# Analyses and algorithms for exploring relational databases

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*Abstract:* - In this paper we present our study on the three rooms apartments of residential assemblies from Bucharest, starting from a particular set presented in [6]. We build a database and we present different results on these data. We study the price per housing unit in relation with other factors: the surface of the housing unit, the number of buildings per residential assemblies, the floor number of buildings, other types of housing units from the corresponding residential assembly, the existence of parking or cellar, the number of facilities and the number of finishing.

*Key-Words:* residential assemblies, economic analyses, relational databases, programming environment.

## 1 Introduction

Optimism or pessimism (see [5]), certainty or uncertainty (see [11]), price evolution (see [11], [13], [14]), all these are key words on the residential assemblies market of Romania. We find data in [11] about the residential rating and about the parameters of project evaluation. Some basic rules and snares in real estate transactions are presented in [13]. In [1], some factors which influence the residential assemblies market are presented. Some residential assemblies are presented in [11], [13] and [14]. In [1] and [6] we find catalogs which describe many residential assemblies. Starting from the data presented in [6], in our paper we build a database, we present a model of analysis of these data and algorithms in order to explore the database. We consider our algorithms interesting for clients, as well as for developers and researchers.

## 2 A database model for the analysis of residential assemblies

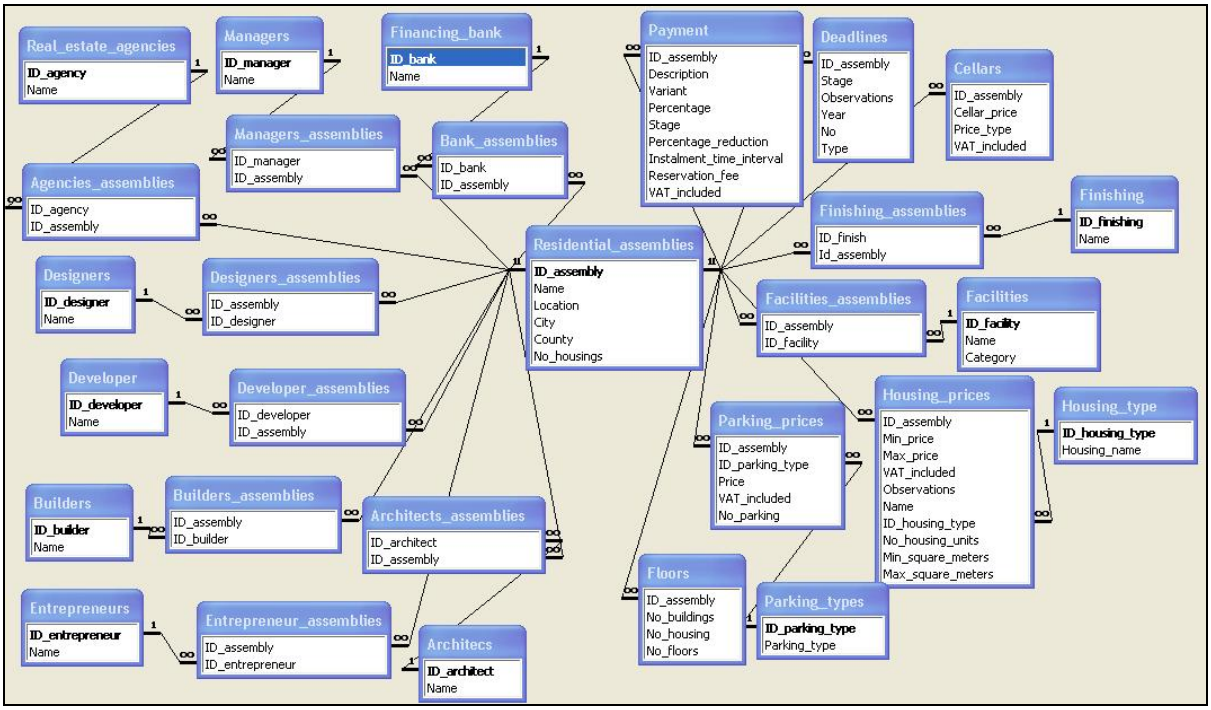


**Fig. 1** Residential assemblies – the database structure

Starting from the data presented in the catalog from [6], we built the database presented in *Figure 1*. In the tables *Financing_bank, Managers, Real_estate_agencies, Designers, Developers, Builders, Entrepreneurs* and *Architects* we have two fields: *ID* and *Name*. For each of these tables we can use more data, like address, city, county, phone number, etc.

