An appraisal model for residential construction: the Italian case

Rubina Canesi, Giuliano Marella

***Abstract*—**The aim of this paper is to analyse the concept of production cost in a contemporary developing city in order to investigate and interpret the actual Italian real estate construction scenario. This study aims at shedding light on how construction costs have been affected by the new Italian sustainable and densification policies, analysing features such as the increase of the overall built volume and of the height of new buildings projects. In this paper we implement a statistical model able to interpret several and different variables influencing residential urban developments in order to define best practices in public policy and private urban development. In order to do this, the present study implements a regression model on 70 property development projects collected in the North of Italy between 2007 and 2015.

***Keywords*—** construction cost; regression model, real estate; urban density and development.

I. Introduction

The current Italian construction market reveals several changes, which both affect and are affected by the latest urban development policy. Italian cities are historically characterized by small and medium development projects' size, applying and implementing extensive models rather than intensive types. The latest urban development policy is promoting sustainable renewal and densification, increasing building density index and subsidizing real estate (RE) private investments and developments. These development policies are supporting the entrepreneurial class in order to revive the housing construction sector, affected by the permanence of the financial and RE crisis. This economic situation has induced conservative approaches by developers, for example lengthening the duration of building site, so as to align the production costs to deferred revenues.

Several studies analysed the relationship between the size of city and the value of its real estate asset [1], but much less has been done to correlate the production costs of a contemporary city with the variability in these costs from one city to another. Urban developments are a fundamental aspect to our understanding of how contemporary cities are evolving and weather and how urban policies are able to capture these changings. The aim of this paper is to investigate whether and how these new construction market's characteristics have affected Italian city production costs; shedding light on those factors that characterize the new urban policy, and that are capable of engendering differences in the cost of planning and developing new buildings.

The article is organized as follows. The first section describes the state of the art as concerns research on city production costs, on the new concept of densification and development and on their consequences on Italian urban policies. In the second part of this paper we describe our data and propose an interpretative regression model able to investigate the performance of property development projects in light of the new Italian development policy and of the continuing crisis in the RE construction industry. In the third section we discuss the statistical results. The last section summarizes our conclusions in the light of our findings.

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II. Literature review

Real estate construction cost performance and predictive models

Several studies analyse the performance of construction costs in order to define a model to predict them. These papers are important as a proper ex ante evaluation of a project construction cost is crucial to establish the feasibility of a development, particularly as regards brownfield requalification, within a densely-built urban fabric. It is also necessary, for all the involved stakeholders, to proper assess the construction costs of a development project in order to reduce the global risk scoring inherent in the completion of the works [2]. For this reason, there is a plenty literature focusing on the effective prediction of city construction costs, divisible into three main areas of investigation [3]:

- the selection and the development of the most effective statistical models for an accurate cost prediction;
- the choice of possible correlated variables; that could influence and engender construction costs;
- the elucidation of the reasons for the cost overrun, i.e. the systematic increase in the cost of completion of a building project with respect to the ex-ante prediction.

This work is interested in developing the first two points of the list above.

Concerning the selection of the best method, the literature has focused on developing statistical models for predicting ex ante construction costs (e.g. of property development projects) with a set of significant variables. The statistical models most often used are regression analyses, fuzzy methods and artificial neural networks [4], [5].

Different studies chose the statistical model which best interprets the involved context and able to better manage the independent selected inputs. Regression models mainly use quantitative data, factor analysis is usually selected to investigate the relationship of dependence between the cost and quantitative and qualitative factors influencing it, such as jobsite organization, the construction company's experience, and the professional expertise of the skilled workers employed [6]-[8]. Fuzzy set theory and fuzzy logic are particularly useful for managing global risk [9], [10], because they are used to support decision-making processes in conditions of uncertainty, and when the information available is only partial or incomplete [11]. Fuzzy logic is performed when the intrinsically aleatory nature of the information outnumbers the reliable information. Similarly, the use of neural networks enables a more accurate prediction of construction costs than can be achieved by means of regression analyses [12-16], especially in the preliminary design stage, when the information available are limited and liable to change during the conceptual building development.

