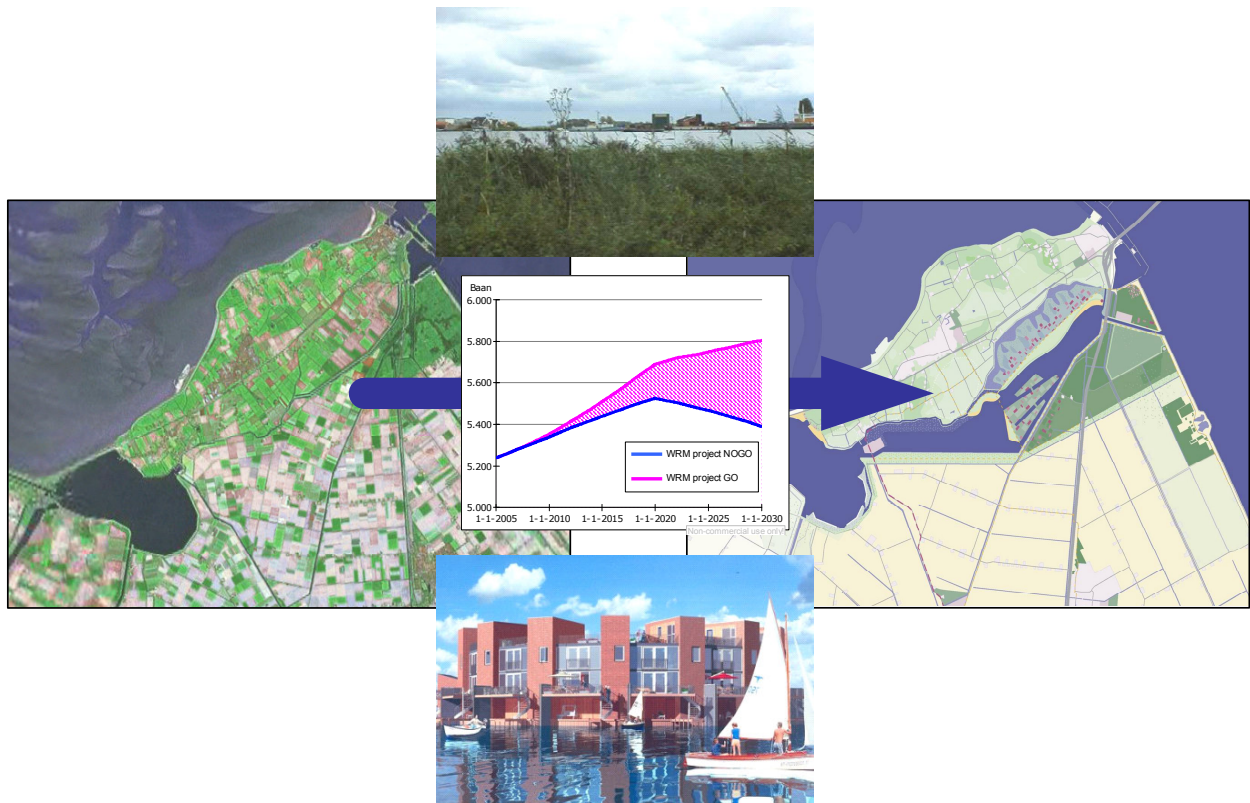


Understanding economic effects of spatial investments

Towards using system dynamics simulation for exploring socio-economic effects in a region



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Preface

This thesis has been written in the scope of the completion of the Systems Engineering, Policy Analysis and Management master at the faculty of Technology, Policy and Management at Delft Technical University. The research has been facilitated by the department of Consultancy: Economy and Space from DHV.

After first having talked to Michiel Pellenbarg from DHV in midsummer of 2005 I immediately was enthusiastic about his idea of creating an instrument, able to support policy makers in making better decisions. My mind started working overtime and before I knew it a research proposal took shape and found its way to Marina van Geenhuizen, Els van Daalen and Hugo Priemus. A question that was pertinent from the start was why no one had studied my idea and why such an instrument did not exist. That question chased me through the thesis project and functioned as a research driver.

I would like to thank Michiel Pellenbarg for supporting me in a great manner. Time has flown by it seems. I would also like to thank Els van Daalen for controlling the scope of this project and Marina van Geenhuizen for the long regional economic discussions. The last member of the thesis team is Hugo Priemus whom I thank for his talent to point out the core of a problem in one sentence.