We have data about 85 residential assemblies from 17 localities (58 residential assemblies from *Bucharest*, 5 from *Braşov*, 4 from *Constanţa*, 2 from *Buftea*, 2 from *Iaşi*, 2 from *Mamaia*, 2 from *Sibiu*, 1 from *Bacău*, 1 from *Băneasa*, 1 from *Cluj-Napoca*, 1 from *Craiova*, 1 from *Pipera*, 1 from *Sat Ploieştiori - Com. Blejoi*, 1 from *Sinaia*, 1 from *Ştefanestii de Jos*, 1 from *Tunar* and 1 from *Vâlcea*)

The minimum number of housings for a residential assembly is 50 (villas). The maximum number of housings is 4600.

In the *Floors* table, we save data such as number of buildings, number of apartments and number of floors. The minimum number of floors is 1 for residential assemblies which include houses or villas. The maximum number of floors is 30.

In the *Parking_types* table we have two types of parking options: underground parking and aboveground parking. We find that 70 assemblies have parking units and for 59 of them, the price is specified. The price is between 3500 and 18500 euros. The VAT is not included.

We find the following 7 types of finishing: air conditioning, central heating, kitchen with domestic appliances, solar installations, marble in the bathroom, furnished bathroom and furnished kitchen.

We find 66 types of facilities which belong to the following 17 categories of facilities: landscape gardening, bank, business, commerce, entertainment, education, event, hotel, care and beauty, local, parking, post, church, health center, security, sport and transport.

A more detailed description of the tables from *Figure 1* can be found in [19].

In this paper we focus on three rooms apartments from Bucharest.

## 3 Study on 3 rooms apartments from Bucharest

In the case of 47 residential assemblies from Bucharest, we find apartments with three rooms.

For many residential assemblies we find an interval of prices for the three rooms apartments. In our study, for each residential assembly, we will consider only the maximum price per apartment, corresponding to each residential assembly.

We find that the price per housing unit is between 100000 and 676000 euros (see also the *Table 1*). The VAT is not included.

In all tables, *No of RA* means the number of residential assemblies.

| | No of RA |
|---|---|
| 600000 ≤price per housing unit<700000 | 1 |
| 500000 ≤ price per housing unit<600000 | 1 |
| 400000≤ price per housing unit<500000 | 3 |
| 300000 ≤ price per housing unit<400000 | 7 |
| 200000 ≤ price per housing unit<300000 | 15 |
| 100000≤ price per housing unit<200000 | 20 |

**Table 1** Prices in euros per housing unit

These apartments have between 79 and 261 square meters. The representative value intervals and the corresponding number of residential assemblies are presented in *Table 2*.

| | No of RA |
|---|---|
| 200≤ square meters <270 | 5 |
| 150 ≤ square meters < 200 | 6 |
| 100≤ square meters <150 | 30 |
| 79 ≤ square meters < 100 | 6 |

**Table 2** The surface in square meters per housing unit in the case of three rooms apartments

In *Figure 2* we present the surfaces of the three rooms apartments and their prices/1000.

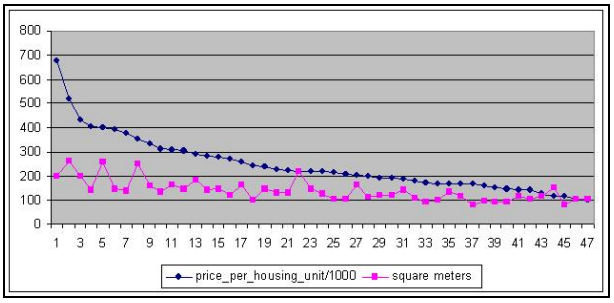


**Fig. 2** Prices_per_housing_unit/1000 and the surface in square meters

We find that the number of buildings is specified in the case of 41 residential assemblies out of the 47 which contain three rooms apartments. The maximum number of buildings per residential assembly is 71 and the minimum number is 1. See also *Table 3*.

