A Methodological Approach for the Parametric Assessment of Residential Construction Costs

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Abstract. This study proposes a methodological approach for the parametric estimation of construction costs in the residential sector, with particular reference to the Italian regulatory and economic context. Through the analysis of five case studies, the developed methodology allows for the organic structuring of cost items by means of a classification in working clusters and intervention categories, integrating the different typologies of surfaces in the calculation of the unit construction cost by taking into account appropriate homogenization coefficients with respect to the gross usable surface. The model is configured as a strategic tool for investors and public administrations, able to support economic planning and resource optimization in decision-making processes.

Keywords: Construction costs · Valuation · Residential property · Cost assessment

1 Introduction

This research intends to provide an operational tool for the synthetic evaluation of construction costs of residential buildings, within the current framework of the ecological and digital transition that imposes relevant evolutions in the construction sector, especially in Italy, where regulatory regulations differ among the regions.

In order to elaborate a best-practice framework on the parametric assessment of construction costs of new residential units in the national and local scale, the different regional regulations that establish subsidized construction costs [1] for social housing have been consulted. With reference to the Lazio region, this survey highlights that the reference construction costs are not consistent with current market conditions.

Taking into account the various entities involved in the building process, the purposes for which construction cost estimation is implemented are multiple: *i)* for the client (contracting authority in the case of public works), the objectives concern the determination of the order of magnitude of the expenditure, the definition of the financial plan of the works and the evaluation of the monetary amount to be considered for the awarding of contracts; *ii)* for the contractor, it is a matter of quantifying the tender, planning the

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payment schedule and the organization of the site and the sequence of operations to be carried out; *iii)* for the designer, it is essential to compare the project alternatives, in order to choose the "best" solution and to calibrate it according to the needs, requirements and performance within the budget constraint [2].

Considering the objectives for which the evaluation is being developed, stakeholders implement various tools for estimating construction costs (official price lists, price analyses, companies' price lists, etc.). The analytical procedure for estimating costs requires the development of an Estimative Metric Computation (CME), which involves the association of unit prices taken from official regional price lists with the quantities of the different categories of work required for the realization of the project.

An accurate cost analysis relies on the quality of information data, which is very often characterized by poor availability, especially when referring to an *ex post* cost evaluation. Within the project lifecycle, the evaluation of construction costs is included in several phases, from the first one of the conception of the project idea to the final phase of its decommissioning, with different purposes.

In the Italian context, starting from a rough estimate in which the order of magnitude of the overall costs and the amounts referring to the main categories of works to be realized are determined, the two design levels allow for a progressively decreasing tolerance of error, as the project becomes more detailed and the cost assessment tools are improved. Art. 41. of the Public Works Contracts Code Legislative Decree no. 36/2023 [3] regulates the articulation of the design according to two levels of technical detail, i.e. the technical-economic feasibility project and the executive project. Therefore, the assessment of the implementation costs of new construction projects follows the increase in technical detail that characterizes the different design levels. In fact, the *ex ante* assessment of intervention costs aims to determine the most likely costs associated with the different operations of which the construction of the building object is composed [4].

Over the past decades, the need for accurate and objective cost assessments has grown significantly. The thorough evaluation of project costs constitutes a cogent challenge, which could affect the performance of the project and its ultimate success [5]. The risks of cost overruns in relation to estimated costs are very high in the construction industry: therefore, an effective cost control process should allow for limiting excessive differentials between the two cost items. Clearly, the contingency of excessively high costs over the budgeted costs significantly affects the feasibility of the entire initiative.

In the relevant scientific literature, the cost analysis is also addressed in the search for the existence of a possible variation in the selling prices of dwellings generated by the amount of construction costs required for the building, which are currently calculated in relation to the gross built-up area (SUL) [6–9].

2 Research Purposes

This research has three main objectives, strictly connected each other.

In primis, it is intended to provide an up-to-date reference on the construction costs of new residential building projects in the territorial contexts examined, through the analysis of representative building works and their systematization in synoptic sheets, in order to return a transparent, clear and traceable comparative picture [10–14].

The second objective concerns the determination of the percentage contribution of the different intervention categories to the total construction cost. In this way, it will be possible to have an idea of the "weight" of the different construction subdivisions, making it possible to act, according to the project budget, on the different areas of intervention depending on specific targets of the client and/or contractor.

