ARCHITECTURAL DESIGN AND CONSTRUCTION COSTS, TOOLS TOWARDS TERRITORIAL SUSTAINABILITY

FEDERICO GARCIA-ERVITI
Universidad Politécnica de Madrid
fdgerv@arquired.es

LUIS RAMON VALVERDE
Universidad Politécnica de Madrid
luisrval@arquinex.es

Abstract
This paper is presented in CIB: Management and Innovation Sustainable Built Environment 2011, as the study and analysis of the residential model of a rural area from the Iberian Peninsula, specifically applied to the case of the province of Cáceres, in the autonomous region of Extremadura, in Spain.
To this end, from a database made up of building projects whose real costs are known, it is intended to establish the links of the different parameters studied through the corresponding functions of statistical analysis. One of the main objectives of this process is constituted by the possibility of establishing those design variables of higher economic importance, so as to keep an economic control of these parameters, generally geometrical and typological, from the very start of the project. And, in general, a higher optimization of resources in the construction of dwellings in the rural environment from their design is intended.

Keywords: Self-development, sustainability, design, costs

AIM

The characterization of a residential building pattern and its repercussions on production costs is one of the tasks which explain the particular features of the economy of the built environment. When this area is immersed within a rural environment with a context of limited economic development, as is the case in the territorial scope of this work, it is essential for the public authorities to articulate policies which encourage and support access to a decent home. Not only for the household economy but also for the public funds which finance the process.
This study takes place within the framework of Management and Innovation for a Sustainable Built Environment CIB International Conference; and its purpose is to determine the repercussions of programmatic, geometric, constructive and technological design parameters on the final cost of a determined constructed object: the owner-developed home. It is with this element that the Public Administration of the European region of Extremadura aims to make use of available land for family units, generally in small rural centres of population.

Thus, the aim is to make an own home more affordable in an environment of limited economic resources, sidestepping the burden of purchasing the land where the building is to be, and providing financial help for the building process. In terms of territorial policy, the end goal is to facilitate the stability of the population in the area and to promote permanent renovation of the built environment. By these means the aim is to achieve sustainable growth of small rural nuclei, in which traditional economic activities, such as farming and cattle raising and their associated small industries, can be integrated naturally and harmoniously.

Along these lines, the purpose of this study is to determine the ideal characteristics, from the point of view of functional and economic efficiency, of a basic residential typology for balanced development of a territorial remit undergoing emigration and depopulation, and which is a factor of social cohesion in rural communities.

THE PHYSICAL SCOPE OF STUDY
Physical and Geographic Framework.

The geographical context for this study is the Province of Cáceres, in the Autonomous Community of Extremadura, a region in the mid-west of Spain, bordering on Portugal.

Figure 1: *Autonomous Community of Extremadura in Spain*

The climate is continental: high temperatures in summer and low ones in winter. The rainfall is fairly low and concentrated in the months of October and April.

The north of the province flanks a large mountain range and is home to several districts - La Vera, the Jerte Valley, the Ambroz Valley, Las Hurdes… made up of population centres which are close together and the municipal districts are small.
The centre of the province is a broad plain crossed by a large river: the Tagus; this area has very few, widely scattered population centres with large municipal districts. The Monfragüe National Park is to be found here.
The south-east of the province is again of considerable altitude and there are small villages set close together, similar to in the north.
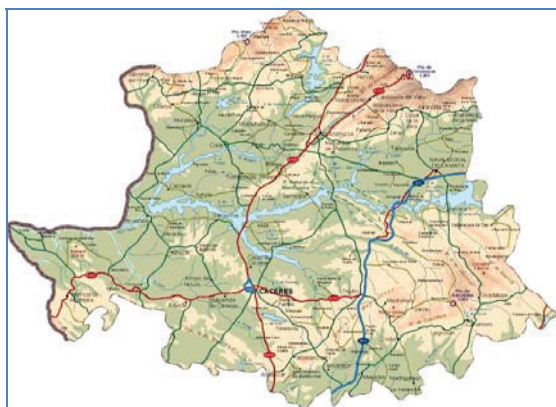

Figure 2: *Cáceres Province, north of Extremadura*

Socio-economic Framework: Population and Main Activities
Cáceres Province has a population of approximately 400,000, of whom 69% live in population centres of fewer than 15,000. The other 31 % live in two main cities of under 100,000 - Cáceres, the capital, with a population of 94,197, and Plasencia, with 41,447. Therefore, the region can be seen to be dominated demographically by a rural structure, which characterizes the aim of this work.