Bedankt!

Teun

Summary

Seeing into the future remains until today a subject for philosophers and science fictions novels. Non-the-less, countless efforts are made today that aim at predicting economic developments, stock level prices and other future events (respectively the CPB¹, financial organizations and evangelists). These predictions all provide a footing for making decisions in the present that will have effects in the future. When making decisions on large spatial investments, an analysis of the effects of the investment is important for both governmental and private organisations. A broad range of methods exists that allow a glance of the future. A sketch or drawing can provide a policy maker with the effects the investment will have on the landscape. A traffic model indicates the expected traffic volume and welfare effects can be assessed with the Social Cost Benefit Analysis (Eijgenraam et al. 2000). However, there seems to be no instrument available for analysis of socio-economic effects of spatial investments on a municipal scale. And the demand for such an instrument is rising. Currently available models that describe socio-economic effects have either a wrong geographical focus, are only focussed on infrastructure or are unable to deal with economic dynamics. Furthermore, none of these instruments facilitates communication between the consultant (the model developer) and the policy maker (the decision maker). This is a shame, according to the former head of the CPB Henk Don (2004), both parties can learn from each other in an effort to make better spatial investment decisions. Therefore, the instrument should have an open and communicable structure.

A methodology that can be used for the development of an instrument that satisfies the demands mentioned above is system dynamics (Forrester 1958). System dynamic (SD) models tend to be small and comprehensible, hence relatively easy to understand. Furthermore they correspond with the feeling that real systems are non-linear, multivariable, time-delayed and disaggregate (Meadows 1976). System dynamics enables learning and makes it also possible to explore possible scenarios and potential policy options (Spector 2000). Combined with a strong visual presentation of causal relations SD makes an ideal method to facilitate communication of socio-economic effects. The question becomes then, to what extend SD can contribute to the ex-ante exploration and assessment of policy options in spatial investments in a region?

To answer this question a system dynamics model is developed that forecasts socio-economic effects on a municipal scale. For a start more research in existing spatial models is executed (van Oort, et al. 2005). This research leads to the conclusion that a lot of concepts of existing models can be used in the "thesis model". For instance the way in which shift-share analysis is used in the REGINA model (Koops 2005). The second step in the development of the "thesis model" is to acquire the requirements for the model. For this purpose consultants and policy makers have been interviewed as respondents in a requirement analysis. The result are that the model must be able to:

- export the data from the instrument to excel for further processing and storage of output data.
- have an interface that includes both a simple ("Jip & Janneke") and a complex presentation of model outcomes.
- include forecasts for regional demography, employment, housing market and gross regional product.

¹ CPB: the Netherlands Bureau for Economic Policy Analysis

- show a distribution of the uncertainty of the outcomes and the sensitivity of the input parameters.
- show effects of different policy options under different economic scenarios.

Based on the list of the requirements, the SD methodology and the literature research a concept model is developed that includes all the important socio-economic variables. The concept model is then translated into a simulation model in the PowerSim Studio 2005 (SD) software package. PowerSim has excellent visual capabilities, supports the design of an interface and has sensitivity analysis functions. Because one of the basic properties of SD is that the model must be kept as simple as possible the regional demographic development is not included in the concept model. Instead the time series outcomes of the PRIMOS² model are used and fed directly into the simulation model (Heida 2002). This reduces the size and complexity of the model notably. Furthermore, as explanatory factor for the development of jobs in the region the theorem that jobs-follow-people is used (Vermeulen & van Ommeren 2005, 2006). This means that the development of dwellings in a region is a leading indicator of the growth of jobs. In order to comply with the requirement that the model must be able to present results in a “Jip & Janneke” style and more complex the user interface of the model has been designed. The final simulation model has over 85% of the requirements implemented, including the most important requirements mentioned in the list above. An example of a requirement that is not implemented is the demand that the simulation model must be able to cope with effects on a provincial scale. This would require more complex variables and relations like province competitiveness and inter regional trade. The geographical focus of the simulation model remains a (multi) municipal scale with at least 20.000 inhabitants.

The simulation model is tested on applicability using historic data validation, group testing sessions and expert interviews. The interviews include several spatial modelling experts³ whose ideas contributed a great deal in the coming about of the thesis model. All experts concluded that they had never witnessed a model with an adaptable interface that allows the user to change input parameters and calculate the outcomes real-time. The group sessions illustrated that the instrument can work very effectively as a communication tool. This success can be attributed to the facts that questions concerning the socio-economic effects can be calculated and answered right away.