The third objective is to sort out a *vulnus* in the estimation of parametric construction costs. While there is in fact a summary procedure for the saleable surface, in which the consistencies of the ancillary areas are transformed into additional main surface (SUL) by means of coefficients which reflect the commercial values due to the reference market context, a methodology for the determination of the construction cost value referring to a unit surface that also includes the ancillary areas by means of appropriate homogenization coefficients with respect to the SUL is missing in the literature. Therefore, through the development of a logical-deductive methodological approach, articulated in different phases implemented on the selected case studies, a new parameter useful for the definition of the unit construction cost is defined, to enucleate the relative financial weight of the various components ("working clusters") of the construction work. The developed methodology may constitute a *vademecum* for estimating, monitoring and updating the construction costs of residential interventions, acting as an operational tool useful both in the design phase and in the economic management of interventions.

The adopted approach integrates empirical analysis with the development of methodological tools, with the aim of supporting planning and economic evaluation, promoting more conscious, efficient and sustainable practices in the estimation and verification of construction costs [15].

The research is structured as follows. Section 3 describes the developed logical-operational methodological approach. Section 4 describes the case studies, located in two Italian regions, in order to highlight possible differences in the outputs not only in terms of the design but also in terms of the market context. Section 5 illustrates the application of the proposed methodology and the resulting results. Finally, in Sect. 6 the conclusions and the practical advantages of the proposed methodology are discussed.

3 Methodology

3.1 Phases

The methodology developed consists of seven steps (Fig. 1):

- *Step 1*: Analytical study of the final-execution level project drawings and the CMEs of the endorsed case studies. For each case study, the following aspects have been verified: *i)* the congruity of the measurements indicated in the CMEs and those detectable from the project, *ii)* the correspondence of the codes and descriptions referred to in the CMEs for each work with those reported in the reference price lists, iii) the reliability of the new prices indicated in the CMEs for specific works, through an appropriate market survey.
- *Step 2*: For each case study, the following was carried out: *i)* the disaggregation of the working clusters that contribute to defining the project (balconies/lodges, vertical connectives, external arrangements, etc.); *ii)* the identification of the intervention categories (screeds, fixtures, painter's works, etc.).

- *Step 3:* Measurement and validation of the quantities for each category according to the working cluster to which they belong, deduced from the project tables and the values declared by the estimated metric calculation.
- *Step 4:* Determination of the total construction cost for each working cluster and in parallel for each intervention category.
- *Step 5:* For each working cluster, it has been determined:

  – the unit cost (€/m^2);
  – the percentage contribution of the accessory clusters to the main cluster, i.e. the SUL, which contributes to the definition of the new parameter, defined as homogeneous built surface (SCO).[1]

In addition, the percentage contribution of each intervention category has been assessed with respect to the total construction cost of the residential and basement portion, as well as the total cost of the entire building intervention.

- *Step 6:* Calculation of *i)* the parametric construction cost per SUL equal to the ratio of the total construction cost to the SUL; *ii)* the parametric construction cost per SCO equal to the ratio of the total construction cost to the SCO.
- *Step 7*: Preparation of a sheet for each case study in which the following will be reported:

  – for each working cluster:

    - the total cost, unit cost and relative percentages;
    - parametric construction cost per SUL;
    - parametric construction cost per SCO.

  – for each intervention category:

    - the total construction cost and its percentage contribution to the construction cost of the entire project;
    - parametric construction cost per SUL;
    - parametric construction cost per SCO.

3.2 Matrix Model

In order to define a parametric construction cost basis for the selected case studies, a matrix model has been developed following the methodological practice defined in

[1] The SCO is here introduced and defined as the sum of the SUL (i.e. main working cluster) and the areas of the accessory working clusters - stairwells/elevator shafts, lift shafts, basement, etc. -, suitably homogenized according to the incidence of the relative unit costs with respect to that of the main working cluster.