The main activity of the rural population is agriculture (fruit-growing, olives, tobacco, maize, tomato, asparagus …) and free-range livestock-raising (cattle, pigs, sheep). Manufacturing industries for the farm produce only exist in district-based cooperatives.

The Owner-Developed Home of Extremadura Regional Government

Present State of Affairs: Background to Public Policies of Residential Owner-Development in Other Fields.

In the rest of Spain there is no record of any other type of housing with public subsidies until 2008, with the exception of State-subsidized community housing (VPO) on a nationwide level. In this case, although the land receives a subsidy, until recently there has been no attempt to encourage development on land of which the developer is the owner.

In the unfavourable context of the economical, financial and property crisis of 2008, the State Plan for Housing and Rehabilitation 2009-2012 funds new building work by the owner-developer for the first time.

The only record in Europe of the existence of public policies for owner-developed housing is in Greece, where, according to Maloutas (2003, 2004) they constituted a means of integrating the rural population into urban society. The latter was at a time of rapid expansion: the early post-war, after the devastation of the rural areas caused by the war and economic crises. Thus, cheap housing was made available in the conditions of a poorly developed welfare state. Furthermore, this author points out that the importance of owner-development in the early post-war is intertwined with the reduction in direct state intervention, as opposed to the important public housing schemes that dealt with the demand for housing in northern Europe. Likewise, Golland (1998), Nicol y Golland (2004) y Haartsen, Groote y Huigen (2000) have analyzed the phenomena of residential owner-development in other contexts and latitudes.

Historic Background to Housing Assistance in Extremadura
In those times repopulation schemes were carried out which built villages from scratch. However they were not as successful as hoped, perhaps due to the lack of roots in what was new, perhaps since the farming tasks on the land were so hard compared to the opportunities of the city. This meant that numerous villages were virtually depopulated by the end of the 80s. As a result of this state of affairs, by the 70s Extremadura had become one of the most depressed regions of Spain, and therefore among the least developed regions in Europe.

The coming of democracy to Spain and, later, joining the EU with its subsidy policies marked the turning point and the initiation of a process of growth in the region. In this context, Royal Decree-Law 31/1978, of 31st of October, on low-cost state-subsidized housing (VPO) gave a direct impulse to incomplete regulations which already were pointing the way to social housing subsidies.

The Spanish Constitution of 1978 sets out in Article 47 that all Spanish citizens have to the right to a suitable and decent home. Moreover, it states that public authorities will promote the necessary requirements and will lay down the relevant regulations to bring this right into effect. The Constitution itself indicates that this right is to be transferred to the various Autonomous Communities. Thus, Extremadura Regional Government, as Public Administration of the Autonomous Community, aware of the characteristics of its population, adopted subsidy measures for owner-developed housing in Decree 11/1996, which are still in force today, with slight modifications.

The table below, which records the owner-developed housing interventions in Extremadura from 1996 to 2007, shows the intervention of over 7,800 homes out of a total of 360,000 homes present in the whole region. This means that over 2% of all housing built over this time has been developed with the Administration's help, following the technical requirements of the owner-developed home.

Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	TOTAL
BADAJOZ	1472	812	933	553	383	296	273	278	214	197	158	82	5651
CÁCERES	536	282	349	214	168	95	80	98	90	92	86	55	2145
Annual total	2008	1094	1282	767	551	391	353	376	304	289	244	137	7796
%	25,75	14,03	16,44	9,835	7,065	5,013	4,526	4,821	3,898	3,706	3,129	1,757	100

Owner-Developed Housing Subsidy Regulation
Owner-developed housing, in short, possesses the following common features of subsidy and required technical conditions.

A) Maximum usable area is 95m2.
B) The beneficiary must be the owner of the land which is legally apt for building.
C) The average annual income of the developer must not be more than 2.5 times the Guaranteed Minimum Wage.
D) The promoter will receive 18,000 euros, which are non-returnable, in two payments. The first one on presenting the final design and the Municipal Building Permit; and the second on obtaining the First Occupancy Licence and the Certificate of Occupancy of the property.