All these models are usually run in order to predict real estate construction costs, they are applied and suggested as predictive models. Instead in this paper we want to verify how costs performance are changing in relation to the new Italian urban policies. Therefore, we do not attempt a predictive model but an interpretative one. In order to do this, we choose a statistical tool able to easily interpret the Italian construction market, the regression model.

In the respect of the second area of investigation, which concerns the selection of the variables, the cost prediction models are unable to investigate which variables could be the most significant in influencing the structure of the cost of a given construction. The most of the studies selects the variables already established in the previous literature. It seems to be of considerable interest, however, to examine which components of a project or jobsite are particularly important in influencing the accurate prediction of the planned construction cost. Some studies identify many fundamental characteristics involved in the construction cost evaluation, e.g. engineering technical elements, construction and design quality, the position and the construction site setup, jobsite organizational aspects, the stipulated contract, stakeholders' profiles [17], [18]. As concerns the physical features of a development project, the variables which most strongly are correlated with construction costs, are the height of the building, the number of storeys, the structural solutions adopted, and the building technology employed [19]. Some recent papers have introduced and analysed other different features, such as the shape of the building [20] - because of the potential increase in the construction cost in the case of projects demanding advanced technologies, or featuring typically high-density typologies with elements of risk and a financial exposure that are difficult to quantify in advance - [21].

The concept of densification in the Italian scenario

Densification is a concept proposed as solution to the excessive soil consumption that has recently characterized the urban development of European cities [22]. The implementation of densification strategies is an aware choice by public administration in order to promote a sustainability use of the urban territory, since sustainable development is widely recognized as a main goal for every government [23]. The high soil consumption, urban congestion, rising the infrastructure cost are just some of the effects due to urban sprawl [24]. Nowadays, public policies are trying to move in this direction, adopting compact city models, combining the concept of density with parameters and requirements guaranteeing high quality urban structures [25]. In the Italian urban context, the latest development policies have promoted sustainable renewal and densification, increasing building density index and subsidizing RE private investments and developments [26]. Responding to these requirements also the skyline of cities is changing, new specific building typologies responds to these characteristics, such as high-rise buildings (e.g. tall buildings and skyscrapers) and low-rise settlements (e.g. block buildings). These building typologies are quite new in the Italian urban context, where the most common typology is the extensive model.

In an urban context, which is not used to develop in height, the peculiarity of these kind of investments are difficult to be appraised in terms of cost, profits, returns on capital and timing [27]. High risks are mainly determined by long lasting and out of sequence cycle in construction that characterize tall buildings [28], since the average duration for a skyscraper's development is about ten years, from ideation to construction [29]. Because of these conditions, there is an increasing market risk that affects predicted rent and market values, due to volatile demand and unpredictable market events. The developer, together with the higher risk related to this typology, must also face the marketability risk due to the Italian contingent real estate crisis, began in 2007. In order to overcome this riskiness, developers undertake a conservative approach, e.g. lengthening the duration of construction building site, in order to reduce the exposed capital, waiting in revenues expected in longer term. Development urban policies are affecting the RE construction industry, e.g. on the building shape, on the urban skyline, on the entrepreneur's approach and behaviour. Therefore, it become essential to study and analyse how these changes, resulting from these new government policies, affect property construction costs.

III. Materials and Methods

Research objectives

The aim of the paper is to test potential relationships and correlations between city construction cost performance and several variables capable of representing the actual conditions and changes of Italian real estate construction market.

Data and variables selection

It is necessary to stress the difficulty to collect data on the Italian context, due to the private companies' privacy, which do not deliver their balance. Because of this limit we decided to restrict our analysis in a limited area (rather than the whole country) in order to remove several variables relating to purely territorial dynamics. We sampled 70 new residential properties built in north-eastern Italy between 2007 and 2015. Our data were collected from qualified sources, i.e. operators in the building sector active in the reference area. Besides limiting the sampling area, as we said above, we selected development projects with some common characteristics, in order to not introduce too many different variables. The selected homogeneous characteristics concern the type of construction (residential construction); type of development (new build); location: in the regions of Veneto and Lombardy.

