Construction industry forecasting system dynamic model

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2010

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Abstract
Construction branch forecasting model allows estimate the industry development problems. The construction industry forecasting model consists of several sub-models (blocks): amount of apartments, real estate prices, needs for apartments and living area forecasting models.
The apartments amount forecasting model bases on principle if there is insufficient number of apartments in the economic system, then, first of all, apartments with small areas are financed and constructed. The increase of apartment's amount depends on the financing, as well as from the average apartment area and construction costs per square meter. The real estate prices influential parameters are the increase or decrease of the housing fund, the total apartment market influence on separate segments in apartment market (and vice versa). The apartment's needs influential factors there are an increase of apartments' amount; depreciation of apartments (reduction of amount); improvement of living conditions.
In paper shown, that the balanced amount of apartment construction in Latvia is approximately 1800 apartments per the year, but considering the fluctuations of surplus and needs, it can temporarily fluctuate from 1434 to 2019.

Keywords: *construction demand, housing fund, system dynamic, market modeling, simulation, economic forecasting*

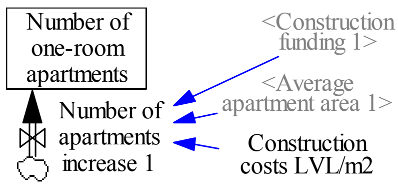
Introduction

The business development of the construction industry depends not only on the ability to optimize operations within industry, adapt to external conditions, but also on the country's economic development, the situation in the market. An urgent issue of every construction company - what problems we will face later, is it possible to start solving future problems now in order to minimize their negative effects? To answer these questions, there was created the construction industry forecasting model.
It is important to note, that recently some forecasting models have been offered to the construction sector, which significantly differ in their application and included correlations. For example, the main issue of 1999 - 2004 model (Skribans 2002a, 2002b, 2003) was associated not only with the demand estimation for construction, but also with the building industry's activity under the conditions of increased demand. The model emphasizes personnel shortage in the construction industry, as well as its consequences - a sharp increase in wages and productivity decline. As a solution to this problem was put forward a hypothesis of an increase in the level of mechanization, which was observed in Latvia in recent years. Similarly, there was made extensive analysis of state and non-construction commercial companies' effect on the construction capacity.
2006 - 2008 model's (Skribans and Počs, 2008) primary function was answer to the question - what should be the Latvian construction so that the living standards and real estate fund would reach the level of developed countries in Europe? Certainly, today the most actual needs have changed, and one of the most important issues is to determine a balanced capacity of Latvian construction, in order to avoid booms, crisis and their negative consequences. In consideration of previously analyzed data on state and non-construction commercial companies' influence on the construction sector, the model focuses on the analysis of housing fund construction. This is a limitation to this study.
The building industry forecasting model consists of several submodels (blocks): number of apartments, real estate price, necessity of apartments, financing and dwelling-space forecasting models. Their meaning and necessity is justified in separate sections. At the end of the study the generated model is used in practice, as well the forecasts are projected with a help of the model.

1. Apartment's amount forecasting model

Apartments' amount forecasting model is based on the principle if there is an insufficient number of apartments in the economic system, then, first of all, the apartments with small areas are funded, purchased and built, i.e., multi-storey buildings with one-room apartments. The economical sense of this assumption is easy to understand. In the case of average paying capacity certain minimal threshold of comfort, which is easier and more effectively provided in apartment houses, is more important than spacious apartments. One-room apartments in such buildings allow to reduce household expenditure on the purchase of the apartment. Hence, in the case of average paying capacity, construction of new buildings consists only of one-room apartment building. One-room apartments' amount forecasting model is shown in Fig.1.

Analyzing Fig.1 and its equation, we conclude that number of one-room apartments depends on its initial amount and growth, marked with the index 1. The application of the index is used in order to make it easier to explain and understand the essence of the model further. Index 1 corresponds to the one-room apartments. The further housing is divided into a one-room, one-bedroom (two-room) and two-bedroom (including multi-room) apartments, according to these groups indexes are used: 2 – one-bedroom apartments, 3 – two-bedroom (including multi-room) apartments.



Where:

- figures material flows;
- figures non-material and information flows;
- <C> converter or stock "C" from the related submodel;
- material flow regulator.
- external environment;
- A stock „A";
- B converter „B";

Fig.1 One-room apartment's amount forecasting model

According with Fig. 1 system dynamic equations are formed. The model figures, as well as explanatory equations are presented in accordance with generally accepted system dynamic designations (Sterman, 2000).

Number of one-room apartments = INTEG (Number of apartments increase 1, initial level)
Number of apartments increase 1 = Construction funding 1 / Construction costs LVL/m^2 / Average apartment area 1

Where: INTEG (**a**, **b**) - the integral from **a**; in initial point, when it is impossible to calculate the integral, the function adopted **b** value.

The growths of one-room apartment number depends on the funding provided for construction, as well as the average apartment space and construction costs per m^2, in other words, on the financing and construction costs. The model does not use apartment construction costs, but use the costs per square meter, because this indicator can be applied both to one-room and two-bedroom apartments, etc. During the construction of apartment houses, the total area costs are the same, but combining partitions, doors and approaches it is possible to create apartments with different rooms and living-area. Consequently, the square meter construction costs of the area are the same for all apartments, regardless of the number of rooms.

