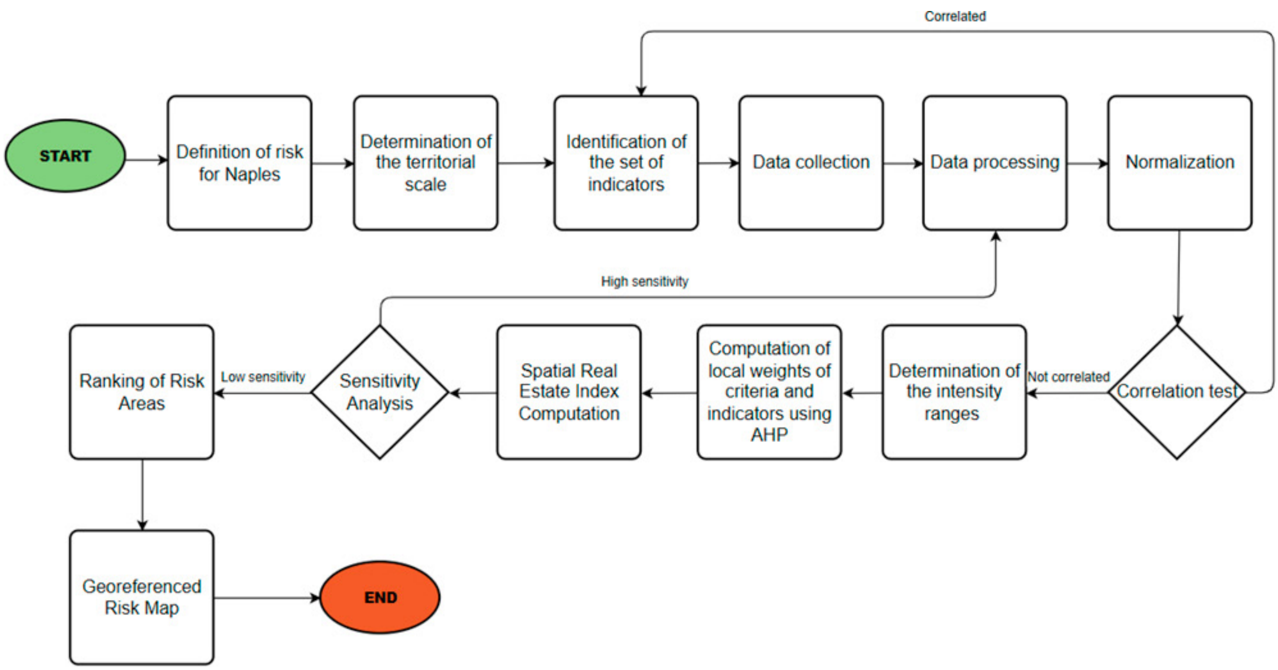

Fig. 1. Flow-chart of the model.

The indicators used in the study are synthetically represented in Table 1, where the sign indicated in parentheses refers to the proportional relationship with the real estate investment risk indicator (Del Giudice and De Paola, 2014a, 2014b, 2014c, 2016a, 2016b; Del Giudice et al., 2020, 2021, 2023; Forte et al., 2018, 2019; Manganelli et al., 2016, 2018, 2022). The adopted weights are listed in Table 2.

Table 1. Summary of the indicators.

Indicator	Description	Risk	Sources of raw data
TRES (−)	Trend in real estate prices for the residential market segment	**Market**	Own processing on Urbistat data (2023) and Regional Statistics of Italian Revenue Agency (2015 - 2023)
TRV (−)	Trend in rental market values for the residential market segment	**Market**	
NTN (−)	Number of Normalized Transactions with respect to the share of property sold, which occurred in a given period of time. It represents the market dynamics	**Market**	
AVS (+)	Average sales time for real estate units in the residential sector	**Market**	
VREV (+)	Volatility of real estate prices	**Market**	Own processing based on data from the TRES indicator
VRV (+)	Volatility of rental market values	**Market**	Own processing based on data from the TRV indicator
Attractivity (−)	Level of attractiveness in terms of job opportunities	**Context**	Own processing on ISTAT data (2021)
Services within 15 minutes (−)	Connectivity level of the zone to the main urban services within 15 minutes	**Context**	Own processing on Urbistat data and API of Google Maps (2023)
Building Maintenance (+)	State of conservation of properties (extraordinary building maintenance expense)	**Context**	Own processing on Urbistat data (2023) and Istat data (2001-2011)
Urban Decay (+)	Level of decay of public and private structures	**Context**	Own processing on data from the Municipality of Naples - Statistical Services and Demographic and Economic Studies Service of the City, and Istat relating to the population census (2001-2011)
Pollutant Concentration (+)	Pollution level	**Context**	Own processing on SciHub Copernicus data, Sentinel 2 and 5P data acquisition with observation period 2022-2023
Index of social hardship (+)	Aggregate index that measures the degree of socioeconomic well-being	**Context**	Own processing on demographic statistics data from the Municipality of Naples (2011), SciHub Copernicus (2023)
Public Green Areas (−)	Measurement of air quality based on the percentage of urban green coverage	**Context**	Own processing on SciHub Copernicus data and Sentinel 2 data acquisition (2023)
Traffic Index (+)	Level of vehicular congestion on the road network measured in terms of average time in traffic	**Context**	Own processing on TomTom Traffic data with observation period 2022-2023
Purchasing Power (−)	Measurement of the propensity to purchase a real estate unit	**Insolvency**	Own processing on Urbistat data (2023)
Housing Rent vs Property (+)	Measurement of the economic potential of the population	**Insolvency**	
Potential Demand (−)	Measurement of the catchment area potentially interested in the acquisition of housing units	**Insolvency**	
Unemployment Rate (+)	Index of the economic-financial stability of the catchment area	**Insolvency**	Own processing on ISTAT data (2023)