As differentiating features, the homes analyzed have the following characteristics:
a) No design criteria is imposed as to number of floors, shape, volume, layout nor programme of use, apart from those laid down by the local urban planning regulations.
b) There is no compulsory specific technical or constructive solution, apart from the general ones which are obligatory in the whole of the state or autonomous community.

Regarding the particular effects that this regulation has on the owner-developed homes themselves, it is worth noting that they present differential features in terms of design and

costs, as well as similarities in the dimensions of the intervention. On the other hand, as the developer is also the user of the home, the programme of use is certain to be met, since the regulations allow certain leeway in the design.

As far as the public consequences of this kind of interventions are concerned, it should be pointed out that owner-development subsidy policies are of moderate economic development, insofar as they are applied to owners of land which is of much lower value than that in the cities. Moreover, the family situation of probate facilitates buying land. On the other hand, these public actions constitute a system of backing for the small plot-owner which prevents speculative actions.

As we are dealing with small-scale interventions, they are favoured by a local economy in which the local building contractors and subcontractors are highly competitive in this class of development. Thus, it is possible to keep out the larger building companies. This makes it possible to keep local jobs and guarantee the stability of the population in the area. Moreover the regulation prevents Transfer Tax for ten years, which ensures the stability of the population in the communities.

The Administration allows the owner-developer to choose the technicians who draw up the project and the works supervisors. This strengthens the communication between technicians and owner. Furthermore, in general, the technician is used to working in the area and knows the technical resources available to the builders.

Lastly, the fact that there is a final supervision of what the Administration technicians have done, before granting the economic subsidies, ensures that the planning and technical property regulations are met. The Autonomous Community's supervision makes sure the building takes place on urban land. This reduces the number of illegal, clearly unsustainable interventions. All this directly favours a compact growth of the centre of population: filling in gaps in the urban grid or by taking place in new-growth areas already planned for this purpose.

Moreover, the system of subsidies and assistance requires administrative legal supervision, which means the whole building process must be legalized, as the new building works must be recorded in a notarial instrument and must be publicly registered. This way, the new building is taxed according to Annual Property Tax.

Lastly but not least, it should be pointed out that the Financial Institutions feel safer giving mortgages as there are good guarantees: firstly a safe land value, since the dweller is the land-owner; secondly there are additional guarantees, like the economic help from the administration and the owner's presence as owner and inhabitant of the property for ten years.

CHARACTERISTICS OF THE SAMPLE ANALYZED

According to the information published by Extremadura Administration, during the period 1996/2001 some 5400 homes were built subject to the owner-development regulations, while in 2001/2008 over 2500 homes were developed. Therefore over 8000 administrative files of this type exist, which means that this type of owner-developments affects approximately 10 % of the population of the Autonomous Community of Extremadura. These figures increase accordingly with the promotions carried out between 2008 and 2010.

For the purposes of this study, a sample of owner-developments has been chosen which is delimited both in time and space, according to the following criteria:

- In geographical terms, the province of Cáceres has been chosen, in the north of the Autonomous Community.
- From the point of view of time, a period has been chosen to allow the works selected to be finished. And so the most recent administrative files analyzed date from 2008. Spain's entry in the Euro system in 2001 has been taken as the starting point of the study, so as to avoid any distortion of the market due to the currency change.

The sample analyzed, as a result of these two limitations, is made up of an approximate total of 800 owner-developed housing administrative files, subsidized by Extremadura Regional Government in the Cáceres province between 2001 and 2008.

SCALING OF OWNER-DEVELOPMENT COSTS

State of Affairs

In Europe the earliest applications of scaling cost methods come from the "Centre Scientifique el Technique du Batiment", Paris, with the European revival after the Second World War, when a large demand for housing required of the French government some system with which to quantify public investments.

Since then there have been several systems which have aimed to draw up a forecast of building costs; I. Paricio (1971) is the pioneer in Spain because he developed and adapted the French ARC scaling cost method to the realities of the Spanish building sector.

In the 80s some methods were published using tabulations, diagrams and parameterization which aimed to fix scaled cost systems. The Architects' Association, in turn, began to establish cost/m2 modules, which are brought up to date so as to estimate the Real Execution Budget according to use and typology. This is for setting the minimum fees of the technicians and so as to be able to reference other costs such as Municipal Licenses, Stamp Duty, the bidding terms for tenders and auctions, financial or investment evaluation etc.