It is possible to calculate the average apartment space, dividing flats by the number of rooms. This together with the construction costs per square meter of an apartment will provide the apartments' construction costs by groups. The model assumes, that the advantage of the population living area size do not differ significantly from the ones actually existing in the market, i.e., if people need an apartment with a certain number of rooms, then its' area corresponds to an average apartment area in this segment. There could be a counterargument to this assumption, because the apartments in Latvia are small compared to ones in the EU, and this assumption will not allow predicting the Latvian housing fund development, considering the EU integration and the equalization processes. The application of average level would automatically discard the small apartments. From author's point of view, living areas' increase will happen, by increasing the number of rooms in apartments, maintaining a medium size room at the average level rather than increasing the room size.

Next model assumption is related to one-bedroom (two-room) apartment construction. If the one-room apartments are built to ensure the population's needs for housing, then multi-room apartments are built to improve population's living conditions. This assumption may be questionable, assuming that the one-bedroom apartments could also be built to provide people with housing, but this derogation from the assumption will be discussed later. One-bedroom apartment construction model is essentially similar to the multi room construction model, see Fig.2.

As shown in Fig.2 and in the corresponding equations, forecasting model for one-bedroom and multi room apartments is identical, differing only in funding capacity and the average apartment area. Both groups unite construction costs per square meter, as it was explained above. If we compare corresponding equations of Fig.1 and Fig.2, than it can be seen, that formulas of the number of apartments growth (from Fig.1) and the improvement of living conditions (from Fig.2) are similar, differing only in the certain group financing capacity and dwelling space. This is understandable, because the mechanisms of housing construction financing and expenditure are the same, but they have different causes: in the first case - provision of housing, but in the second - the improvement of living conditions.

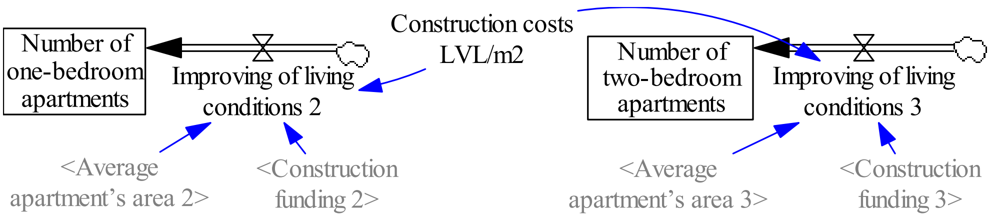


Fig.2.1 One-bedroom apartment model **Fig.2.2** Multi-room apartment's model

Fig.2 Multi-room apartment's number forecasting model

According with Fig. 2 system dynamic equations are formed.

Number of one-bedroom apartments = INTEG (Improvement of living conditions 2, initial level)
Improving of living conditions 2 = Construction financing 2 / Construction costs LVL/m^2 / Average apartment's area 2
Number of two-bedroom apartments = INTEG (Improving of living conditions 3, initial level)
Improving of living conditions 3= Construction funding 3 Construction costs LVL/m^2 / Average apartment's area 3

Previously it was mentioned, that the one-bedroom apartments could be constructed not only to improve living conditions, but also to provide people with housing. This option has a high probability; it is necessary to combine both of the above indicated models for the one-bedroom apartments. If we analyze the segments of two-bedroom or multiple room apartment, then that kind of apartments practically are no built to provide residents with housing, therefore the model for multi room apartment segment will not be modified. Advanced model to forecast the number of one-bedroom apartments is shown in Fig.3.

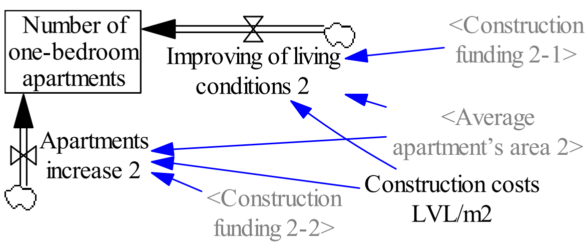


Fig.3 One-bedroom apartment's number forecasting model

According with Fig. 3 system dynamic equations are formed.

One-bedroom apartments = INTEG (Improving of living conditions 2 + Apartments increase 2, initial level)
Improving of living conditions 2 = Construction financing 2-1 / Construction costs LVL/m^2 */ Average apartment's area 2*
Number of apartments increase 2 = Construction financing 2 -2 / Construction costs LVL/m^2 */ Average apartment's area 2*

As shown in Fig. 3 and its equations, one-bedroom apartment number depends on both, the improvement of living conditions and the provision of housing (*apartments increase*). Together they change the initial number of available apartments. Their economic essence, and calculating formulas were considered above, only it has to be noted, that funding of Fig. 3 is split into two parts, with the indices 2-1 and 2-2, where the first digit indicates, that the funding is related to the one-bedroom apartment segment, but the second separates the funding for living conditions' improvement from provision of housing.
Theoretically, the model described above, points to maximize high or even unlimited number of housing growth. This is not real, because after a certain lifetime, all the buildings are aging, so it is necessary to take into account the housing decline. Data on the number of apartments and housing removal from operating in public studies and in statistical databases is not available. Actual removal of buildings from operating or building depreciation can not be determined, therefore, further practically simulating the market situation, is analyzed the system sensitivity, leaving the index in different positions. Apartments' removal from operating or housing depreciation model is very simple and is shown in the Fig.4.