We chose to introduce two kinds of variables. The dependent output is the unit construction cost (CC in €/m3) of the analysed building project. The independent inputs were selected consulting literature and including other variables judged to be capable of better interpreting the actual conditions of Italian RE construction market.

We compiling a survey-chart, consulting the developers involved in the survey, in order to sample the building in the database. After this, we selected the most meaningful variables, reducing them to 7, first removing any variables mutually and exclusively correlated with one another, then those less meaningful for the purposes of the present study. The final selected variables were clustered together in Table 1.

Building Characteristics	- Volume (Vo) - Number of Storeys (NS) - Material Finishing (MF)
Characteristics of the Building Process	- Duration of construction site (Du) - Company size (CS)
Real Estate Market Characteristics	- Surface Planned to be built (SP) - Market Value (Val)

Table 1. Independent variables of the model

The group *Building Characteristics* describes the construction in physical terms. We chose three variables able to perform the tendency of the Italian urban development on increasing the densification both volumetric and with high-rise building. The variable Volume (Vo) of the building in m^3 was introduced to investigate whether the new urban policies (that promote densification with higher building density index) affect also construction costs. The second variable is represented by Number of Storeys (NS), to investigate the relationship existing between the height and density of a building and the construction cost per m^3. Finally, the Material Finishing (MF) of the building, introduced as a control variable with a view to explaining the model, given that the quality of the design work and of the materials employed explain a significant part of the cost level of a piece of real estate.

The group *Characteristics of the building process* includes two types of variables, which could be significant indicators of the building process, investigating the methods used to complete the process and the stakeholders involved. The first variable of this group is the duration of the building site (Du), in months, since the construction timeline of new development projects has been stretched after the global financial crisis. This variable was introduced to test for any presence and preponderance of economies of scale due to the dilution of the fixed costs, or the prevalence of an increase in the overrun costs with any prolonged duration of the building site. The second variable is the size of the construction company (CS), to test the dependence of the costs on the size of the firm, considering two possible interpretations, i.e. the existence of economies of scale or a competitive advantage for the smaller-sized companies.

Finally, the group *Real Estate Market Characteristics* is introduced to seek any correlations between construction costs and local real-estate markets. To perform this group, we chose two variables that reflect different aspects and formalizations of the real estate sector, the Surface Planned to be built (SP), in m^2, which represents the liveliness of the property market in a given area; and the unit Market Value (Val), expressed in €/m^2. This input was used to identify any possible correlations between construction cost, attractiveness of a particular market, and the balance between supply and demand. These collected RE values were deduced from the market prices quoted in the database of the *Consulente Immobiliare*. To compare these data over time, in order to avoid temporal bias, we use the inflation index provided by the Italian Institute of Statistic (ISTAT).

Results of descriptive statistics

We conducted a descriptive statistical analysis on the sample collected in order to analyse the characteristics of the Italian property construction market (Table 1).

	Building Characteristics			Build Process	
Name	Vo	NS	MF	Du	CS
Mean	10930	5.03	3.06	23.43	3.38
StDev	10478	2.32	1.01	6.05	0.80
Min	800	2.00	1.00	9.00	0.00
Q1	6510	3.00	2.00	18.75	3.00
Median	8597	4.50	3.00	24.50	3.00
Q3	14459	6.00	4.00	28.00	4.00
Max	86145	11.00	5.00	35.00	5.00

	RE Market Characteristics		
Name	SP	Val	CC
Mean	261317	2075	351
StDev	137420	861	103.0
Min	44638	1075	169.
Q1	166362	1450	308.3
Median	18557	1825	343.9
Q3	454327	2450	280.1
Max	454327	4550	670.2

Table 2. Sample's descriptive statistic

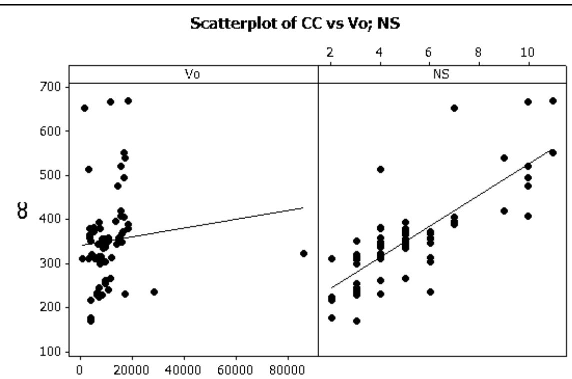
The results identified a mean construction cost of 350.96

€/m^3, with a near-Gaussian distribution where 75% of the properties incurred unit costs below 380 €/ m^3. A slight positive asymmetry emerged, due to the median value being lower than the mean, pointing to the presence of a slight preponderance of properties with construction costs below the median (Table 2).