There are some points of attention that should be regarded when using the thesis model. The CPB scenarios that are used to forecast the economic growth have a large influence on the outcomes of the simulation model. The contrast between an optimistic or pessimistic scenario can change the final investment decision as the difference for jobs for instance rises up to 20%. However, sensible use of economic scenarios can also improve the investment decision. The value of the prediction made by the model is tested by an historic validation. The model proved to have an average deviation from the actual regional jobs of 4,4%⁴. This is regarded as acceptable for the use of the instrument as socio-economic effect exploration instrument. Based on the sensitivity analysis and historic validation and excluding the effect of different CPB scenarios the uncertainty bound of the model outcomes is 10%. This should be kept in mind when working with these outcomes.

² PRIMOS is a demographic forecast model which makes forecasts for all the Dutch municipalities.

³ The expert interviews included spatial model experts F. van Oort, M. Thissen and W. Vermeulen.

⁴ Based on time series: 1998-2005. Historic PRIMOS and CBS data is used and the historic industry sector performance is calculated with regression analysis based on data from 1993-1998.

The simulation model is developed with the aim to apply the model in different projects, hence for different regions. This is made physically possible through the loosely coupled relation between the input variables in an Excel database and the simulation model in PowerSim. Furthermore the model is built in components that can be adapted to fit effects of different regions. The simulation model is therefore physically capable of dealing with different project regions. As mentioned above the municipal level binds the geographical scale of the model. Differences that exist between urban and rural regions do not present a problem for the simulation model (Interview Vermeulen). However regions with extensive industries and high concentrations of jobs have more complex economic relations. Unless these relations are built into the model it should not be used for industry intensive regions.

The verdict on the simulation model is that it can be used for the assessment and exploration of socio-economic effects. The question remains what the added value of system dynamics is? First the causal thinking (inherent to SD) relates closely to mental models, which makes discussions of the relations in the model relatively simple. This simplicity is desired for the communication between policy makers and consultants. Therefore the most important principle when using a SD methodology is to make sure that the policy maker understands the consequences of a proposed policy option. This will assist policy makers in understanding the non-linear developments in a project region. The elaborate visual representations of the outcomes of the simulation model also contribute to a better understanding of the economic system by the policy maker (Forrester 1980). It also provides a platform on which the consultant (assisting the policy maker) and the policy maker can discuss potential situations in the project region. This in turn involves the consultant more in the local issue, giving him or her a more profound basis on which to form recommendations.

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1 Research project setup

1.1 Introduction

Political decisions concerning large infrastructural and spatial projects cause a lot of controversy. Not only because these decisions have far going consequences for the Dutch landscaped but also because doubt exists to whether these projects are economically justifiable. The economic benefits are – in some cases – very slim and vulnerable to scrutiny because the benefits do not hold in all economic scenarios. Recent projects that are now under construction (e.g. the Betuwe lijn and the HSL) have led to increased social and political discussions about the economic benefits of such projects. In 2004 a temporary commission⁵ (TCI 2004) was appointed by the government to research the causes of the budget overruns and delays in large infrastructure projects. Next to this political development already in 2000 a directive was drawn up for the vindication of large (infrastructure) projects. The directive stems from the Research program Economic Effect of Infrastructure (OEI) and advocates a methodology that is called Social Cost Benefit Analysis (SCBA) (Eijgenraam et al. 2000). The use of a SCBA is obligatory for large national projects, however it is also deployed voluntary for projects on a smaller geographical scale⁶. SCBA helps quantifying welfare costs and benefits and is aimed at preventing double counting of effects of an investment project. Although the SCBA includes positive and negative welfare effects, it does not illustrate the terms on which policy makers reach their intended policy goal.