The everyday use of the computer over the last decade has facilitated the fast and accurate development of the cost estimation procedures. Not only due to the appearance of very complete and easily available price books, but also because of computer applications which carry out scaled cost analysis easily and reasonably accurately.

Another important factor is that over the last few years, Public Administrations (the Councils and the Departments of Public Works within the Autonomous Community) have been compiling a great deal of information that can now be used as a research database. It has been compiled directly via statistical questionnaires, or indirectly via reception of projects for granting licences. This fact, which may seem insignificant, has had a great effect on the development of this kind of research because, until less than a decade ago, many local authorities did not ask for a final design in their remit. This has now changed considerably with the appearance of Law 15/2001 of December 14th, of Extremadura Land and Regional Development Planning. Since then, there have been a number of registered and recorded homes that permit a rigorous scientific analysis of the present situation.

As for the overview, in previous models and empirical findings on building costs estimation models there are independent variables such as location, construction year, building type, number of floors, quality, and building technology (Kouskoulas and Koehn, 1974); construction year and location, total building area, combined percent area of health center and commons, area per unit, number of floors, and percent area of structured parking (Sonmez, R., 2004), the characteristics of the functional elements (Carvajal, 1992; Yaman and Tas, 2007); risk factors inherent in construction such as underestimation, completion delays, inadequacy of cash flow, poor site investigations, changes in scope of work, defective construction works, non-availability of funds and under-valuation (Odeyinka, H.A., 2007); the cost of building materials, interest rates, property price, foreign exchange rates, labour cost, national disposable income and money supply (Windapo, A.O. and Aiyagba, R.O., 2005); or physical and typological data, such as no. of storeys, no. of columns, no. of rooms or type of foundations (Arafa, M. and Alqedra, M., 2011).

In most of these research studies, the independent variables correspond to the technological and socio-economic characteristics of the geographic area in which the research is to be performed, as well as the features of construction typology analyzed in each case. Likewise, the explanatory variables used in this work have been adapted to the particular characteristics of the rural environment and socio-economic conditions in which self-development takes place in Cáceres. Thus, as has been set out in depth in the following headings, other factors have been introduced, such as the structural characteristics of the local building industry, access to the building site, and pre-existing buildings. To these variables are to be added those which refer to physical aspects of the land, such as topography and resistance of the subsoil, as well as geometric characteristics and built housing programme, which, bearing in mind the local production methods, have a real effect on the final building costs.

Characterization of a Scaled Cost Methodology
There are three ways of predicting building cost:

- Once the final design is complete, using economic measurement and evaluation of every item and unit that compose it. This is not in itself a scaling system.
- A unit cost module estimate reached by using previous experience in real building costs in similar constructions
- Using cost modules set down by Administrative bodies or by professional organizations respected by the Professional Bodies. These are usually below the real level.

The following required characteristics of a scaling method arise from these three scaling approaches:

a) Sufficient agility so as to be able to manage as few as possible basic meaningful variables which affect the final cost. Thus it can be used in the preliminary phases of the design process, in which most of the parameters which are to define the projected building are unknown
b) The method's ability to adapt to the peculiarities of every construction, once the setting, the design variations and the derived technical building considerations have been observed
c) Enough accuracy to ensure the likelihood of getting it right and which makes it possible to detect the scattering produced in each case, as compared to the characteristics of the average building

d) The method must allow for regular updates and even be adaptable to other fields of work or other construction types

e) The method must be simple to calculate so it may be used in a basic way. Thus it will be accessible to any owner-developer or small-scale building contractor.

f) The method must allow preliminary detection of the factors which most affect the final price, in order to aid design decision-taking before starting the design phase

g) The prescaling must be included in some IT supported service. This makes data entry easier, sidestepping complex mathematical operations.

METHOD DEVELOPMENT: FACTORS ANALYZED IN COST SCALING

For the development of this study, an analysis is carried out of the design factors and parameters which determine the final cost, giving a scaling model which combines three factors:

.- One cost module M expressed per unit of buildable area
.- The buildable area S
.- The intrinsic determining factors for each building work C

The cost module M is based on the scaling systems established by the administrative bodies. This indexing allows for permanent up-dating. The buildable area S is, firstly, limited by the regulations themselves for owner-developed housing and, secondly, determined by the convenience or economic and programme limitations of the private developer.