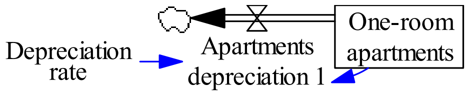


Fig.4 Apartments' depreciation model for separate living fund group

According with Fig. 4 system dynamic equations are formed.

*Apartments depreciation 1 = Depreciation rate * Number of one-room apartments*
One-room apartments = INTEG (-Apartments depreciation 1, initial levels)

In the example of one housing fund group (see Fig.4) is shown, that the housing depreciation depends on the depreciation rate and the apartment number. Depreciation gradually reduces number of apartments (existing real estate). Similar model is used for all real estate groups. Bringing together one-room, one-bedroom and two-bedroom apartment models, we obtain the total housing forecasting model. The common model equations were analyzed in advance, so the analysis will not repeat here. It is important to note, that the housing group models are related, together using construction costs of square meter area. In this submodel, they are no longer related to each other, but it is known, that the apartments with a variety of rooms are significantly related to each other in real estate market. Decreasing or increasing the price of a single group is followed by changes in another group, etc. This phenomenon, as well as other economic relationships in real estate market is discussed below.

2. Real estate prices forecasting model

The model is based on the principle, that once a certain price is up to date and fair until the price will not change the parameters affecting it. At affecting parameters of prices, are accountable the housing fund extension or reduction, overall housing market effect on certain segments of the housing market (and vice versa). Let us consider them separately, start from the housing fund impact on the real estate prices. The model is shown in the Fig.5. It is important to note, that housing fund reduction is negative form of expansion, therefore these two types of changes are used in the one model, the model is called the expansion model, while noting, that this also could be a reduction model.

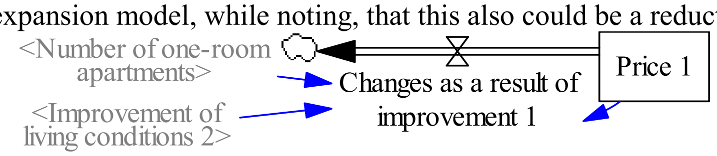


Fig.5 Influence of housing fund increase on prices

According with Fig. 5 system dynamic equations are formed.

Price 1 = INTEG (Changes as a result of improvement 1, initial level)
*Changes as a result of improvement 1 =Improvement of living conditions 2 * Price 1 / Number of one-room apartments*

Analyzing Fig.5 and its equation, we can say, that the price of the real estate segment decreases with the improvement of living conditions to residents in this segment. The model of price changes has been named the *Changes as a result of improvement*. This can be explained by following - if the household improves its living conditions, then they are moving to live in larger apartment, to another better real estate segment. But in the former real estate segment the former apartment will stay empty. Apartment vacation reduces prices for all apartments in the same segment only if a release of the one apartment will not be observable in the market. But, if the mass (2-3 thousand. or more) of the households at the same time (or phase) decided to improve the living conditions, the market development would be very difficult to forecast (but especially for this purpose developed model will allow it).
In the model, living conditions will improve gradually, i.e., the one-room apartment' households will move to one-bedroom households and one-bedroom to two-bedroom segment. Accordingly the one-bedroom apartment increase reduces prices in the segment of the one-room apartment, two-bedroom apartment number increase reduces price in the segment of one-bedroom apartments. The model (Fig.5.) by changing the constants and indices can be applied to segments of the one-room apartments and one-bedroom apartments. It is assumed in model, that such growth model does not exist for the segment of two-bedroom apartments, because they are the largest available apartments in market, largest flats to improve housing conditions households do not seek.
Also the Fig.5 sets out the *changes as a result of improvement* affecting factors. They are, firstly, *improvement of living conditions* 2 (or the number of newly built one-bedroom apartments), *price* and *number of one-room apartments* in one-room apartment segment. It is understandable, that the more new apartments are being built, the greater would be its impact on the market, so the improvement of living conditions directly affects the price. How much the price is affected it is set by the ratio of price and the number of apartments. Higher price level sets the greater fluctuation amplitude of price. The more apartments in the housing market, the less is the impact of one apartment, so the number of apartments in the analyzed segment reversibly influences the price changes.
Previously examined housing fund expansion and real estate prices influence model will allow to assess the consequences if the living conditions in Latvia were massively improved. The model provides that with the new housing construction the price of old real estate will decline. Given, that the price differences of old buildings and new buildings may become so high, that residents may temporarily refuse to improve their living conditions. This means, that excessive construction or boom, might be detrimental to the further development of the building.
Next submodel analysis the overall housing market impact on certain market segments, as well as the individual segments of the market impact on the common market. Their mutual influence model is shown in Fig.6.