In *Figure 3* we present the number of buildings per residential assembly and the housing_unit_prices/10000 for the three rooms apartments.

| | No of RA |
|---|---|
| buildings number=71 | 1 |
| buildings number=48 | 1 |
| 10≤ buildings number <20 | 8 |
| 5≤ buildings number <10 | 10 |
| buildings number=4 | 5 |
| buildings number=3 | 4 |
| buildings number=2 | 5 |
| buildings number=1 | 7 |

**Table 3** The number of buildings per residential assemblies

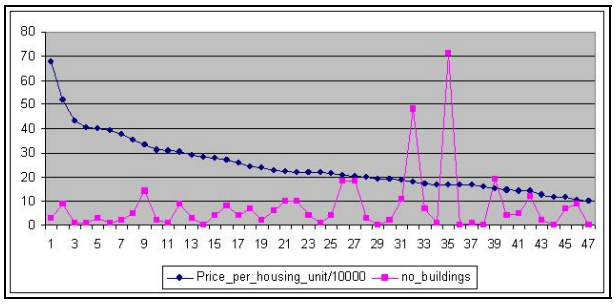


**Fig. 3** Price_per_housing_unit/10000 and the number of buildings per residential assembly

In the catalog, the buildings' floor number is specified in the case of 45 residential assemblies. The maximum number of floors for a building is 30 and the minimum number of floors is 1. See also the results presented in *Table 4*.

| | No of RA |
|---|---|
| floors number =30 | 1 |
| floors number =24 | 2 |
| floors number =20 | 3 |
| 15≤ floors number <20 | 8 |
| 10≤ floors number < 15 | 18 |
| 5≤ floors number < 10 | 21 |
| 1≤ floors number < 5 | 6 |

**Table 4** Number of floors per housing unit

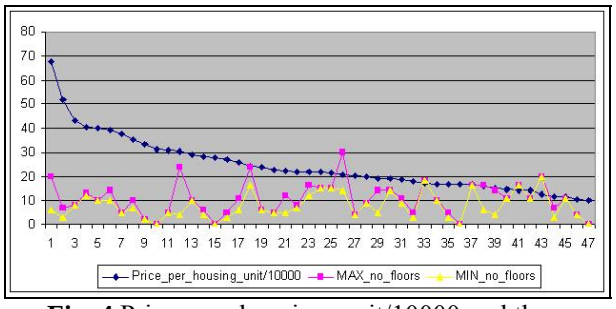


**Fig. 4** Price_per_housing_unit/10000 and the number of floors per building

In *Figure 4* we present the housing_unit_ prices/10000 for the threes rooms apartments and for each corresponding residential assembly, we also present the minimum and maximum floor number.

In the residential assemblies in which we find three rooms apartments, we also find: 1 room apartments, 2 rooms apartments, 4 rooms apartments, 5 rooms apartments, duplex, 3 rooms duplex, 4 rooms duplex, studio, penthouse and villa. See also *Table 5*.

| Housing unit | No of RA |
|---|---|
| apartments with 1 room | 1 |
| apartments with 2 rooms | 47 |
| apartments with 4 rooms | 32 |
| apartments with 5 rooms | 6 |
| duplex | 2 |
| duplex with 3 rooms | 3 |
| duplex with 4 rooms | 2 |
| studio | 31 |
| penthouse | 17 |
| Villa | 1 |

**Table 5** Types of housing units

For each residential assembly, we find between 2 and 6 types of housing units. See also *Table 6* and *Figure 5*.

| | No of RA |
|---|---|
| Number of housing unit types =6 | 4 |
| Number of housing unit types =5 | 10 |
| Number of housing unit types =4 | 22 |
| Number of housing unit types =3 | 9 |
| Number of housing unit types =2 | 2 |

**Table 6** Number of housing units per residential assembly

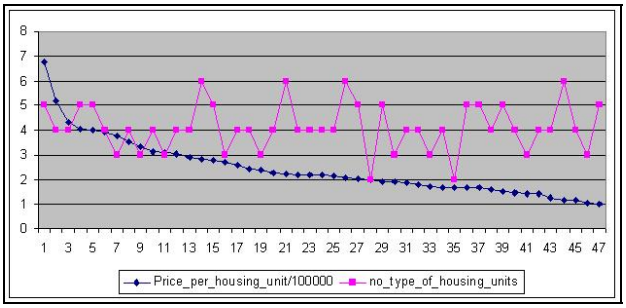


**Fig. 5** Price_per_housing_unit/100000 and the number of housing unit types

In the *Parking_types* table we have two types of parking options: underground parking and aboveground parking. We find that 42 assemblies have parking and for 36 of them, the price is specified. For 22 assemblies we find both types of parking, 6 assemblies have only underground parking and 8 assemblies have only aboveground parking. The price is between 3500 and 18500 euros. See also *Table 7*. The VAT is not included.