Some conclusions of the TCI issued that even more care should be taken in quantifying risks early in a project. They observed the systematic underestimation of the costs and overestimation of the revenue on large infra structure projects (TCI 2004 pp. 15). To counter these effects more funded arguments resulting from independent research have to be collected. Especially the early phases of decision-making lack structure in coming to a clear judgement. Premature, unfunded prognoses may not be allowed to influence the future decisions as these early projections are often biased and based on speculation. These problems are not only present on a national scale; projects on a lower geographical scale also require better assessment in early policy phases. The demand for these regional effect studies has risen over the last year⁷. A problem that policy-supporting consultants face is that the instruments for policy analysis at their disposal are either unsuited for smaller projects (Vermeulen & van Ommeren 2005, 2006), only focused on infrastructure (Thissen 2005) or unable deal with the economic dynamics (Blok, 2002). A possible solution to the problems mentioned above could be an instrument in the shape of a simulation model that is able to support policy makers in dealing with risks early in the policy process. Both consultants and policy makers should be involved in the development of this instrument. In that line of thought Don (2004) writes that policy makers and (model developing) consultants should work more closely together in order to learn from each other. The policy makers are often not aware of the underlying model assumptions where they often should be in order to put their policy proposal in perspective. Don too, established the lack of risk assessment in large, complex projects and thinks that econometric models can assist policy makers in pointing out the high risk factors in their policy proposals.

⁵ Tijdelijke Commissie Infrastructuurprojecten (TCI)

⁶ From the website of Ecorys: visited on 29-03-2006: http://www.ecorys.nl/projecten/vv_infra_p1.php

⁷ An increase in tenders was noticed by employees of DHV Economy and Space (June – September 2005)

Currently available economic models for regional economic projections are either too complex or not suited for the assessment of municipalities. Therefore an instrument needs to be developed that has an accessible structure, this way the model becomes an instrument that is able to illustrate how economic results come about. This does not mean that the existing models cannot assist in the coming about of the thesis model. The thesis model should facilitate the collaboration between policy makers and consultants and enable smoother knowledge exchange. Furthermore, the model should support policy makers in dealing with uncertainties that are present early in the policy process.

1.1.1 Research issue: assessing system dynamics applications in spatial problems

Last year the engineers of DHV Economy and Space (E&S) observed an increase in the demand from local governments for long-term regional investment effect studies. In these studies an assessment is conducted of the economic effects of an investment on regional scale. Such an investment can be infrastructure development, a city extension plan or area redevelopment. This increasing demand can be attributed to two major developments. First the introduction of the dual system directive in March 2002: in the dual system the municipal tasks have been divided more clearly. Members of the municipal council have a larger monitoring responsibility toward the city administrators. The administrators have to justify investment plans and need support in the form of an effect analysis or forecast. A second and perhaps more significant development is the gradual shift from admission planning towards development planning⁸. Roughly put, development planning allows ideas for regional development to come from the municipalities instead from the central government. In this situation the municipality has to justify the proposed investment towards the central government, an effect analysis or model can be a supportive tool in this matter

The current analytical methods that E&S have available are sufficient to supply their clients with an economical forecast, however a standard model or modelling approach is not used. There are models available on the market developed by other firms and institutions however these models do not fulfil the specific needs of DHV E&S. Either the geographical scale is too high and lacks a municipal scope, the model is too complex or the model is too costly to use. The SCBA is an available technique; however the SCBA remains more a way of inventorying welfare effects than it is an actual simulation model. Several models have been developed by both public organizations as by private firms, like The RAEM model, developed by the Netherlands Institute for Spatial Research (RPB). RAEM is a monopolistic competition model that is aimed at evaluating policy on transport infrastructure (Thissen 2005). It does this however on a national scale; the results are therefore focused on a national level of policy making, not on lower geographical scales. Furthermore the RAEM model is extremely complex and would, even for a model expert, be hard to comprehend and is not suited for interaction between consultant and policy maker.

A model that focuses more specifically on the municipal level is PRIMOS, developed by ABF Research. It is designed to make forecasts on demographic developments in Dutch municipalities until 2040 (Blok 2005; Heida 2002). The PRIMOS model could not be used for the early assessment of projects because it does not include socio-economic effects. Several other models use the time series data output of PRIMOS as input data hereby omitting a demographic model component. A model that is able to calculate economic effects on a municipal level is REGINA. The REGINA

⁸ From brochure of the Rathenau institute, Habiforum and NIROV: Ontwikkelingsplanologie als social-culturele opgave (2004)

model is developed by the Netherlands Organization for Applied Scientific Research (TNO) and is aimed at providing regional employment and industry growth projections. Compared to the RAEM and PRIMOS model, the REGINA model is relatively easy to comprehend (Koops 2005). The primary function however, remains identifying differences in economic growth between regions or municipalities, not the ex-ante calculation of regional investments. These currently available models can be considered complex black-box systems that can only be used by model experts. This leads to a situation where only the model expert is aware of why the model behaves as it does; while in fact it is important to convey this knowledge to the policy maker in order to let them make better decisions (Don, 2004). The models that are discussed all lack the ability to be able to be used in situations where the policy maker and consultant together can come to solutions. To sum up, there are four issues why the currently available models do not suffice:

1. The geographical scale is too high, not on a municipal level
2. The models do not sufficiently deal with uncertainties
3. The models are too complex
4. Policy makers are not aware of the underlying model assumptions

The four issues mentioned above and the demand for an instrument that can quantify and communicate socio-economic effects in region lead to the use of system dynamics. System dynamics provides insight for policy makers in regional investment decisions based on causal relations. SD has certain advantages; it relates closely to “mental models” that people perceive in a problem (Forrester 1958, 1969) and is therefore easy to communicate. Furthermore SD is an approach that is used for general understanding of a problem and SD models tend to be small and comprehensible, hence relatively easy to understand. **System dynamics transforms these mental models into causal relationship diagrams indicating directionality and nature of the effect.** It corresponds with the feeling that real systems are non-linear, multivariable, time-delayed and disaggregate (Meadows 1976). Most people are capable of logically deducting these causal relationships between two factors and so creating a visual model from their mental model. System dynamics enables learning and makes it also possible to perform explorations of possible scenarios and policy options (Spector 2000). This enables a consultant, supporting a policy maker to involve him or her in the socio-economic processes that take part in “their” project region. With a visualized model, feedback loops can be identified that would have been obscured in a mental model due to the complexity and non-linearity of the real-life system. The ability of transforming complex, mental models into tangible and quantifiable models is a great strength of the system dynamics approach.

An effort to model the dynamics of a growing city has been undertaken by Forrester (1969) with his Urban Dynamics (UD) model. This model simulated a small rural community that grows up to be a medium sized town. The model incorporates different types of housing, work and industries. This UD model functions as a starting point for the development of this thesis model. This means that the thesis model will not be focused on infrastructure development but on housing projects, regional facilities and the expansion of business parks.

1.1.2 Research objective

The general objective of this master thesis is threefold. The first objective is to plot a set of demands that need to be fulfilled by the instrument. These demands consist of a scientific part and a practical part. The scientific demands come from studying existing model and performing a

literature study. The second objective is to create (part of) this simulation model. The third and final objective is to convey the knowledge gained during the completion of this thesis project towards other people.

The simulation model is intended for use in regional policy processes meaning in and between municipalities. More specifically the respective purpose of the simulation model is to support policy makers in the process of developing alternative policy options and testing the consequences of those options. The model can assist policy makers in attributing uncertainties and dealing with them early in the policy process. In that sense the model can be called an instrument that is aimed at strengthening the development of new policy.

1.2 Research questions

To overcome the problems mentioned above an approach will be explored in this thesis project that has the potential to provide policy makers with an ex-ante assessment of the economic effects of their policy options. The approach will aid in exploring questions concerning long-term economic effects on a multi municipality geographical scale. The angle of approach that will be used is called System Dynamics (SD). Using SD has several advantages; it relates closely to 'mental models' that people perceive in a problem (Forrester 1980, Meadows 1976) and can therefore directly be used in communication with the client. Furthermore SD is an approach that is used for general understanding of a problem and tends to be small and comprehensible (Meadows, 1976), meaning that SD models are transparent and relatively easy to understand. SD models express the kind of dynamics that is also present in reality and that is impossible to express with linear models. The goal of this SEPAM masters thesis is to develop – part of – a simulation model aided by SD that assesses the long-term, socio-economic effects of regional investments. This model should be able to make long-term forecasts, include multiple scenarios, first and second order economic effects and estimations about the regions prosperity. The main research question therefore is:

How can the system dynamics approach contribute to the ex-ante exploration and assessment of policy options in spatial investments in a region?

Substantiating the main research question is a set of 3 sub questions that contribute to finding the answer to the main question. The first sub question concerns the leading economic indicators and their underlying relations have to be discovered. In order to find these indicators the user requirement and existing regional economic model should be analyzed. Annotating that during the search for the instrument requirements realism should be kept in mind. Interesting requirements might surface that are impossible to implement for time or resource constraints. Furthermore the requirements found through the analysis must not contradict; where contradiction is established choices will need to be made whether to accept the one or the other. By asking what can be learned from the existing regional economic instrument know issues can be picked up in an early stage. Studying the existing models also leads to the question what data sources are required for calculating the desired effects.