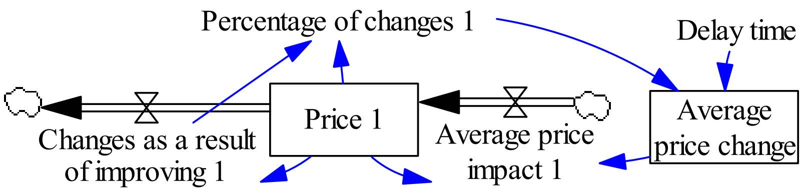


Fig.6 Separate housing found group prices and average price mutual influence model for one housing fund group

According with Fig. 6 system dynamic equations are formed.

Price 1 = INTEG (Average price impact 1 - Changes as a result of improving 1, initial level)
Percentage of changes 1 = - Changes as a result of improving 1 / Price 1
*Average price impact 1 = Price 1 * Average price change*
Delay time = 1

In one housing group example, Fig.6, have shown, that from the prices and its changes are calculated the percentage of price change, which affects the average price changes. The average price changes in turn affect the price of each particular group. Thus it is created a model of feedback effects. Average price change affects all housing fund groups, so the average price changes are analyzed in a separate equation.

Average price change = DELAY FIXED ((Percentage of changes 1 + Percentage of changes 2) / 2, Delay time, 0)

Where: DELAY FIXED (**a**, **t**, **b**) - time delay operator. Indicator **a** (value) has been delayed at time **t**, at the beginning, during delay, indicator **b** is used.

Analyzing housing fund segment prices and the average price of the mutual effects of the model, it is important to note, that average price changes resulting from one-room and one-bedroom price changes, as the simple average of the previous period (or after the delay time). The time delay provides the specific system dynamics operator DELAY (FIXED). It is necessary to take into account time delays, because not all market processes market participants recognize instantly.

One-room and one-bedroom apartment prices are used under the previous assumptions of the model: within the increase of improvement of well-being level, only to those groups forecasted needs and demand reduction, and it is a consequence of direct price reduction. Direct price reduction in these groups indirectly reduces the prices of two-bedroom apartments segment, despite the fact, that the need and demand for two-bedroom apartment segment is not reduced. It is based on the fact, that the prices of various room apartments almost completely are correlated, but when it is valued by the prices per square meter, then the correlation will be more directly.

It is understandable, that the above-considered the number of apartments and living area price models are critically dependent on the housing fund demand. Housing fund demand from one hand depends on the paying capacity of population, but on the other - the need for housing. Paying capacity of the population is closely related to overall national economic development; it is a very broad question, so in this study it is not viewed. Apartment's needs are closely related to the reflected model; therefore they are discussed in next subsection.

3. Apartment needs and financing forecasting model

Apartment needs forecasting model is based on the principle, that at the beginning defined need volume remains constant, while on it does not work affecting factors. Among the affecting factors are increase of apartments – are reduced the number of housing needs; depreciation of apartments (number reduction) – are increased the number of housing needs; improvement of the living conditions – are reduced the number of housing needs.

The first two factors are easy understandable: the direct changes of the housing needs, affect the needs contrary. But the effect of third factor is slightly more complicated. The model provides the improvement of living conditions, moving from small apartment to apartment with a larger number of rooms. For this, it is necessary to build a new apartment. The new apartment building reduces a need of an apartment in housing fund segment, but the vacation of an apartment reduces apartment need in another housing fund segment. Thus, the improvement of living conditions (the building of new houses) affects two real estate fund segments. Conceptual, apartment's needs forecasting model of one housing fund group, is shown in Fig.7.

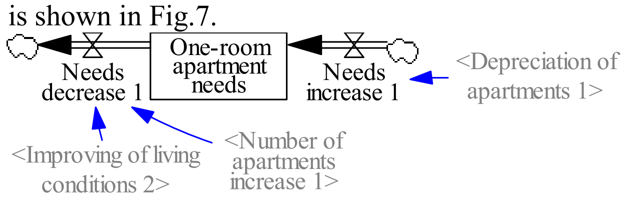


Fig.7 Apartment's needs forecasting model for test housing fund group

According with Fig. 7 system dynamic equations are formed.

One-room apartment needs = INTEG (Needs increase 1 - Needs decrease 1, initial level)
Needs increase 1 = Depreciation of apartments 1
Needs decrease 1= Number of apartments increase 1 + Improving of living conditions 2