GOAL	Real Estate Risk Index																	
TYPES OF RISK	Market						Context							Insolvency				
INDICATORS	TRES	TRV	NTN	AVS	VREV	VRV	ATTR	15MIN	MAIN	URBDECAY	POLL	SOCIAL	GREEN	TRAFFIC	PURCHASE	RENTvsPR	DEMAND	UNEMPL
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
INTENSITY RANGE	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7

Fig. 2. Structure of the AHP for the computation of local weights (priorities).

Table 2. Summary of the priorities derived from the AHP.

Indicator	Local Weights
Public Green Areas	0,05
Attractivity	0,06
Urban Decay	0,02
Index of Social hardship	0,08
Building Maintenance	0,27
Services within 15 minutes	0,06
Traffic Index	0,23
Purchasing Power	0,22
Potential Demand	0,28
Pollutant Concentration	0,02
Housing Rents vs Property	0,24
Unemployment Rate	0,09
NTN	0,11
TMFV	0,05
TRES	0,20
TRV	0,17
VREV	0,17
VRV	0,07

3. Results

The main results of the proposed model consist of a georeferenced map in a GIS environment showing the risk level for the administrative municipalities of Naples based on the ISRR indicator, as well as a textual summary of the ranking of this indicator. These results have been validated through subsequent sensitivity analysis, in which the model has proven to be robust in terms of variable weight stability, showing no significant variations in the first and last 25% of index values, respectively, in high-risk areas (former Italsider industrial areas in Bagnoli) and low-risk areas (upper

Vomero). It follows that any scenario variation attributable to potential investor subjectivity does not affect the obtained ranking (see Figure 3).

The possible operational implications of the conducted study, which also reflect its innovative aspects, consist of:

- Collection and rationalization of a vast wealth of environmental, economic, and sociodemographic data not easily obtainable about the city of Naples, resulting from heterogeneous sources, including the acquisition of satellite data for estimating physical observables that have completed the overall knowledge framework of Naples's administrative municipalities.
- Establishment of a dashboard of indicators that portrays, from unprecedented perspectives, the state of the art of Naples as of the latest census of 2021, through a multidisciplinary approach introducing variables aimed at assessing the environmental and economic sustainability of municipalities concerning the latest and most innovative urban models (including the "15-minute city") and in line with the objectives set by the Agenda 2030.
- Application of a predictive system, capturing not only investment risk on a spatial basis but also predicting the return on the transformation value of sub-municipal realities compared to trend urban models, including the aforementioned "15-minute city".
- Zoning on multiple thematic risk levels of the city of Naples with a georeferenced map that, due to its graphical immediacy, provides easily accessible results for investors or stakeholders interested in public-private partnerships; based on the achieved results, the model can generate thematic maps that can be adapted to different scenarios and investment needs of a variety of stakeholders, following adequate assessment of investor desiderata.
- Possible reuse of the risk analysis results for monitoring the progress of urban redevelopment projects in the municipalities of Naples.

In the Table 3, the indication of high and low-risk bands of the administrative municipalities of Naples under investigation is provided, also with reference to the sensitivity analysis of the model where, alternatively, each criterion (market, context, insolvency) has been predominantly considered compared to the others (+100%).