- 1) *What are the leading indicators and underlying relations of an instrument for the ex-ante exploration and assessment of policy options in spatial investments in a region?*
 - a. *What are the user requirements of such an instrument?*
 - b. *What can be learned and used from the existing models or instruments for regional economic analysis?*
 - c. *What are the generally accepted data sources that can be used as input parameters for such an instrument?*

The second sub question concerns the construction of the simulation model. To come to the final simulation model two translations have to be made. First the translation of the requirement analysis, literature study and existing model study into a concept model. And second the translation of the concept model into the final mathematical simulation model.

- 2) *How to construct an instrument for the ex-ante exploration and assessment of policy options in spatial investments in a region?*
 - a. *How are the notions from the requirement analysis, literature study and existing models translated into a conceptual model?*
 - b. *How is this conceptual model translated into a mathematical simulation model?*

The third sub question focuses on the applicability of the instrument once it is finished and tested. How detailed is the information that can be extracted from the instrument and how accurate are the forecasts? It also has to be seen if it has been possible to fit all the user requirements into the final instrument. Furthermore the third sub question satisfies contemplation concerning the applicability of the developed instrument on multiple regions and different geographical scale levels. As economic differences exist, between for instance; a rural region and an urban region the question is whether the instrument is applicable in different regions.

- 3) *What is the practical applicability of the developed instrument?*
 - a. *What is the robustness of the model in terms of predictability?*
 - b. *Can the instrument fulfil the requirements that were initially set at the start of this research?*
 - c. *Is the instrument applicable for regions with different characteristics?*

1.3 Research framework

The research questions from the previous section form the basis for the research framework. The research framework illustrates the methodology and strategies used in the coming about of this thesis project. The framework assists in structuring the research tasks, it paves a path of steps that have to be taken in order to complete the research (Verschuren 1999). The research is structured in thirteen activities (steps) that have to be executed in order to answer the research questions.