Concerning the physical characteristics of the buildings, they had a mean volume of 10,930 m^3, which roughly corresponds to apartment blocks consisting of approximately 50 apartments on five floors above ground (Table 2). The Material finishing of the buildings (which was usually good) and the size of the construction companies involved were both perfectly consistent with the median of the reference sample, showing a Gaussian distribution indicative of typical quality levels and entrepreneurs (Table 2). When it came to construction times, on the other hand, the mean duration of the jobsites for our sample was 23.43 months, with a distinctly platykurtic distribution indicative of a marked variability due to the high standard deviation and a modal value of approximately 27.5 months, a considerable rightward shift with respect to the mean value identified (Table 2).

The variables used to describe the local property market identify new RE development located mainly in municipalities which grant a lot of new residential space (261,317 m^2). The markets with the largest numbers of new buildings were also those with price quotations ranging from 1,450 €/m^3 (first quartile) to 2,450 €/m^3 (third quartile), with a mean of 2,074.80 €/m^3. This is due to an evident right skewness distribution, which confirms the inertial tendency to build in markets which are already active and economically receptive and also the tendency to build in markets where the demand settles around more modest selling prices but the number of sales completed is higher.

In Figure 1 we report scatter plots between the selected independent variables (x-axis) and the input, Cost of Construction (y-axis). These represent the possible relations that we want to test and verify with the regression model, in the next paragraph.



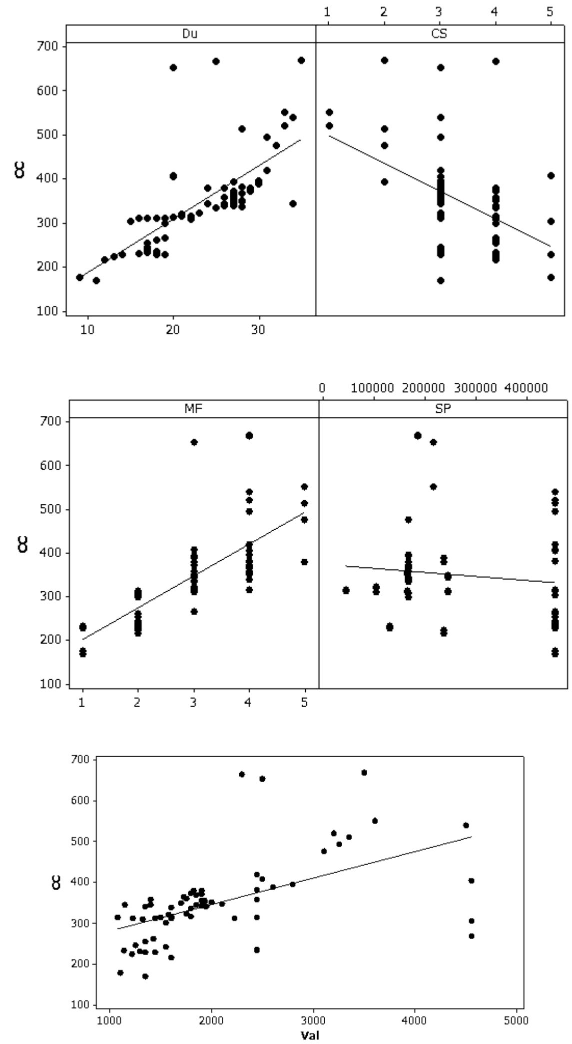


Fig. 1 Scatterplots with independent variables and the CC dependent variable (y-axis)

IV. The Interpretative Regression Model

To perform construction costs in RE development projects we developed a multiple regression model, because of its advantages such as the interpretive simplicity and the precision of results, and outputs, which provide sufficient detail to allow the work to be reproduced.