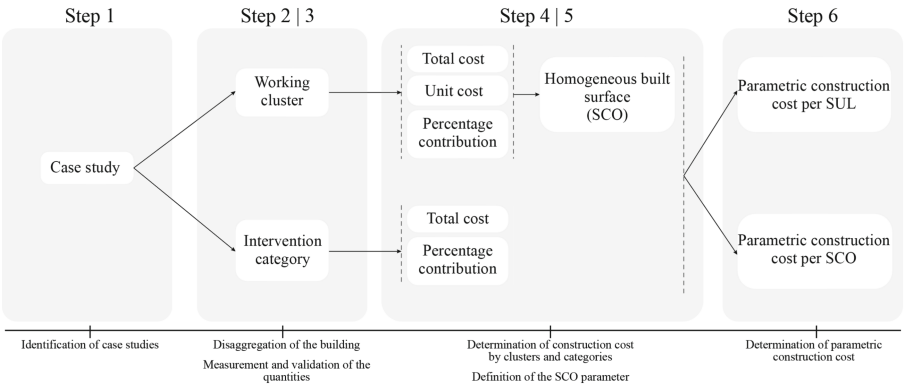

Fig. 1. Conceptual workflow of the methodology steps.

Sect. 3.1. The aid of such a model is useful for systematically representing and managing complex relationships between data, making it possible to organize large amounts of information in a clear and readable tabular form, facilitating the interpretation and analysis of the interdependencies between the various components. Using the following system architecture, it is possible to examine and quantify the relationships among different variables, supporting comparative analyses and scenario simulations.

In addition, the modular structure allows data to be easily updated and modified, making the tool suitable for continuous monitoring and economic review even during all project phases.

The reference matrix (Fig. 2) has been elaborated from a dual classification of the items that contribute to defining the total construction cost.

The first classification - 'working clusters' - considers the building components that, together with the SUL reference components, constitute the SCO. This classification has allowed to identify the working clusters in Table 1.

The second classification - 'intervention categories' - considers the disaggregation of the total intervention into technologically homogenous building components. The categorization used in the calculation phase has been considered. This classification has made it possible to identify the following categories in Table 2.

Table 1. Working clusters.

Basement	Main surface area
External arrangements and/or porches	Roofing/solar sheet
Gardens/private gardens	Stairwells and hallways
Lift shafts and elevator rooms	Technical rooms/volumes
Lodges, balconies and terraces	

Table 2. Intervention categories.

Air conditioning	Masonry
C.A. and Clay Concrete Works	Painter's works
Carpenter's work	Partitions
Dividers	Photovoltaic system and solar collector
Earthmoving	Plasterboard work
Elevator system	Plasters
Electrical system	Prefabricated elements
Exterior fixtures	Retaining wall
Fire alarm system	Sanitary water - heating system
Floor and wall coverings	Screeds
Foundations	Sewage system, lifting water and connection Gas
Green works and urban plough	Stonework
Industrial Flooring	Structural joints
Infill wall	Thermal and acoustic insulation
Interior fixtures	Waterproofing
Iron and steelwork	

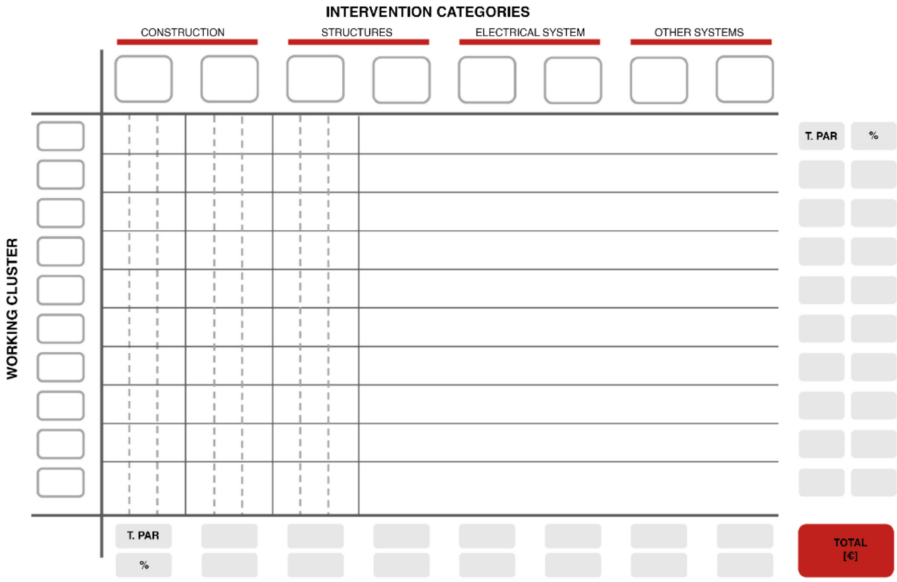

Fig. 2. Content structure of the matrix model.