As already mentioned, needs are affected by its initial level, increasing and decreasing, which depend on the building of apartment and depreciation, as well as improvement of living conditions. Of these factors has not been discussed only the initial the level of needs.
To define the initial level of needs is difficult. Its determination the author proposes to split into two stages. Looking for a need's maximal limitation, it is possible to use statistical data. Statistics of built apartments might indicate on their needs. If apartments are built, they are needed. Of course, it is not recommended to take into account during the boom built 9319 apartments in 2007 (6). But this objective could serve as an intermediate level. So, in Latvia during the period 1990 – 2008, in average built 3837 apartments (per year), this 19-year average apartment construction amounts are similar to the last ten years the average apartment construction amounts (3428 apartments in average were built in 1997 - 2008), indicating, that in all conditions apartments are needed. Considering, that in the analyzed period was included the result of boom, it is possible, that the maximum potential needs are lower.
The second stage sets the minimum level of needs. The minimum level could adopt a zero. This means, that the needs are not and all apartments have been used. Some experts might challenge this assumption, based on the fact, that part of the constructed apartments during 2007 – 2009 remain empty, they are not demanded. The market is saturated. The model allows to use negative values of the needs. To saturation assessment, author proposed to use during the year actually built and within ten years built average disparity. For example, if the constructed apartments in 2008 were 8084, and ten-year average apartment construction was 3428 apartments, then the overproduction amount is 4656 apartments. This is quite a lot, but the number is so large due to the boom and the long nature of the construction process. Complete the ongoing construction in the crisis time is sometimes more rewarding than to leave it unfinished.
Despite the above argument, the lower limit of needs is not clearly defined; the upper limit could also be controversial. These values, as well as model sensitivity to these indicators should be specified in the simulation process.
Previously it was said, that the model of living conditions improvement affects the two real estate fund group, but there was shown only one housing fund group. Included economic correlations for both groups are equal; therefore the second affecting group is not shown.
Farther the model of necessities is attracted to the building financing. In case if there are necessities, building of apartments is possible. It is assumed, that construction funding could theoretically vary from zero (no funding) to the maximum possible need full satisfaction. These data will be clarified later, in the simulation process.

4. Apartment's living area forecasting model

For living area model the author does not pay big attention, because it is only additional model. One of the key assumptions, mentioned above, was due to the fact, that people are trying to buy an apartment with the properties, which are similar to existing apartments on the market. Consequently, the average area of each test group is unchanged. In unchanging average area circumstances, knowing the number of apartments, it is possible to calculate the total living area. This is done in the living area forecasting model, which is shown in Fig.8.

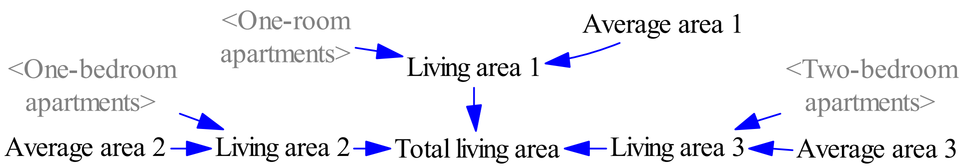


Fig.8 Living area forecasting model

According with Fig. 8 system dynamic equations are formed.

Total living area = Living area 1 + Living area 2 + Living area 3
*Living area 1 = One-room apartments * Average area 1*
*Living area 2 = One-bedroom apartments * Average area 2*
*Living area 3 = Two-bedroom apartments * Average area 3*

In Fig.8 it is shown, that total living area is formed as sum of living area in real estate groups. Living area in groups is calculated from a predetermined number of apartments and the average fixed living areas. The average areas are taken from statistical sources.
Constructing industry forecasting model is completed, in the next subsection are discussed the practical results of model activity.

5. Construction industry forecasting model results

Before viewing results of model, is necessary to underline once again, that not all of the data is certainly set, some data output has set only possible fluctuation limits. They are:

- depreciation of buildings (ranging from 0 to 0.57% per year of the total housing fund);
- housing initial needs (ranging from -4656 (surplus) to 3428 (needs));
- housing construction funding (ranging from zero to the maximum possible need full satisfaction (3428 apartments));
- construction business profit margin (ranging from 5% to 15%).

The first model experiment is performed with an indefinite data-medium parameters, i.e., depreciation of buildings = 0.285%, flat initial needs = 0, the housing construction funds - half of the maximum possible needs (1714 apartments), the profit margin = 10%. Experimental results are shown in Fig.9 (1.-5.). Results are divided into five groups, since it is possible to show all of the modeling results. Figures give a general schematic concept of the indicators' dynamics and their potential development. Simulation process is discussed in 15-year period, from zero on (2009), when the model has been worked out.

Fig.9.1 Prices forecast by groups (Ls/m^2)