The third factor is a multiple one, as it is conditioned by the correction coefficients set down by the particular typology of home C_i, which increase or decrease module M. This introduces a factor of flexibility into the design process. These variables stem from three differentiating concepts which are intrinsic to the building itself:

A) Circumstances brought about inevitably by the surroundings and the physical environment of the plot CS

B) Circumstances determined by the design parameters CD.

C) Circumstances which arise on account of the implementation of the building, determined by the technical solutions adopted during the building process, which we shall call CT.

Consequently the cost of implementation will be a result of the formula
$$M \times S \times C = M \times S (CS + CD + CT)$$

Determining factors of the plot: CS.

As for intrinsic determining factors of the plot where building is to take place, the following circumstances will be born in mind:

A) Town/village: refers to the type of population centre where the building takes place. The thresholds of the different categories are:

A4: population centres which do not have builders or building suppliers.

A3: population centres which have both builders and building suppliers.

A2: which, as well as builders and suppliers, have carpenters, metalworkers and locksmiths.

A1: which, as well as builders, suppliers and the tradesmen mentioned above, have plumbing and wiring subcontractors and other essential housing fixtures.

B) Accessibility: this refers to the ease or difficulty in bringing the machinery to the building site and for storing the material conveniently. The following thresholds can be designated:
B4: difficulties in access and in material storage onsite.
B3: good access to the site but difficulties in storage of materials.
B2: difficult access to the site but ease of material storage onsite.
B1: good access from the road for supply lorries and ease of material storage onsite.

C) Building already existing: this refers to previous buildings onsite. The following categories have been defined:
C4: residential building, which would also imply the annulment of existing installations, with particular care to be taken with party walls.
C3: farm building, warehouse or similar, with low property appraisal value, whether in ruins or not, with particular care to be taken with party walls, but on the supposition there are no or minimal installations.
C2: Brickwork walls, rough stone wall or similar enclosing the plot.
C1: Plot completely empty and ready for immediate start to building work

D) Terrain: Refers to the mechanical characteristics of the ground the building is to sit on. The following categories are defined:
D1: for those whose bearing capacity is less than 1.00 Kg/cm2; in other words soils classified according to regulation as soft, fluid clay.
D2: for those whose bearing capacity is between 1.00 and 2.50 Kg/cm2; in other words: for hard clay and sand soils according to regulations.
D3: for those whose bearing capacity is greater than 2.50 Kg/cm2; in other words: for coarse sand and gravel.
D4: for those which are rocky in general.

E) Topography: refers to the slope or height difference in the plot.
E4: Height difference greater than 2.20 metres.
E3: Height difference between 1.40 metres and 2.20 metres.
E2: Height difference between 0.60 metres and 1.40 metres.
E1: Height difference less than 0.60 metres.

Design conditions CD

F) Factor of form of the building: in terms of the relationship between the area and the volume of the projected building.
F1: Less than or equal to 0.945, only an exception could be less than 0.85
F2: Value from 0.945 to 1.04 inclusive.
F3: Value from 1.04 to 1.135 inclusive.
F4: Value greater than 1.135, exceptionally greater than 1.23

G) Building annexes: refers to the inclusion of unimproved garage or premises on the ground floor, semi-basement or basement.
G4: Unimproved Garage or Premises in semi-basement or basement.
G3: Unimproved Premises on ground floor of more than 35 m2.
G2: Unimproved Premises of up to 35 m2 or garage, either concept on ground floor.
G1: Without annex, neither an unimproved premises nor garage.

H) Exterior wall openings: refers to the area of the fachade used for enclosed balconies, balconies and windows.

H4: façades with more than 17 m2 of opening.

H3: façades of from 13 to 17 m2 of openings.

H2: façades of from 9 to 13 m2 of openings.

H1: façades of less than 9 m2 of openings.

I) Plumbed room: includes the area of the bathroom, the toilet and kitchen, and the relation of this to the total built area of the home.

I4: Home with more than 20 m2 of plumbed rooms.

I3: Home with from 17 to 20 m2 of plumbed rooms.

I2: Home with from 14 to 17 m2 of plumbed rooms.

I1: Home with less than 14 m2 of plumbed rooms.