A further classification by macro-categories, such as construction, structures, electrical and other systems, has been considered in the identification of the intervention categories [16].

Once the matrix has been constructed, the data have been placed by associating each item of the metric calculation with the corresponding reference category, according to the working cluster to which it belonged. For each item, quantity, unit cost and total cost values have been reported.

A first analysis has involved the calculation of the subtotals of the individual clusters, making it possible, once the area has been determined, to define the relevant unit costs and the percentage incidences in relation to the unit cost of the SUL. At the same time, the subtotals of the individual intervention categories and their percentage incidences with respect to the total cost of the building intervention have been calculated.

The percentage contribution of each cluster contributes to the definition of the SCO parameter. The need to define this parameter arises from the need to consider certain accessory surfaces (e.g. stairs, lifts, terraces, gardens, etc.) that, although not directly included in the SUL, have a significant impact on the overall construction cost of the building. The SCO constitutes the sum of the SUL (i.e. main working cluster) and the surfaces of the accessory working clusters - stairwells and hallways (ST), lift shalfs and elevator rooms (LIF), basement (BAS), etc. -, suitably homogenized according to the incidence (IC_{ST}, IC_{LIF}, IC_{BAS}, etc.) of the relative unit costs with respect to that of the main working cluster (Eq. 1).

$$SCO = SUL + (ST \cdot IC_{ST}) + (LIF \cdot IC_{LIF}) + (\ldots) + (BAS \cdot IC_{BAS}) \tag{1}$$

In this way, it is possible to obtain a concise measure of the overall economic impact of the different surfaces that constitute the size of the building work to be realized.

4 Case Studies

A sample of five newly constructed residential properties, built between 2023 and 2024, has been analyzed, apart from one case study for which a cost update has been carried out. The analysis has been conducted on buildings located within the Italian territory (Fig. 3). Among the selected properties, three are situated within the urban transformation area of Rome (Lazio), one is in the province of Viterbo (Lazio), and the fifth case study is located in the province of Naples (Campania).

The building types considered include tower blocks and linear structures, characterized by the presence of an underground level used as a garage or car park. The number of residential units ranges from approximately 30 to 60 flats, with different layouts including one-bedroom, two-bedroom, and three-bedroom units. Each building is served by at least one vertical connection, consisting of a stairwell and a lift shaft. All the analyzed buildings exhibit high energy performance, in line with current efficiency and sustainability standards.



Fig. 3. Location of the case studies.

5 Application of the Methodology

5.1 Working Cluster

The analysis of unit costs and their incidence on the working clusters, based on the averages of the case studies in the city of Rome (Table 3), highlights significant dynamics in cost distribution. The SUL is the main cost component, accounting for 74.47% of the total cost of the intervention, confirming its relevance in defining construction costs. However, accessory clusters, such as the "lift shafts and elevator rooms" and the "stairwells and hallways," show an incidence of 49.47% and 35.11%, respectively, despite representing only 0.79% and 3.64% of the total cost. The "lodges, balconies, and terraces" cluster also stands out with an incidence of 22.78% on the SUL and 6.99% on the total cost. The "basement" has an incidence of 11.31% on the SUL. Finally, the comparison between the unit cost of the SUL (2,793.33 €/m^2) and the SCO (2,084.62 €/m^2) shows a difference of 25.53%, highlighting the significant impact of accessory surfaces on the overall construction cost.

The analysis of the average unit costs, extended to the entire set of case studies (Table 4), allows for an expanded perspective on the distribution of construction costs across the different working clusters. Compared to the averages for Rome, several significant variations emerge. The SUL remains the primary cost component, accounting for 71.92% of the total intervention cost, slightly lower than the value found in the Roman cases (74.47%). However, accessory clusters show a different relative incidence: in particular, the unit cost of the "lift shafts and elevator rooms" is noticeably higher (79.59% of the SUL, compared to 49.47% for the Roman average), indicating a higher economic impact of this component in the non-urban contexts considered. The "stairwells and hallways" also register an increase in unit cost (37.38% of the SUL, compared to 35.11%

Table 3. Summary sheet of average parametric costs and related homogenization coefficients for the case studies in the city of Rome.