Fig.9.2 Apartments' needs forecast by groups

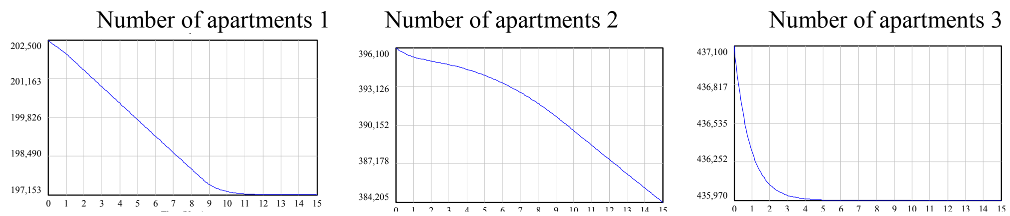


Fig.9.3 Number of apartments' forecast by groups

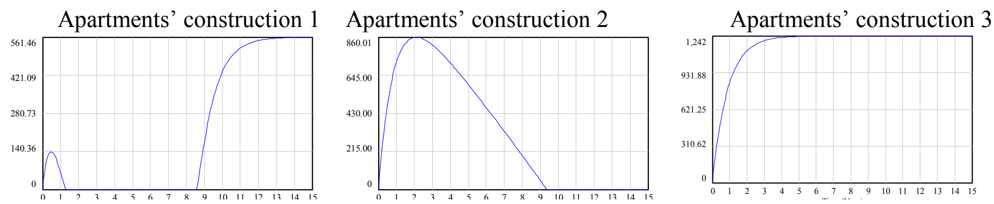


Fig.9.4 Apartments' construction forecast by groups

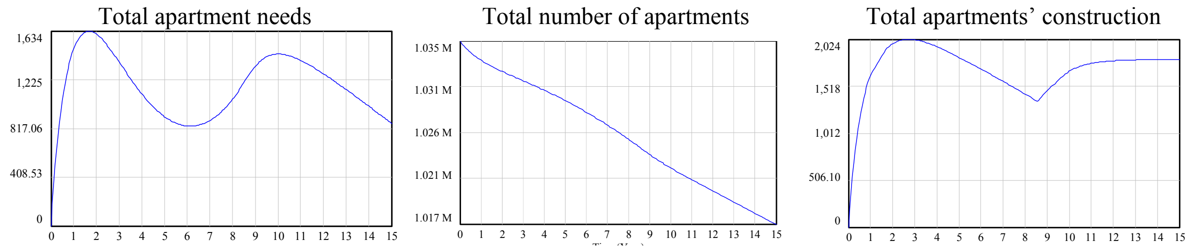


Fig.9.5 Total result forecast

In the first figure group are the prices in real estate market (Fig. 9.1) It is clear, that prices decrease in all real estate groups. It is important to note, that these prices reflect not the speculation, inflation and other economic factors, but the need, demand and construction impact on prices. In each test group the price reduction will be separate: in the first group, the reduction would be 5.6%, in the second - 7.6%, in the third - 3.1%. First and third groups had similar price reductions. The pace of the first group will be faster in 7-8 years, but further it will more gradually decline. In the second group price reduction will have a solid pace throughout the test period. These price changes are explained by the changing needs and apartment numbers.

It is clear, that the apartment needs have diverse dynamics (Fig.9.2). Apartment needs in the third group will grow very rapidly, but after six years will stabilize and remain unchanged until the end of the analyzed period. It could be concluded, that there is set a maximal limit of needs, which in this group would be achieved. Stabilizing the indicator at a certain level could also indicate the achievement of equilibrium in housing removal from services and new construction amount in the given group.

Speaking about the second group, it is obvious that in the first two years needs of this group will grow almost as fast as in the third group, but later there will be a decrease. After 10 years, it will return to the initial level at zero, and later without changing the temps, needs will continue to decline, creating a two-room apartments' surplus. The surplus is associated with the improved living conditions of residents. Those of the second group moves to the third group, as a result the apartments in the second group remain unnecessary.

The most interesting is the dynamics of the first group. In the beginning, during 6 years, needs will decline creating a surplus of apartments. The surplus formation is associated with the improved living conditions of residents, i.e., switching to the second group. Further the situation will change, needs will start to grow as rapidly as they have declined. Around the 9th year of forecasting the surplus would be eliminated, real needs are formed, which will reach their highest point till the 12th year of forecasting and then will stabilize. The increase of needs and further stabilization is explained with a reduction of the apartments' number (due to depreciation) and further with the achievement of equilibrium in housing removal from service and new amount construction in the given group.

Analyzing the total housing needs, it is evident from Fig. 9.5 that by assumptions the initial number of needs is zero, but in short period it will reach its maximum - 1964 apartments, further during 4 years it will decrease by almost half, then a 4-year growth period will begin again. After ten years amount of needs will start to decline, direction of change and temps are not going to change. On the one hand the total housing dynamics look very strange, but it has a very simple explanation: it is a simple sum of the group needs. If the needs increase in all groups, accordingly grow the total needs, but if there are multi-dynamics in the groups, then it is not possible to predict the overall results analytically; a forecasting model which is designed specifically for this purpose allows to do it quantitatively.

The next group of images is associated with the prediction of the number of apartments (Fig. 9.3). It appears that the number of flats will decline in all analysed groups but the size and pace of reduction will be different. The fastest pace of decline has the first group, during the nine-year period it will lose approximately 3% of the housing fund, but starting from the tenth year, the decrease will stop and as it was said, the number of apartments will reach equilibrium level. The pace of decline in the second group will be almost constant and during 15 years the group will lose a little over 3% of the housing fund. In the third group the decrease will be only during the first few years and it will be very insignificant - 0.23% of the housing fund. It is important to note that analytically construction funding advantage is given to the first group, while the lowest – to the third group. However, the model results show that number of apartments in the third group will decline least. This could indicate that the