We tested inputs pairwise correlations, Table 3. Some correlations are quite strong, i.e. MF_Du Pearson's correlation coefficient (P"r"=0.791); such statistical indicators, however, should be checked on a qualitative level, as not necessarily implying a real dependence correlation. We must therefore ensure quality control on the model which does not analyse only the numerical results but which can also interpret the significance of the variables, according to a logic of interpretation.

	Vo	NS	Du	CS	MF	SP
NS	0.265 0.027					
Du	0.182 1.131	0.637 0.000				
CS	-0.151 0.211	-0.388 0.001	-0.511 0.000			
MF	0.084 0.488	0.583 0.000	0.791 0.000	-0.495 0.000		
SP	0.011 0.925	0.130 0.282	-0.252 0.035	0.126 0.298	-0.210 0.082	
Val	0.188 0.119	0.679 0.000	0.347 0.003	-0.266 0.026	0.429 0.000	0.365 0.002

Table 3. Pearson's Correlation Test and P-Value

In a linear regression model, (b_0, b_1, . . . ,b_n) shows the coefficients for a model with *n* variables (v_0 ,v_1 , . . . ,v_n), *e* is the prediction error and output *y* is then defined as follows:

$$y = \sum_{k=0}^{n} b_k v_k + e \quad (1)$$

We estimate the following regression, which performed better the inputs, function with some control variables:

$$\text{CC}_{ptg} = \alpha + \beta_1 Vo_{ptg} + \beta_2 NS_{ptg} + \beta_3 MF_{ptg} + \beta_4 Du_{ptg} + \beta_5 CS_{ptg} + \beta_6 SP_{tptg} + \beta_7 Val_{ptg} + \varepsilon_t \quad (2)$$

The dependent variable is the Cost of Construction (*CC*) of a property development project (*p*) in a fixed year (*t*), in a given province (*g*). The independent variables are: i) the Volume (*Vo*); ii) Number of Storeys (*NS*); iii) Material Finishing (MF); iv) Duration of construction site (*Du*); Quality of construction materials (*Qu*); v) Company size (CS); vi) Surface planned to be built (SP) and vii) Market Value (Val). The regression model's results are presented in Table 4.

The regression equation is
CC = 189 - 0.00111 Vo +25.7 NS + 1.39 Du - 12.4 CS + 20.0 MF - 0.000116 SP + 0.0109 Val

Predictor	Coef.	SE Coef	T	P
Const.	189.50	58.83	3.22	0.002
Vo	-0.00111	0.00065	-1.70	0.094
NS	25.685	4.794	5.36	0.000
Du	1.286	2.029	0.68	0.497
CS	-12.354	9.686	-1.28	0.207
MF	20.03	11.43	1.75	0.085
SP	-0.00012	0.00006	-2.01	0.049
Val	0.01093	0.01160	0.94	0.350

Table 4. The Regression Model

We tested the residual normality with its distribution (Figure 2) and with the Shapiro-Wilk Test, which confirmed the null hypothesis of normality (Prb>z = 0.04324).

