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This research had as its aim to provide answers to two different questions the municipality of Zoetermeer was asking; how do we advance residential migration or household filtering and what is the housing program for the coming 10 to 15 years going to look like? These questions were being asked because of a local interest and a regional demand respectively. To provide the answers, the migration data was first analysed and based upon it and a number of other inputs a number of housing programs were designed using a decision-making model which was developed. Both questions were thus being answered with the use of one housing program.

User value

The use of the model which was designed is strongly dependant on the process of defining the input, which consisted of the living environments, the dwelling models and a number of city-wide variables. The two are thus almost part of the same iterative process and should be used as such. This likely makes the process too complicated to any given employee of the municipality, which however is hard to prevent, as the approach is also relatively new in the field of urban planning and the development of housing programs specifically.

The outcome of the model seemed to be useful at first sight and the municipality's program manager of housing responded positively to the speed at which a new program could be calculated. This provides potential for implementation of this model as well as its outcome. The outcomes would not be directly applicable, but by optimization the program through a number of iterations, the outcome could come very close to what is desired as a housing program by Zoetermeer, without the need to place design decisions in the hand of others of spend longer periods of time on making these iterations.

Social Value

In terms of social value the model has potentially provided the municipality with a step forward in terms of its housing program and did so with the aspect of migration in mind. It should however be kept in mind that the results will not likely be implemented directly, as the municipality is an organisation which is greatly intertwined with politics and the implementation of any program is thus also greatly dependant on the support it gets from the political environment. Moreover, this report was written during the municipal election of a new municipal council and thus might have been finished shortly after it would have been most useful, i.e. during the formation of a new coalition. Nonetheless it will provide the municipality with new information and view on how it could solve, or attempt to solve, the problems it is facing.

In terms of overall societal value, the results of the research are expected to be rather easily transferable to other municipalities or developments, as the model was built with just that in mind. Both the model for the calculation of migrations chains as well as the decision-making model can be cleared of any data and be filled with any input desired. If any other town or city would like to use the model to construct their housing program, it could do so provided they have the capability to provide the input. Only very little alteration would be required and these would mostly be quality of output alterations, such as the map of Zoetermeer being replaced by the map of the current location. Other than these little alteration, the model is completely set up to facilitate any number of desired dwellings, distribution of dwellings, 15 adjustable dwelling models and 9 adjustable living environments, the model is adjustable to aim at almost any optimization and has the flexibility to facilitate additional input if required, although the latter would naturally require some adjusting to the model.

Scientific Value

In view of the Master track Management in the Built Environment, the research linked quite closely to a number of aspects which have been discussed in the two years of curriculum. Firstly, it aims to solve large scale urban redevelopment problems, which have been central in many parts of the track. Secondly, it applies a decision-making model, which was learned of from a course, in practice and proves that, within a reasonably short period of time, quite decent outcomes can already be achieved. Lastly, knowledge on a number of aspects such as multi-actor decision-making and financial land exploitations had to be applied to the development of the model and the process in general to combine the many inputs and facilitate the actors' aims and goals.

This research also combined housing market analysis with operational research. The housing market analysis was done in the form of researching the residential migration chains that are present in Zoetermeer. This was done using the proven method of Markov Chain Theory, but even though it was proven to show these outcome over twenty years ago, the analysis of migration chains has since barely happened by municipalities and the scientific field in general, or very little was written about it at least. Application of the theory did happen in other fields or research, such as migration of animals, but this research showed that it could also be applied to residential migration using pre-existing data.

In the process of collection this data, some hurdles had to be overcome however. The first was that the two databases in which the information was stored had only been digitalized between 2011 and 2014 and contained useable data for only very few years. Had the database been more precise, concise and structured, than the results concerning migration chains could have been more detailed as well. Nonetheless, the most recent years showed this useable structure and one can thus be hopeful that this kind of analysis can be done in the future as well.

The analysis of the data provided another hurdle however. As is discussed in this report, the Markov Chain Theory requires a number of criteria to be met by the data. Two of these are homogeneity of migration chances and stability of migration patterns. The former provides the research with a contradiction, as extensive diversification of dwelling models results in too little cell coverage. This in turn results in skewed migration chances and distorts the findings from reality. The latter is not likely to be met either, as the patterns are likely to change, not only through time, but through the sheer fact of the interventions which are planned based upon them. Adding dwelling which were previously non-existent in the stock will shift and alter the chains. It was for this reason that the recommendations said to continue analysing the migration patterns throughout the coming years.

The usage of the two databases, the BAG and BRP, was new as far as literature showed. Previously the same mathematical theory was applied to samples found in a national questionnaire, the WoON and the WBO, but using *all actual* migrations registered within a municipality was new.

A weak point of the methodology was the fact it required quite a lot of input which was previously not specified and thus needed to be defined in the process as well. This resulted in the definition of living environments using vague verbal descriptions. Additionally one discussion was held with a number of actors, but a number of actors had to cancel shortly before the meeting and only one such discussion could be held due to time constraints. For this reason, the living environments are not as specifically defined as they could or should be to truly show use the input of Zoetermeer. Similarly, the dwelling models had to be defined based on general characteristics provided by the Fakton report and the archetypes were thus not truly representative of the dwelling models desired by Zoetermeer. The two input were discussed with Zoetermeer however and seen as sufficiently accurate to use for this research.

Ethical issues and dilemmas

Two ethical dilemmas were encountered during this research. The first was that the data which was required to analyse migration chains was private and could not be shared by the municipality. This meant that the municipality had to process the data into matrices which could not be traced back to the individual and provide these to the research. This turned out to be fairly easy, as the department of Research and Statistics within the municipality was very willing to aid in this research and provided multiple iterations of these matrices. The resulting matrices could be put into the Markov Chain model by the researcher and privacy would be maintained as the matrices contained only three characteristics of any dwelling; value range, ownership type and dwelling type.

The second dilemma was encountered in the development of the model. The first version of the model used the input of a number of different variables, but this proved to be too difficult to retrieve and use as input. What resulted was a model which used values for variables which were likely all off by an unknown degree and thus would provide an output which would not be useful, if any outcome could even be found. To resolve this issue, the model was made more detailed, but this meant that a great number of actors and their input were no longer being used or considered in the model. This was however accepted, as the model would likewise also not provide directions in terms of their fields. In short, no input concerning a topic was met with no output on that same topic. Still, the exclusion of certain actors was based on the initial aim of this research to provide a housing program and thus disciplines such as infrastructure, public space, greenery and the like were not taken into account, which is strange as they too influence a living environment.