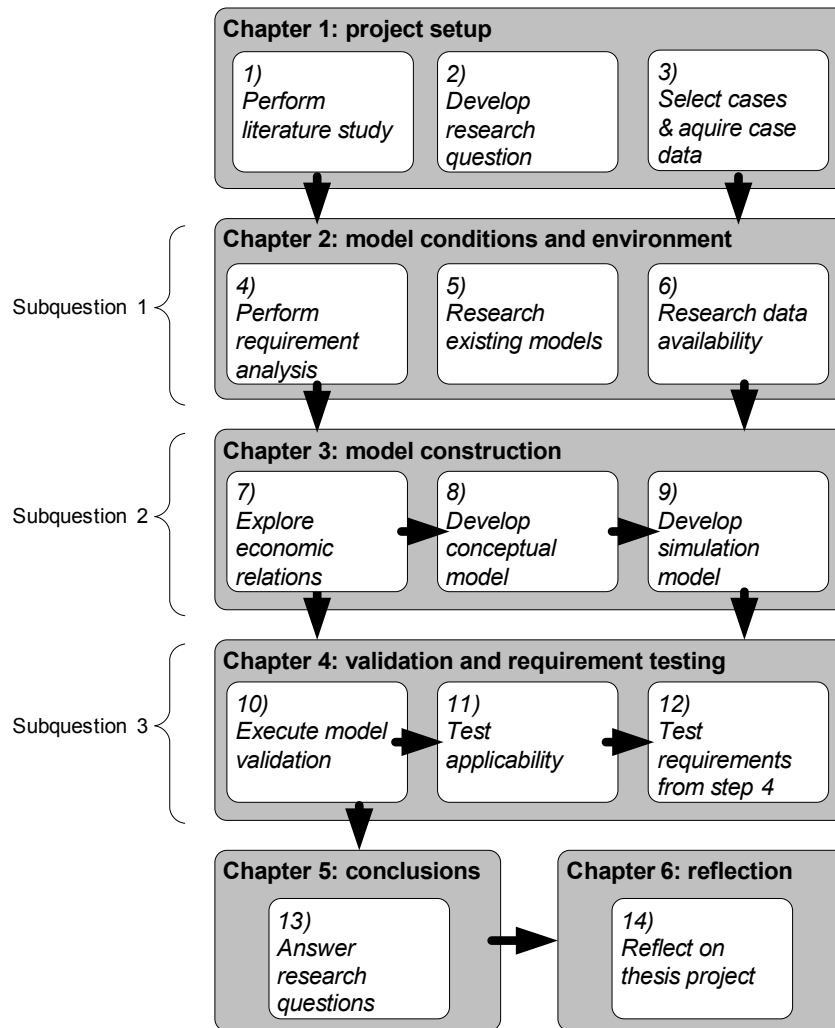


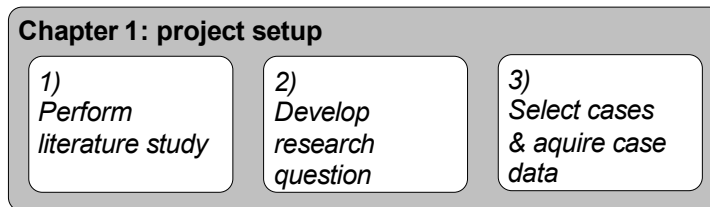
Figure 1.1, the research framework

The “kick-off” of the project can be found in chapter 1 and comprises of the first three steps. First a preliminary literature study assists in formulating the research questions. A case study will be used throughout the project to illustrate the practical implications of choices that are made. The next three steps try to answer the first sub question. In step 4 a requirement analysis is performed to get a grip on the most important economic indicators and user demands. Then in step 5 a selection of existing economic models analyzed. Questions are answered on what can be learned from these models and why do they not fulfil the current demand for policy instruments? After having researched the available data the economic relations that lie at the basis of a regional economy are studied (7). Then, using the gained knowledge a conceptual model is developed in step 8. This conceptual model is subsequently translated into a simulation model in step 9. Performing steps 7 through 9 answers the second sub question. The final sub question is answered

by step 10, 11 and 12 in chapter 4. The model that is created in step 9 has to be validated first and then tested on how far the requirements of step 4 have been reached. Finally chapters 5 (step 13) en 6 (step 14) describes the main thesis question and respectively reflects on the project.

1.3.1 Chapter 1: project setup

The project setup in chapter 1 forms the introduction to the subject of regional economic sciences with its authors, theories and particular way of working. In these steps the initial idea for the thesis project is delineated and transformed into a structured research question and research strategy.



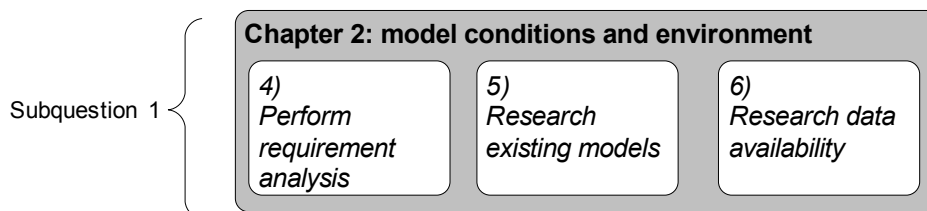
Step 1: In a literature study an overview is provided of the different modelling techniques for forecasting socio-economic effects in relation to regional planning. This theoretical research also functions as reference frame and as positioning mechanism of this thesis project. Some of the major contributors to this research are Forrester (1958, 1969, 1980), Meadows (1976), Nijkamp and Reggiani (1998) and Armstrong (1993). The survey of spatial economic planning models in the Netherlands by van Oort, Thissen and Wissen (2005) particularly provided insight in the state-of-the-art of spatial economic models in the Netherlands.

Step 2: Using the literature study, previous knowledge on simulation models and the counsel of the TU Delft and DHV supervisors the research question and sub questions are drawn up in step 2. This set of questions forms the basis of the research and also translates into the chapter division of this document.

Step 3: In order to relate the theoretical notions to practical implications a case study is used. The case study is preferably a project within DHV; this will simplify data acquisition and increase chances of cooperation from the case actors.

1.3.2 Chapter 2: model conditions and environment

In chapter 2 the conditions under which the instrument has to perform and requirements that it must comply with are identified. Using the requirements a set of existing economic models is studied in order to obtain economic concepts, data input and the different model goals. Finally it is also important that the data availability is researched in this phase of the project; as for the construction of the instrument in form of a simulation model several data sources are required. After performing these steps the first sub question can be answered.