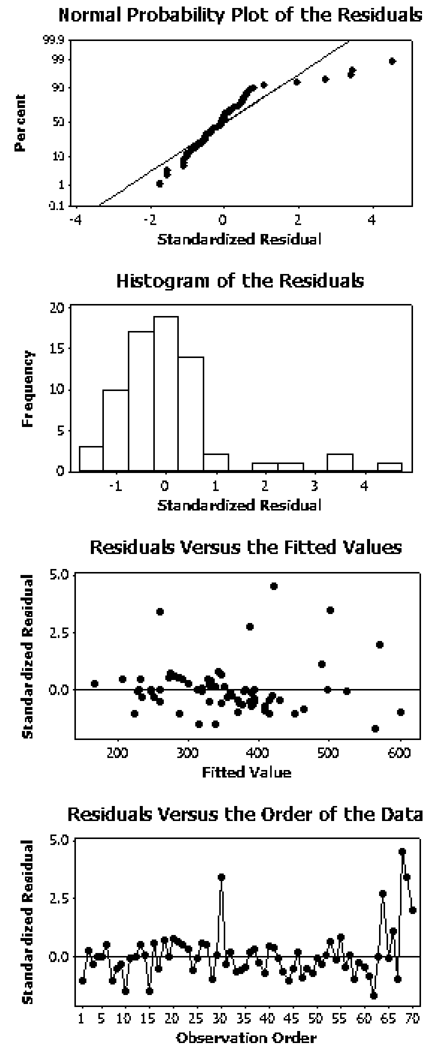


Figure 2 Residual Plots for CC

V. Results and discussion

Before presenting results, we must stress that the proposed model is not predictive, widely criticised in the literature since the 1960s [30], [31]. RE construction market is very complex and deals with several and different variables, for this reason it is very difficult to meet the stringent assumptions required by regression statistical models. In particular, the need for a large number of data, the presence of strong correlations between involved variables, together with the fact that the procedure does not consider valuers' subjective inputs, all contribute to invalidate the model's ability to interpret reality correctly.

Therefore, we do not want to provide a predictive model but an interpretative one, proposing a tool for supporting decision-making in the design and urban planning stage. It is important to stress that the interpretation of the correlation of the independent variables is always considered *ceteris paribus.*

The regression model (Table 4), which performs the equation (2), confirms some of the correlations predicted by the scatterplots in Table 3, with an adjusted R^2 equal to 72.6%, quite high in a regression model which performs RE market. More than their numerical quantification is interesting to investigate the signs of the significant correlations (p-value>0.05) identified by the regression (2), since the proposed model is interpretative and not predictive.

The Volume variable (*Vo*) confirmed the economies of scale, revealing a negative linear dependence in relation to the unit construction cost of the building. This tendency reflects the new Italian RE construction model (with high-density), which try to responds to new urban development policies. The dependent variable is instead positively dependent on NS, an increase of about 25.68 €/m^3 for each additional constructed storey. Finally, as expected, *CC* is significant and positive correlate with the variable Material finishing (MF), as this feature was included in the model as a control variable; higher quality, higher costs.

In the group which represents the *Characteristics of the building process*, the duration of construction *(Du)* is positively correlated, validating the assumption that any prolongation of the construction process coincides, *ceteris paribus*, with a more than proportional increase in the fixed costs of the jobsite that would override any potential advantages achievable from economies of scale deriving from the simultaneous operation of several jobsites. Therefore, we can say that the lengthening of the duration of building sites, caused by the economic crisis and by the conservative behaviour of developers, leads to higher costs.

As regards the Company Size (CS), it reveals a negative linear dependence in relation to the unit construction cost of the building, because of the distribution of the fixed costs in several simultaneous construction sites.

The characteristics referring to the category of the Real Estate Market predictably confirmed a positive association between construction costs and the market values recorded (Val). It reveals also a negative dependence between the Surface planned to be built (SP) and the CC. This stresses that where the market is more lively (higher SP) the costs are more competitive.

VI. Conclusion

In order to interpret actual Italian construction market which is affected by many changes, our study surveyed 70 RE building projects in northern Italy. Urban developments are a fundamental aspect to our understanding of how contemporary cities are evolving and weather and how urban policies are able to capture these changings. The new Italian development policies are promoting sustainable renewal and densification, increasing building density index and subsidizing real estate private investments and developments. These urban policies are supporting the entrepreneurial class in order to revive the housing construction sector, affected by the permanence of the financial and RE crisis.

Our interpretative regression model identified a strong correlation between construction costs and the new characteristics of the construction market, introduced by these urban strategies, e.g. the increase of urban density (in terms of volume and height) and the duration of building site.

The relationship that emerged was by no means obvious, especially in such a traditionally static context like the Italian one, where cost component analysis is usually done by features which rarely grasp the correlation with urban dynamics. It is important to stress these correlations in an effort to predict the evolutionary dynamics of our cities in terms of private investments. City expansion and regeneration are not only a matter of real-estate markets, in terms of property purchases and sales; they also depend on the trend and variation of construction costs for urban transformations.

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