J) Transitional areas: these are the areas set aside for access, corridors, halls and landings and the relation of this area to the rest of the building.

J4: area greater than 30 m2 of corridors or shared zones.

J3: area from 20 to 30 m2 of corridors or shared zones.

J2: area from 10 to 20 m2 of corridors or shared zones.

J1: area less than 10 m2 of corridors or shared zones.

Technical specifications CT

K) Foundations

K1: of continuous ditches with lightly reinforced concrete.

K2: of continuous ditches and reinforced concrete footing.

K3: of isolated footing, party wall of reinforced concrete.

K4: of footing and ditches with retaining walls of reinforced concrete.

L) Structural System

L1: using load-bearing walls and perforated brick 1 foot thick.

L2: using load-bearing wall and perforated brick 1 foot thick and some beams or pillars with steel profile (mixed structure).

L3: using reinforced concrete porticos.

L4: using porticos with standardized profiles of rolled steel.

M) Roofing System

M1: 100% of the plot area covered with sloping roof, with no traffic-bearing roof surface

M2: 75% of the plot area covered with sloping roof and 25% with traffic-bearing roof surface.

M3: 50% of the plot area covered with sloping roof and 50% with traffic-bearing roof surface

M4: 100% traffic-bearing roof, including patio area if it exists.

N) Degree of prefabrication in the construction, determined by the existence of:
- A) Lintel beams
- B) Gutter channels
- C) Vents
- D) Steps.
- E) Partition walls.

F) Eaves, balcony and external façade mouldings.
G) External chimneys and /or their chimney pots.
H) Blinds housing box

N4: low of prefabrication, at most two of the prefabricated elements.
N3: medium-low level of prefabrication, at most four of the prefabricated elements
N2: medium-high of prefabrication, at most six of the prefabricated elements
N1: high level of prefabrication, at least seven of the prefabricated elements

Sample-Taking for Statistics.
A data-gathering template is drawn up with these fourteen variables and their sensitivity levels. This is to be filled in systematically in every owner-developed housing file which is subsidized by Extremadura Regional Government in Cáceres Province. The information is gathered by means of the analysis of the final designs drawn up for application for Municipal Building Licence. They will come from the municipal archives of all the towns and villages in the province.

RESULTS

Results of the First analysis of the Data-Base.
In the initial phase a mathematical model was developed with as many equations as unknown quantities. In this case it gave a number of necessary equations of fourteen conditions with their respective four levels, with a total of 14 x 4 = 56 unknown quantities. Thus, a matrix is obtained in which each row had 56 digits or coefficients of each one of the unknowns. Of the latter, 14 were of equal value to the unit, giving the other forty a null value.

This equation system matrix was associated with a null value determinant. This implies that the proposed determining factors are related to each other, there being some kind of relation in common which joins or links them. If the determining factors are related to one another, it is important to know the degree of relationship, because determining a certain relationship could establish a scaling criterion.

Results of the Second Line of Research.
The statistical analysis has consisted of a rectilinear adjustment following the minimum squares method. In this, the aim is to construct a straight line to join Variable Y – identified with percentage increase in the building cost module of the School of Architects (M)- with each of the X Variables identified with the 14 characteristics or parameters under study. Thus, for every condition there will be a straight line of the type $Y = aX + b$, where "a" and "b" are unknown quantities to be discovered following the method above. This way, a mathematical link is obtained between the various determining factors and the percentage increase which qualifies the scaling based on the modules of the School of Architects.

The resulting equations for each determining factor are the regression lines found by the least squares method of the form $Y = aX + b$, whose values "a" y "b" are reflected in each corresponding statistical chart. After undergoing the selection implied by the real values of the boundary conditions imposed by the reality of the marketplace, once the values of the regression coefficient of each line have been analyzed, and therefore its degree of inter-relation, the resulting equations are:

For Town/ village	$Y = 2{,}39\ A$
For accessibility	$Y = 3{,}04\ B - 3{,}04$
For existing buildings	$Y = 4{,}18\ C - 4{,}18$
For topography	$Y = 3{,}68\ E - 3{,}68$
For factor of form	$Y = 3{,}47\ F$
For wall openings	$Y = 2{,}39\ H - 2{,}39$
For plumbed room	$Y = 2{,}24\ I$
For foundations	$Y = 2{,}42\ K - 2{,}42$
For structure	$Y = 3{,}59\ L - 3{,}59$

Assigning the possible values according to the parameterization proposed for each of the variables - or, to put it other words, attributing the values 1, 2, 3 or 4 to each of the variables – we obtain cost increase percentages for each concept at every one of the levels. These will constitute the values gathered in the final chart which is representative of the scaling method for the various determining factors.