	Incidence of the cluster unit cost on the SUL [%]	Incidence of total cluster cost on SUL [%]	Incidence of total cluster cost on total intervention cost [%]
Basement	23.38%	11.31%	8.41%
External arrangements and/or porches	23.64%	4.43%	3.31%
Gardens/private gardens	5.78%	0.60%	0.44%
Lift shafts and elevator rooms	49.47%	1.08%	0.79%
Lodges, balconies and terraces	22.78%	9.42%	6.99%
Main surface area (SUL)	–	–	74.47%
Roofing/solar sheet	18.23%	2.09%	1.55%
Stairwells and hallways	35.11%	4.88%	3.64%
Technical rooms	14.82%	0.56%	0.41%
SUL - Unit cost [€/m^2]	***2,793.33***		
SCO - Unit cost [€/m^2]	***2,084.62***		
Difference [%]	25.53%		

for Rome), while their incidence on the total cost of the intervention is similar (3.81% versus 3.64%).

The "lodges, balconies, and terraces" category exhibits a higher unit cost compared to the Roman average (28.30% of the SUL, compared to 22.78%), resulting in a significant impact on the total cost (6.55% compared to 6.99%). A similar phenomenon is observed in the "external arrangements and/or porches" cluster, which exhibits a higher incidence on the total cost (4.73% compared to 3.31%). This suggests a heightened emphasis on both design and economic considerations for this cost item in the provincial case studies. The "basement" category exhibits a higher incidence on the total cost (12.65% compared to 11.31% for the Roman average).

Finally, the unit cost of the SUL, equal to 2,476.70 €/m^2, is lower than the value observed for the Roman averages (= 2,793.33 €/m^2), and the same contingence is etected for the unit cost of the SCO (1,793.99 €/m^2 versus 2,084.62 €/m^2). This results in an overall percentage difference of 28.08%, which is slightly higher than the value recorded for the Roman case studies (25.53%). The findings point out the pivotal role that geographical location and territorial particularities play in shaping the distribution of

construction costs, underscoring the necessity for a meticulous evaluation that is tailored to the distinctive attributes of each project and its respective market context.

Table 4. Summary sheet of average parametric costs and related homogenization coefficients for the case studies in the cities of Rome, Viterbo (RM) and Quarto (NA).

	Incidence of the cluster unit cost on the SUL [%]	Incidence of total cluster cost on SUL [%]	Incidence of total cluster cost on total intervention cost [%]
Basement	25.44%	12.65%	9.04%
External arrangements and/or porches	22.77%	6.74%	4.73%
Gardens/private gardens	4.89%	1.09%	0.74%
Lift shafts and elevator rooms	79.59%	1.76%	1.23%
Lodges, balconies and terraces	28.30%	9.10%	6.55%
Main surface area (SUL)	–	–	71.92%
Roofing/solar sheet	14.58%	2.40%	1.71%
Stairwells and hallways	37.38%	5.32%	3.81%
Technical rooms	13.78%	0.46%	0.34%
SUL - Unit cost [€/m^2]	***2,476.70***		
SCO - Unit cost [€/m^2]	***1,793.99***		
Difference [%]	28.08%		

The results obtained have been summarized in a line graph (Fig. 4) to compare the incidences of unit costs (coefficients of homogenization) for each working cluster across the different case studies analyzed. The outputs lend themselves to interesting considerations.

A significant aspect has emerged from the incidence of the unit construction cost of the 'lift shafts and elevator rooms' cluster - compared to the unit cost of the main surface area - which has shown a considerable percentage discrepancy across the different case studies. In particular, the highest values have been recorded in the *Ex Mercati - V. Trieste (VT)* and *Via di Villa Bonelli (RM)* projects, where percentages have exceeded 100%, outlining a design choice that has resulted in a high economic impact on this component.