For 2 assemblies we find 3 different prices for parking units, for 35 assemblies we have 2 prices (generally, a price for underground parking and a

price for aboveground parking) and for the other 22 there is 1 price.

| | No of RA |
|---|---|
| $15000 \leq$ parking_ price $< 20000$ | 11 |
| $10000 \leq$ parking_ price $< 15000$ | 24 |
| $5000 \leq$ parking_ price $< 10000$ | 13 |
| $3000 \leq$ parking_ price $< 5000$ | 3 |

**Table 7** Parking prices in euros

In *Figure 6* we present the maximum price per parking units and the housing_unit_prices/10000 for the threes rooms apartments.


**Fig. 6** Price_per_housing_unit/10000 and the price_per_parking/1000

We find cellars for 18 assemblies. The price is between 650 and 850 euros per square meter (in the case of 5 residential assemblies) or between 1250 and 8000 euros per cellar (in the case of 13 residential assemblies – see also *Figure 7*), when the VAT is not included.

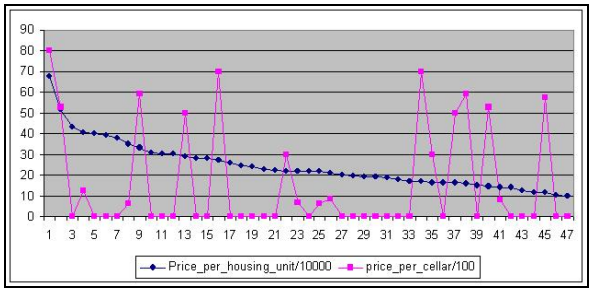


**Fig. 7** Price_per_housing_unit/10000 and the price_per_cellar/100

We find between 1 and 4 finishing for 27 residential assemblies (see *Table 8*). These are the followings: air conditioning, central heating, marble in the bathroom, furnished bathroom and furnished kitchen. In *Table 9,* we present the number of residential assemblies where we find each type of finishing.

| | No of RA |
|---|---|
| No of finishing = 4 | 1 |
| No of finishing =3 | 4 |
| No of finishing =2 | 9 |
| No of finishing =1 | 13 |

**Table 8** Number of finishing types per residential assembly

| Type of finishing | No of RA |
|---|---|
| air conditioning | 14 |
| central heating | 12 |
| furnished bathroom | 12 |
| furnished kitchen | 8 |
| marble in the bathroom | 1 |

**Table 9** Finishing types

In *Figure 8,* we present the number of finishing types per residential assembly and the housing_unit_prices/100000 for the threes rooms apartments.

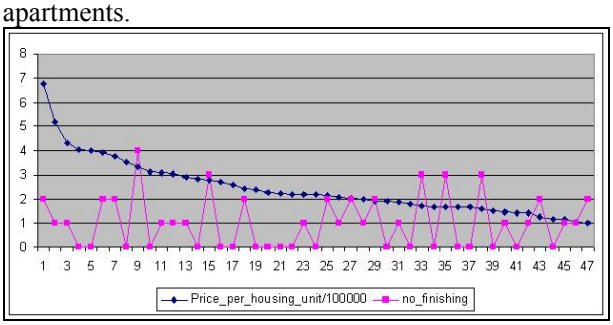


**Fig. 8** Price_per_housing_unit/100000 and the number of finishing types

We find 41 types of facilities which belong to the following 14 categories: landscape gardening (fountains, gardens, parks, green spaces), bank (banking agencies), business (offices), commerce (commercial center, dry cleaning station, flower shop, market, launderette, car wash), entertainment (playground for children), education (nursery school, school), event (conference center), care and beauty (massage, spa center, Jacuzzi, beauty salon, sauna), local (bar, coffee bar and restaurant), parking, church, health center (medical center, pharmacy), security (secure access, Interphone, guard services, surveillance systems), sport (basketball court, sport club, swimming pool, jogging track, fitness club, weightlifting club, squash room, golf course). In *Table 10* we present the number of residential assemblies in which we find each category of facilities.

In *Figure 9* we present the price_ per_housing_unit/100000 and the number of facility categories per residential assembly.