proposed financing will not be used in the first two groups, since there is no corresponding need for it. Needs and demand for two-bedroom apartments remain. In overall (Fig. 9.5) the real estate during 15 years will decrease by 1.74%, at the same time building removal from service draws up around 4.2%, which means that the difference is covered with apartment construction.
Apartment construction which can be seen in Fig. 9.4 at large extent depends on the housing needs (from Fig. 9.2). If needs grow, accordingly the housing construction grows; if needs stabilize, then also the construction stabilizes. In case of need decrease the construction output will also decline, but if needs decreased to negative numbers (apartment surplus), the construction would stop at zero level. Analyzing the forecasted data on the total housing construction, it is set that at the above-mentioned conditions the balanced housing amount is approximately 1800 apartments per year, but with overproduction and fluctuation of needs this value in short-term could range from 1434 to 2019.
Besides the factors already discussed, the model also allows to predict other parameters, for example, in the test scenario the annual funding is not spent each year completely, but it is accumulated. This suggests that so small amounts of construction are not connected with the small funding, but with small needs, as well as that the level of proposed funding at the beginning was chosen incorrectly. Previously the average or baseline scenario was viewed, further will be looked at the modeled indicator sensitivity to the initial data modification. And the first undefined parameter is depreciation of buildings, which under the assumptions vary from zero to 0.57% of the total housing fund, the model sensitivity data to the changes is showed in Fig.10.

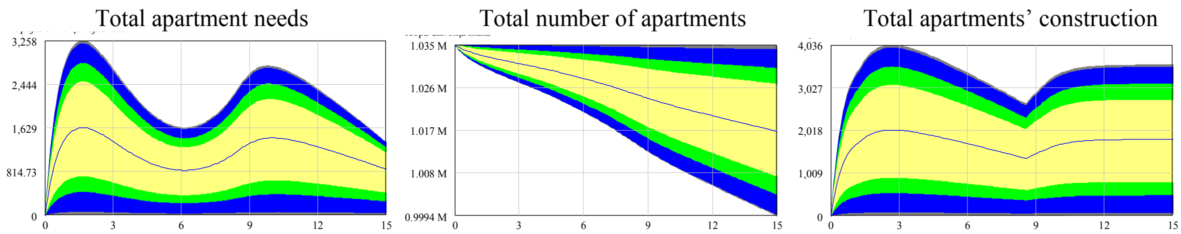


Fig.10 Model result sensitivity to depreciation rate

Model sensitivity to the depreciation rate is presented in the Fig.10. In this figure, as well as in all other images of sensitivity analysis, the above mentioned baseline is noted with plane (middle) line, compared to that colored plots show to what extent the analysed parameter can fluctuate. For the impact of the depreciation rate, it is evident that the initial data may significantly affect the indicators of the whole industry. Firstly, if the depreciation rate is increased then housing needs will grow directly proportional, housing amount tearing down, but residential construction is growing. Reducing the depreciation rate to zero, needs will decrease, the number of apartments will remain almost unchanged, construction output will also decline. It is a normal expected reaction to the changes of depreciation rate.
The most interesting thing in Fig.10 is that at the zero depreciation (apartments will not be removed from service), the model shows with a probability of 95% that the housing construction could stabilize at 500 apartments per year in Latvia, that slightly falls behind the number of apartments constructed in 2000 - 2002 when it was 800 dwellings per year. Difference - 300 apartments – about 3% during the „bubble" could be negligible, but at the normal expected volume of housing construction- 1800 apartments – it draws up about 17%, which is already substantial. Modeling results and statistical data allow us to conclude that the construction market can be characterized not only counterbalanced the volume, but the minimum amount of construction, which should always be provided. In this study, the fixed minimal amount of housing construction in Latvia is said to be 500 dwellings per year.
Construction output is related to needs. The next initial data is associated with the uncertainty situation in the Latvian real estate. It is not known, is there a surplus or deficiency in the housing market. In Fig.11 there is a situation modeled where the initial housing needs range is from -4656 (surplus) to 3428 (deficit).

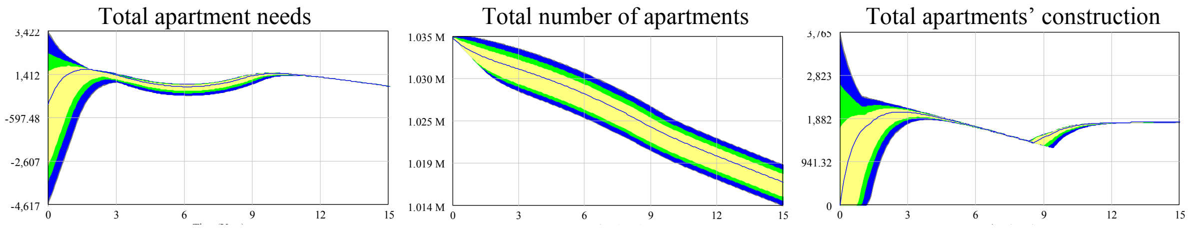


Fig.11 Model result sensitivity to initial market condition

Fig.11 shows the sensitivity of net results to the changes in the initial needs, it means that this indicator is not mixed up with the previously viewed depreciation rate. This principle is suitable by default for all the indicators of a sensitivity analysis, if not stated otherwise. The graph shows that despite the initial needs, housing needs and construction output after three years will approach to the baseline, but later will coincide completely. This in turn will affect the overall number of apartments. If there is a housing surplus at the starting point, then considering that residential construction during the initial years will be negligible, then due to the depreciation the number of dwellings will decrease, compared to baseline, but if there is a deficit of apartments, the housing fund will increase.
The next undefined factor to be analyzed is financing. The study examines the housing financing fluctuations from zero to the full satisfaction of maximum possible needs (which is corresponding to 3428 apartments), see Fig.12.