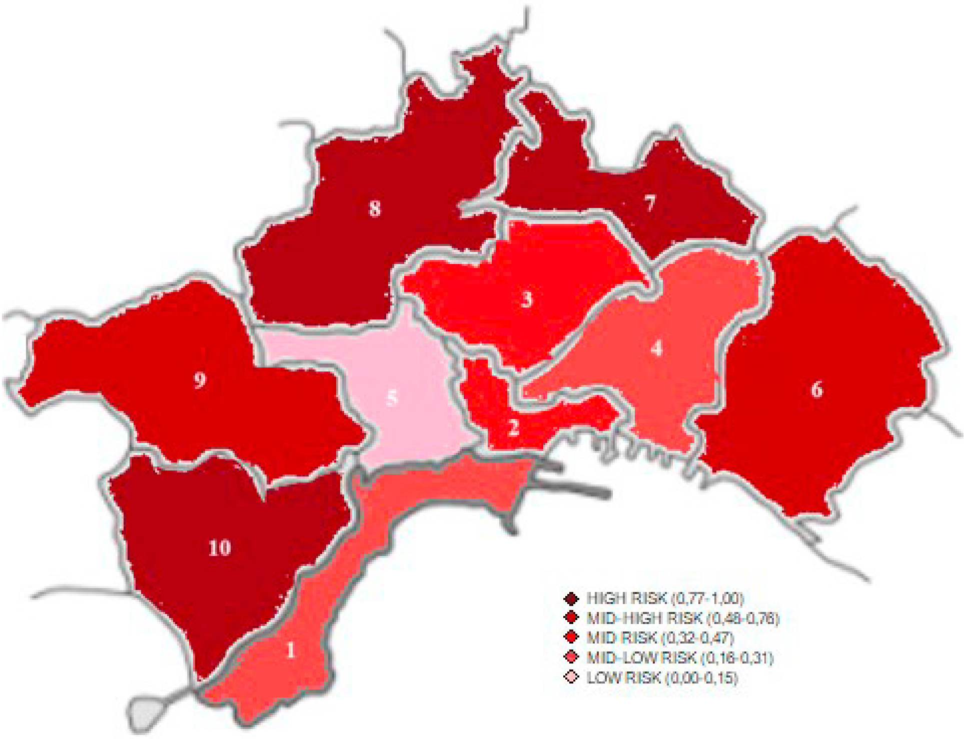

Fig. 3. Georeferenced map.

Table 3. Sensitivity analysis

BASE SCENARIO		MARKET ORIENTED		CONTEXT ORIENTED		INSOLVENCY ORIENTED	
Municipality	I_{SRR}	Municipality	I_{SRR}	Municipality	I_{SRR}	Municipality	I_{SRR}
7	1	7	1	7	1	7	1
10	0,89	6	0,83	8	0,83	6	0,75
8	0,84	10	0,83	10	0,79	8	0,71
6	0,71	8	0,8	6	0,61	10	0,7
9	0,56	9	0,56	9	0,46	9	0,49
3	0,36	3	0,33	3	0,33	3	0,33
2	0,24	2	0,19	4	0,25	2	0,3
4	0,22	1	0,16	1	0,23	4	0,28
1	0,19	4	0,15	2	0,21	1	0,21
5	0	5	0	5	0	5	0

4. Concluding remarks

The municipality identified by the study as the highest-risk area in three out of four computed scenarios, corresponds to the former Italsider areas, which marked the era of industrialization in Naples, leaving a deep scar that reverberated not only on remediation costs due to soil pollution but also on property valuations. Currently, debates are ongoing regarding the removal of the so-called “colmata a mare”, or a concrete platform and waste material from the blast furnace built in the 1960s to support the expansion of Ilva-Italsider industrial area. After the plant’s closure, the structure remained in place, becoming a subject of debate for remediation efforts.

Conversely, in lower-risk areas lie the Spanish Quarters, whose revitalization over time, also spurred by commercial initiatives like B&Bs, as well as the intrinsic folklore of the area, has shed light on the potential for tangible returns on investments, given the influx of tourists crowding the alleyways of the neighborhoods and surrounding areas.

Therefore, empirical and contextual results have affirmed the validity of the real estate investment risk synthetic index, providing potential investors with a customizable dashboard of indicators tailored to desired detail levels and urban redevelopment plans. The model is subject to improvement, and progress in research could drive the implementation of corrections and/or enhancements towards data fusion, which, for most indicators, has allowed for precise estimates aligned with the actual investigated situation.

A potential future horizon could involve automating processes, previously done manually, through scripting in Python, thereby establishing a scalable database over time. By doing so, instead of merely capturing a snapshot of the areas under investigation, the indicator would be capable of providing real-time updates on characteristic trends in the real estate market.

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