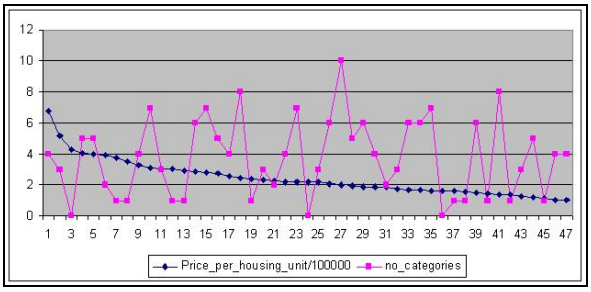


**Fig. 9** Price_per_housing_unit/100000 and the number of facility categories

| Category | No of RA |
|---|---|
| parking | 42 |
| sport | 34 |
| commerce | 25 |
| security | 24 |
| entertainment | 19 |
| local | 18 |
| landscape gardening | 17 |
| education | 13 |
| care and beauty | 11 |
| health center | 7 |
| event | 2 |
| business | 2 |
| bank | 2 |
| church | 1 |

**Table 10** Categories of facilities

We find facilities for 44 residential assemblies. For a residential assembly we find between 1 and 10 categories of facilities, like in *Table 11*.

| | No of RA |
|---|---|
| Number of categories =10 | 1 |
| Number of categories =8 | 2 |
| Number of categories =7 | 4 |
| Number of categories =6 | 6 |
| Number of categories =5 | 5 |
| Number of categories =4 | 7 |
| Number of categories =3 | 6 |
| Number of categories =2 | 3 |
| Number of categories =1 | 10 |
| Number of categories =0 | 3 |

**Table 11** Number of facility categories per residential assembly

We find between 1 and 16 types of facilities per residential assembly, like in *Table 12*.

| No of facilities per residential assembly | No of RA |
|---|---|
| Number of facilities = 16 | 1 |
| Number of facilities =10 | 3 |
| Number of facilities =9 | 1 |
| Number of facilities =8 | 5 |
| Number of facilities =7 | 2 |
| Number of facilities =6 | 6 |
| Number of facilities =5 | 6 |
| Number of facilities =4 | 5 |
| Number of facilities =3 | 2 |
| Number of facilities =2 | 3 |
| Number of facilities =1 | 10 |
| Number of facilities =0 | 3 |

**Table 12** Number of facilities per residential assembly

In *Figure 10* we present the price_ per_housing_ unit/10000 and the number of facilities per residential assembly.


**Fig. 10** Price_per_housing_unit/100000 and the number of facilities

In *Table 12,* we present the number of residential assemblies in which we find each type of facilities.

| Facility | No of RA | Facility | No of RA |
|---|---|---|---|
| parking | 42 | offices | 2 |
| playground for children | 19 | bar | 1 |
| commercial center | 18 | basketball court | 1 |
| secure access | 15 | church | 1 |
| nursery school | 12 | massage | 1 |
| sport club | 10 | medical center | 1 |
| green spaces | 9 | golf course | 1 |
| restaurant | 9 | Jacuzzi | 1 |
| coffee bar | 8 | launderette | 1 |
| swimming pool | 8 | park | 1 |
| fitness club | 8 | surveillance systems | 1 |
| pharmacy | 6 | school | 1 |
| gardens | 6 | fountains | 1 |
| guard services | 5 | beauty salon | 1 |
| sauna | 5 | flower shop | 1 |
| dry cleaning station | 3 | squash room | 1 |
| Interphone | 3 | weightlifting club | 1 |
| spa center | 3 | jogging track | 1 |
| conference center | 2 | market | 1 |
| Banking agencies | 2 | car wash | 1 |

**Table 12** Types of facilities

In the *Deadlines* table, in the field *type,* we use the following values: *building,* and *housing units*. The field *No* refers to their number, in the field *Observations* we use values such as: a month, a quarter of a year or a season. For each assembly we find between 1 and 4 stages of construction. We find deadlines for these stages, in the following way: in 2009 for 29 assemblies, in 2010 for 23 assemblies, in 2007 for 16 assemblies, in 2008 for 15 assemblies, in 2012 for 4 assemblies, in 2011 for 2 assemblies and in 2013 for 1 assembly (see also [8]).

In the following section we present more complex algorithms in exploring the database.