In contrast, for the case studies of *Lucrezia Romana Bis, Comparto C (RM)* and *Comparto Z16 (RM)*, the corresponding coefficients have been lower (15.87% and 22.74%,

respectively). Similarly, for other work clusters, such as 'lodges, balconies, and terraces,' 'external arrangements,' and 'basement,' there has been significant variability across the projects. This contingency has highlighted the heterogeneity of unit construction costs for the working clusters depending on the specific project, thus resulting in notable differentiation due to the design and technological characteristics of each intervention.

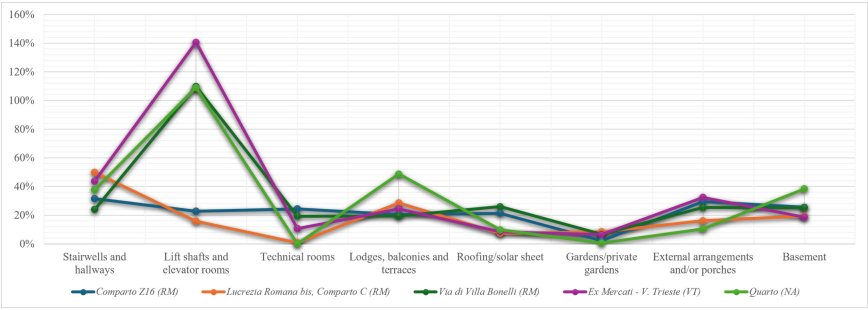

Fig. 4. Comparison of homogenization coefficients for the case study clusters.

Analyzing the incidences of the total costs of the working clusters in relation to the overall economic dimension of the entire intervention (Fig. 5) for each case study, a more uniform trend has been observed compared to the unit cost comparison. This result suggests that, although each case study has been characterized by specific design choices that have significantly influenced the unit costs of the working clusters, the overall cost distribution has tended to rebalance in the total calculation. This phenomenon has been particularly relevant in parametric analysis contexts, as it has allowed for the identification of established cost trends, which can be useful for the development of predictive models and reference benchmarks.

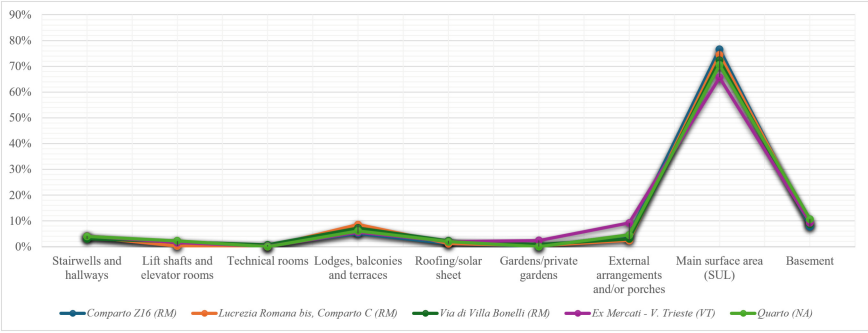

Fig. 5. Comparison of working cluster weights against total cost for each case study.

5.2 Intervention Categories

To provide a comprehensive characterization of the construction costs of the project, enabling the involved subjects (contracting authority, contracting company, designer, site manager, inspector, etc.) to quickly identify the contribution of each cost item (intervention categories) of the initiative, interactive project sheets have been elaborated for each case study. These sheets summarize: *i) in primis*, the intervention categories, with the corresponding construction costs and their percentage shares of the total construction cost, *ii)* the unit construction cost related to the SUL, *iii)* the unit construction cost related to the SCO, *iv)* the details from point i), differentiated for above-ground floors