As a consequence of the above statistical analysis of the variables and parameters which affect the construction costs, the following conclusions may be reached:

a) There is an obvious scattering between the existing cost scaling methods and the reality of the marketplace. This can reach a variation of 20% to 55% in the case of official reference prices of the School of Architects, in comparison with the final cost of a building work.

b) The order of influence in building costs in €/m2 is as follows: Existing buildings, Accessibility, Form Factor, Structure, Topography, Town/ village, Wall openings, Plumbed rooms and Foundations.

c) There are five determining factors which do not affect the €/m2 of the home: Terrain, Annexes, Level of Prefabrication, Roofing System and Transitional Areas

d) A quick, easy-to-calculate scaling method has been achieved.

e) This is a method linked to official data about local building costs, like that of the School of Architects' Reference Budget. This means it can be permanently updated.

f) The method has an average scaling error of 7.70 %. It has been proven that it will never reach ten percent.

g) The error of the method is always positive, so there will be no unpleasant surprises in terms of the developer's investment or the contractor's offer.

h) All that is needed in order to the method is some sketches of the Design, a visit to the plot and very few technical decisions. Moreover, the scaling method makes some initial reflection necessary at the very start of the process which would not normally happen otherwise.

CONCLUSIONS

The owner-developed home in Extremadura constitutes an alternative to the speculative development system. It gives impetus to self-sufficient lifestyles in small rural communities, favouring their stability and sustainable regional development. But it is necessary to adopt efficient measures to achieve economical viability. These measures must optimize the public resources of the Administration, which backs and subsidizes the development process, as well as the private income of the owner-developer. The latter are severely limited in developing economies like that of Extremadura. The building costs scaling tool, which is proposed here, develops a mathematical model by means of statistical analysis. This model allows, in the

preliminary stages of the design, the drafters of the design to determine the characteristics that the designed building requires in order to reach the most efficient solutions.

REFERENCES

- Arafa, M. and Alqedra, M., *Early Stage Cost Estimation of Building Construction Projects Using Artificial Neural Networks,* Journal of Artificiall Intelligence 4 (1):63-75, 2011.

- Carvajal, E., *El Predimensionado de Coste en Arquitectura,* Consejería de Obras Públicas y Transportes, Junta de Andalucía, 1992.

- Golland, A., *Systems Of Housing Supply And Hosing Production In Europe,* Ashgate Pub., 1998.

- Haartsen, T., Groote, P. And Huigen, P. (Ed.), *Claiming Rural Identities: Dynamics, Contexts, Policies,* Van Gorcum & Comp., 2000.

- Kouskoulas, V. and Koehn, E., *Predesign Cost-Estimation Function for Buildings.* Journal of the Construction Division, Asce, 100(Co4): 589–604, 1974.

- Nicol, C. and Golland, A., *Innovation to the Develpmernt Process: The Self-Build Mov* (In *Housing Development. Theory, Process And Practice,* Ed. Golland, A. And Blaks, R.) Routledge, 2004.

- Odeyinka, H.A., *Modelling Risk Impacts on the Budgeted Cost of Traditionally Procured Building Projects* in: Boyd, D (Ed) Procs 23rd Annual Arcom Conference, 3-5 September 2007, Belfast, Uk, Association of Researchers in Construction Management, 755-763, 2007.

- Sonmez, R., *Conceptual Cost Estimation of Building Projects with Regression Analysis and Neural Networks,* Canadian Journal *of* Civil Engineering, 31 (4) 677-683*, 2004.*

- Windapo, A.O. and Aiyagba, R.O., *Modelling the Determinants of Housing Construction Costs in Nigeria, Cobra 2007,* Rics and College Of Architecture, Georgia Institute Of Technology, Atlanta, United States Of America, 2005.

- Yaman, H and Tas, E., *A Building Cost Estimation Model Based on Functional Elements,* Itu Aiz, Istambul Technical University, Vol: 4, No: 1, 73-87, 2007-1, 2007.