# 4 Algorithm for obtaining aggregated values sets

## 4.1 Algorithm presentation

Data analysis is used in many departments or sectors such as finance departments, marketing departments, manufacturing sector, sales departments etc. Data analysis applications typically aggregate data across many dimensions (n>=0). For aggregations, many tools are known. We recall some from these:

An *SQL* aggregate function (*AF*) produces one answer:
*Select AF (attribute_value) from table*
which corresponds to one aggregation type.

An *SQL* aggregate function (*AF*) and the *Group by* operator also yield one answer:
*Select attribute_1,...,attribute_n, AF (attribute_value) from table group by attribute_1,...,attribute_n*
which corresponds to one aggregation type.

The *Rollup* operator (from *Oracle*) – corresponds to *n+1* aggregation types.

The *Cube* operator – corresponds to $2^n$ aggregation types (the maximal set possible)**.**

In the case in which *n* is not small, $2^n$ is a considerable value. In the case in which the user wants to obtain (in the same result table) other subsets of aggregated values than the sets given by the known tools, we propose two algorithms.

In the beginning, we remind how we want to refer to the sets of aggregation types (see [17],[18]). In order to specify the aggregation types, we propose the user to make specifications, which contain combinations of "*m*" and/or "*f*" and/or "*u*", where:
*f* – means one field used for grouping,
*u* – means one field not used for grouping,
*m* – means zero, one or more fields not used for grouping.
Now, we consider the table presented in *Fig. 11*. Here, the fields *field1, field2, field3, field4, field5* form the maximal set used for grouping and the field *fvalue* is used for aggregation.

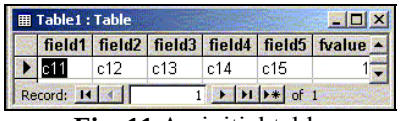


**Fig. 11** An initial table

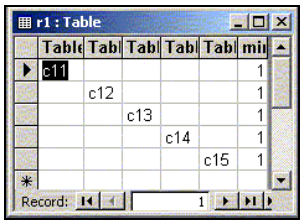


**Fig. 12** The result for *m f m*

The specification *m f m* produces the results presented in *Fig. 12* (which correspond to five aggregation types).
The specification *m f u f m* produces the results presented in *Fig. 13* (which correspond to three aggregation types).
The specification *f m f m* produces the results presented in *Fig. 14* (which correspond to four aggregation types).
In such specifications we can also eliminate some fields for a certain *f*.

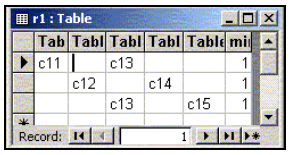


**Fig. 13** The result for *m f u f m*

The user must specify the *n* fields used for grouping. Using specifications, which are composed of "*f*" or/and "*m*" or/and "*u*", the user can obtain any wanted subsets of aggregation types for the *n* specified fields.

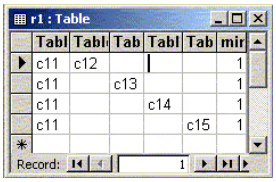


**Fig. 14** The result for *f m f m*

The implementation is presented in [18], using a programming environment (we have worked in *Delphi*) and a database (there we used databases from *Access*).
For grouping and for aggregation, we can use fields from one or more tables.
Also, we can build new tables with fields regarding the criteria on the fields from the initial tables, like in the following example.

Now, in our study we consider only the apartments which have cellars. We find that only 18 residential assemblies (out of 47) have a cellar. See also *Table 13*.

### 4.2 A study on the residential assemblies which include three rooms apartments with cellar

First, we create a table which has the following fields: *ID_assembly*, *c1,…c9, f1, f2 ,f3, f4, Price* and *Square_meters*.

For space economy in the presentation, we denote the category fields in the following way: parking – c1, sport – c2, commerce – c3, security – c4, entertainment – c5, local – c6, landscape gardening – c7, education – c8, care and beauty –c9, air conditioning – f1, central heating – f2, furnished bathroom – f3 and furnished kitchen – f4.

In this table, in the fields *c1,…c9, f1, f2, f3, f4,* we use the value 1 if we find the category (finishing) for the corresponding *ID_assembly* and the value 0, if we do not.