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SUMMARY TABLE OF COSTS AND INCIDENCE PERCENTAGES: | **BUILDING**

	CATEGORY	COST [€]	INCIDENCE [%]
1	Earthmoving	707,570.48	3.69%
2	Foundations	1,073,724.59	5.61%
3	Structural joints	128,815.00	0.67%
4	Sewage system, lifting water and connection Gas	182,409.01	0.95%
5	C.A. and Clay Concrete Works	4,328,132.66	22.60%
6	Masonry	77,209.48	0.40%
7	Infill wall	360,089.46	1.88%
8	Partitions	163,238.23	0.85%
9	Dividers	559,227.21	2.92%
10	Waterproofing	594,876.22	3.11%
11	Thermal and acoustic insulation	262,329.03	1.37%
12	Screeds	472,341.18	2.47%
13	Plasters	1,304,072.26	6.81%
14	Painter's works	435,279.23	2.27%
15	Prefabricated elements	315,771.32	1.65%
16	Industrial Flooring	53,592.59	0.28%
17	Floor and wall coverings	1,332,517.80	6.96%
18	Interior fixtures	386,864.68	2.02%
19	Exterior fixtures	1,256,465.57	6.56%
20	Carpenter's work	49,701.75	0.26%
21	Iron and steelwork	250,165.16	1.31%
22	Stonework	330,801.07	1.73%
23	Photovoltaic system and solar collector	159,984.00	0.84%
24	Electrical system	1,255,201.91	6.55%
25	Sanitary water - heating system	2,858,467.25	14.93%
26	Elevator system	221,398.74	1.16%
27	Green works and urban plough	30,964.69	0.16%
	COST/INCIDENCE	19,151,210.57	100%

PARAMETRIC COST TABLE

SUL	19,151,210.57 / 7,721.99	=	**2,480.09** Cost of work per m²
SCO	19,151,210.57 / 10,674.85	=	**1,794.05** Cost of work per m²

Select:

DESCRIPTION

RES + BAS

MACROCATEGORIES

PLAN

GLOSSARY

Fig. 6. Extract sheet for intervention categories.

and basement levels, *v)* the disaggregation of the project into macro-categories of intervention, specifying their total costs and percentage shares of the total construction cost. Additionally, each sheet includes design tables, relevant descriptions of technological and locational aspects, and a glossary to assist in understanding acronyms and other terms that define the informational matrix. Figure 6 provides an excerpt of a project sheet.

6 Conclusions

In recent years, numerous construction, promotion and development operations have contributed to the definition and dissemination of process control systems capable of identifying the main variables that most influence the success of an entrepreneurial initiative. With reference to the determination of construction costs, the reference literature has mainly focused on the definition and experimentation of estimation methods, distinguishable into synthetic and analytical methods. The former are used to determine the order of magnitude of the intervention expenditure (budget), to compare project alternatives and identify the 'best' solution. Analytical methods are used to determine the order of magnitude of the monetary amount of the cost of the work [6]. The increasing focus on methodological approaches capable of virtuously relating the pre-project decision-making phase [17] and the construction phase, demonstrates the current peremptory nature of tools capable of supporting the processes of choice and effective management of monetary resources.

The proposed methodology has been implemented on five new-build initiatives located in the cities of Rome, Viterbo and Quarto (NA), allowing its operational effectiveness to be appreciated. The analysis has highlighted the potential of the developed matrix model, which, through a structured classification of construction components - mainly working clusters and intervention categories - allows a rigorous systematization of all the items that contribute to the definition of the construction cost, highlighting their relative incidences.

In addition, the definition of a reference methodology for the operators involved, as a *vademecum* for estimating, monitoring and updating construction costs in the residential sector, can allow to generate a unit cost value referring to a specific surface unit, named "homogeneous built surface", that could be significantly different from the classic saleable surface used for the commercialization of unit properties.

The methodological approach developed is configured as a support tool for investors both in the phase of assessing the economic feasibility of building initiatives - in a current context characterized by a constant increase in unit construction costs - and in the decision-making phase, relating to the identification of design solutions to be implemented. Thanks to its analytical structure, the model is useful not only in the design phase for the optimization of technical and economic choices, but also in the financial management and monitoring of interventions, contributing to a higher reliability in the cost assessments.

Furthermore, the methodology is designed to ensure that the assessment process remains both rigorous and transparent, thereby facilitating the integration of sustainability performance criteria into the planning and management of construction projects.

This approach, in turn, encourages a more prudent allocation of resources and supports the adoption of sustainable development strategies within the housing sector [18, 19].

However, it must be acknowledged that although the proposed methodology has proved effective in the context studied, further validation on a wider range of territorial and typological scenarios is required to fully assess its generalisability. Future research developments could include the refinement of homogenisation coefficients to account for different building technologies and regulatory frameworks, as well as the incorporation of dynamic cost variables linked to sustainability performance indicators. In this way, the model could gradually evolve into a more comprehensive tool for supporting strategic decision making in an increasingly complex and sustainability-driven construction sector.

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