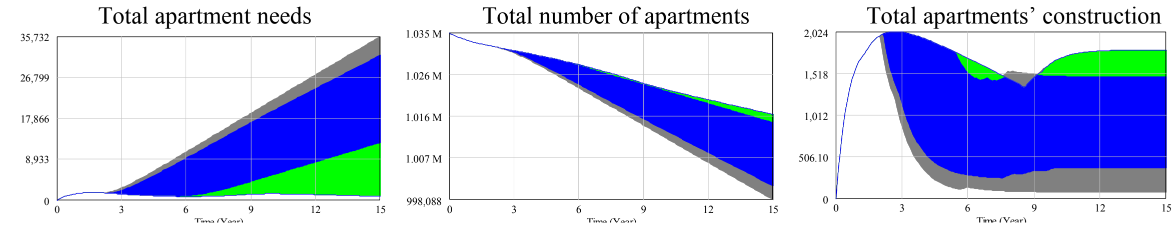


Fig.12 Model result sensitivity to financing changes

Fig.12. shows the sensitivity of model results to changes in funding. Obviously, by reducing the funding, the needs for housing will grow, the real estate fund and construction output will fall. It is a normal, predictable response. Increasing funding, construction output will not above the baseline scenario, as well as the total number of flats will remain in the baseline level. This is because with the funding increase the needs do not decline, but remain in the level of the baseline scenario. Previously it was said that in the baseline scenario all the funding allocated will not be spent, but accumulated. In which case in real situation under the conditions of restricted construction, the real estate prices will grow, followed by a speculative building boom, housing oversupply. In our conditions, this situation is hypothetical, the housing financing in the coming years will not be larger than needs, so there are no correlations in the model which by redistribution of accumulated funds would create the building boom. Model reflects a prudent use of funds according to real needs, i.e., determine the volume of construction, which is balanced, i.e., does not cause ineffective booms and dramatic crisis. It was one of the objectives of the study and the model is designed according to it.
The next factor to be analyzed is a profit margin of construction companies, which ranges from 5% to 15%, and it's impact on the model results is reflected in the Fig.13.

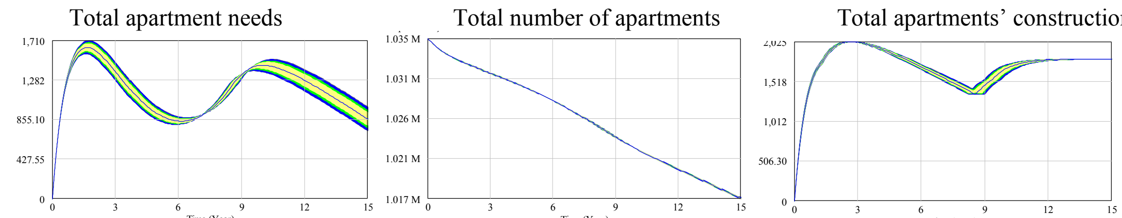


Fig.13 Model result sensitivity to income norm

Fig. 13 shows that model results are almost independent from the construction sector's profit. However, for absolute impartiality it was necessary also to show the effect of income norm indicator, despite it's insignificance.

The overall effect of all the undefined factors is reflected below, see Fig.14.

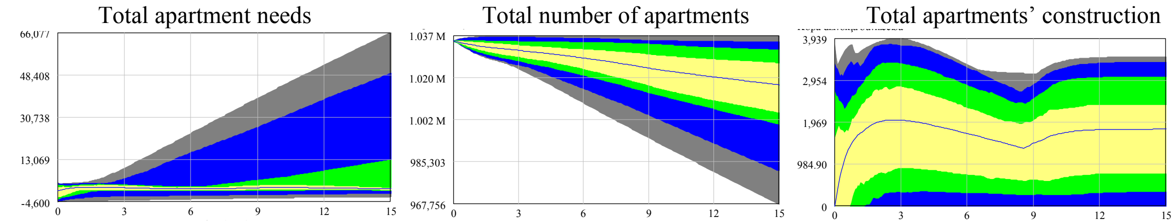


Fig.14 Model result total sensitivity to all unknown factors

Comparing the data in Fig.14 with a data in Fig. 10-13 visible, that biggest influence in cumulative results can cause financing reduction, including it's falling to zero level. But such scenario is unlikely to happen. Another key exposure factor is the depreciation of buildings and their removal from service; it could significantly increase the volume of construction. In this case, the depreciation is the development factor of the construction, but funding can only limit it. The effect of both factors was discussed previously. Other model factors are minor or have short influential time.

Overall the sensitivity analysis confirms the baseline scenario, supplements it and expands the horizon of potential boundaries. The developed model can be used to analyse different scenarios in Latvia, by adapting patterns – also beyond it. The model is particularly useful in forecasting the possible long-time effects in the construction industry and real estate markets, including decision-making in national economy.

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