We use the following specification of aggregation types:

$$f\,m\,f\,m$$

which refers to the apartments which have parking units and at least one other facility or finishing. We calculate: minimum price per housing unit (min_price), maximum price per housing unit (max_price), minimum surface per housing unit (min_sm), maximum surface per housing unit (max_sm) and the number of corresponding residential assemblies (no_RA).

The result of this specification of aggregation types is presented in *Table 14*. We have offered only one specification as example, but we can formulate many others.

| ID_assembly | c1 | c2 | c3 | c4 | c5 | c6 | c7 | c8 | c9 | f1 | f2 | f3 | f4 | Price | Square_meters |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 86 | 1 | | | 1 | 1 | 1 | 1 | 1 | | 1 | | 1 | 1 | 165000 | 119 |
| 136 | 1 | 1 | | | 1 | | | | 1 | 1 | 1 | 1 | 1 | 330000 | 158 |
| 139 | 1 | 1 | 1 | 1 | 1 | | | | 1 | | 1 | | | 216800 | 147 |
| 80 | 1 | 1 | 1 | | | 1 | | 1 | | | | | 1 | 207000 | 105 |
| 103 | 1 | | | 1 | 1 | 1 | | 1 | 1 | | | | | 141520 | 116 |
| 151 | 1 | 1 | | | 1 | | 1 | | 1 | | | | | 272000 | 122 |
| 102 | 1 | 1 | 1 | | | | | | | 1 | 1 | | | 216050 | 105 |
| 147 | 1 | 1 | 1 | | 1 | | 1 | | | | | | | 167559 | 101 |
| 163 | 1 | 1 | | 1 | | | | | 1 | | 1 | | | 676000 | 200 |
| 120 | 1 | 1 | | | | 1 | | | | 1 | | | | 517019 | 261 |
| 129 | 1 | | | 1 | 1 | | 1 | | | | | | | 218000 | 218 |
| 90 | 1 | | | | | | | | | 1 | 1 | 1 | | 158000 | 97 |
| 142 | 1 | 1 | | | | 1 | | 1 | | | | | | 404000 | 140 |
| 108 | 1 | | | | | | | | | 1 | | | | 146613 | 92 |
| 104 | 1 | | | | | | | | | 1 | | | | 116874 | 81 |
| 146 | 1 | | | | | | | | | | | 1 | | 290449 | 182 |
| 155 | 1 | | | | | | | | | | | | | 350000 | 250 |
| 157 | 1 | | | | | | | | | | | | | 164000 | 79 |

**Table 13** Apartments with three rooms and cellars

| Total | c1 | c2 | c3 | c4 | c5 | c6 | c7 | c8 | c9 | f1 | f2 | f3 | f4 | min_price | max_price | min_sm | max_sm | no_RA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 1 | 1 | | | | | | | | | | | | 167559 | 676000 | 101 | 261 | 9 |
| 2 | 1 | | 1 | | | | | | | | | | | 167559 | 216800 | 101 | 147 | 4 |
| 2 | 1 | | | 1 | | | | | | | | | | 141520 | 676000 | 116 | 218 | 5 |
| 2 | 1 | | | | 1 | | | | | | | | | 141520 | 330000 | 101 | 218 | 7 |
| 2 | 1 | | | | | 1 | | | | | | | | 141520 | 517019 | 105 | 261 | 5 |
| 2 | 1 | | | | | | 1 | | | | | | | 165000 | 272000 | 101 | 218 | 4 |
| 2 | 1 | | | | | | | 1 | | | | | | 141520 | 404000 | 105 | 140 | 4 |
| 2 | 1 | | | | | | | | 1 | | | | | 141520 | 676000 | 116 | 200 | 5 |
| 2 | 1 | | | | | | | | | 1 | | | | 116874 | 517019 | 81 | 261 | 7 |
| 2 | 1 | | | | | | | | | | 1 | | | 158000 | 676000 | 97 | 200 | 5 |
| 2 | 1 | | | | | | | | | | | 1 | | 158000 | 330000 | 97 | 182 | 4 |

**Table 14** Results for the three rooms apartments with cellars which have parking units and at least one other facility or finishing

## 5 Conclusions

Using algorithms like the one presented in *Section 4* and the analyses presented in *Section 3*, we can perform different studies on the residential assembly market, which can be interesting for clients (when they want to buy apartments), but also for developers (when they want to build something). The case presented in this paper is just one example and we

consider that it can be adapted to situations on many other residential assemblies from Romania and other countries.

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