Step 4: The requirement analysis will shed light on the user requirements that can be demanded from a socio-economic instrument. The users are split-up into two groups. The first group

is a selection of consultants that have to work with the instrument in assisting policy makers coming to better decisions. The consultants have to fully understand the conceptual notions behind the model and be able to adjust model parameters and relations. The second group consists of policy makers that are supported by the instrument in their decision making process of a spatial investment. Next to requirements from users two more requirement sources are researched. The problem situation itself provides a set of requirements. These requirements relate to the policy phase the project is currently in, the political positions of the actors, their standpoints, opportunities, threads possible and influence on the outcomes (de Bruijn et al. 1998). Finally literature sources are used to find the requirements for the instrument.

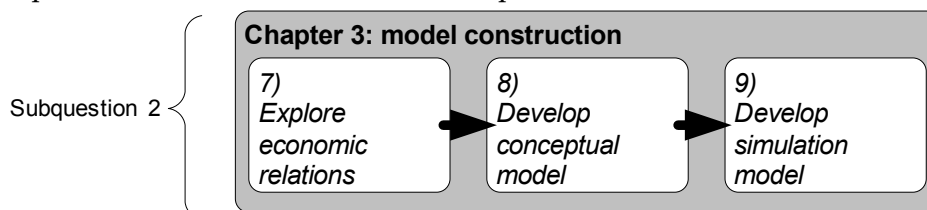
Next to these requirement sources the requirement analysis focuses on three issues that are of great importance for the deployment of the simulation model as instrument in policy making process:

- **Communication:** a broad spectrum of requirements regarding communication issues like: presentation, sensitive or undisclosed information, user interface data interpretation etcetera.
- **Model performance:** relates for instance to the maximum allowed calculation time, robustness of the instrument and sensitivity of the input parameters.
- **Problem setting:** the problem setting involves the geographical, financial and political scope of the spatial investment.

Step 6: In order to prevent errors in the model construction steps knowledge is required about the availability of data. Data will be required either as model parameter input or as validation data. A large part of the data will come from Statistics Netherlands and their online databank⁹ with historic time series data on COROP¹⁰ and municipal level. Other data will have to be collected from other governmental agencies like the Social and Cultural Planning Office of the Netherlands (SCP) or the Netherlands Bureau for Economic Policy Analysis (CPB). Another source of data are the outcomes of existing models like PRIMOS (Blok et al. 2005, Heida 2002), which provides demographic forecasts, and other available models currently in the possession of DHV.

1.3.3 Chapter 3: model construction

In chapter 3 the knowledge from theoretical concepts, the requirement and data analysis and the knowledge of existing models comes together to eventually result in a simulation model. First the economic relation has to be specified the conceptual model is developed. Finally in step 9 the conceptual model is translated into a computer based simulation model.



⁹ The CBS StatLine Databank: www.cbs.nl/statline

¹⁰ COROP stands for Coordination Commission Regional Research Program. COROP divides the Netherlands in 40 agglomerations (regions) that each consist of a number of municipalities. COROP agglomerations provide information for different governmental organizations (e.g. Netherlands Statistics)

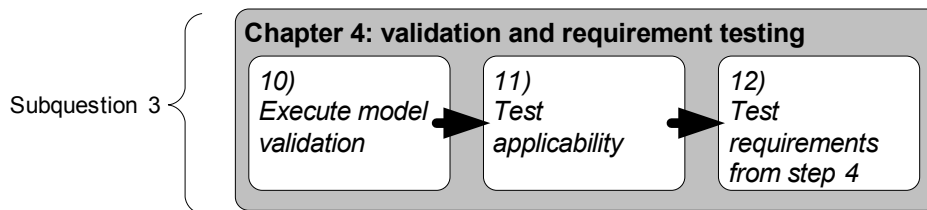
Step 7: In step 7 a link is made between the prior knowledge of existing models, economic literature and the requirement analysis by exploring the economic relations. From the requirement analysis the desired output variables are known (what information is demanded) and using the literature the underlying relationships are analyzed further. The relationships will have to be quantified and causal loops have to be identified.

Step 8: The variables and relations from step 5, 6 and 7 form the basis for the conceptual model of the instrument. In order to prevent a profusion of variables and causal relations that would obscure transparency a selection in variables is made. The conceptual model entails all the major economic relationships and in turn provides a basis for the final simulation model.

Step 9: With the base model up and running the case specific model(s) can be built. The case specific model accounts effects that are dedicated for a specific region. The case model is tailored to give answers to specific questions the client has, as not every client is interested in the same output data.

1.3.4 Chapter 4: model validation and requirement testing

Now the conceptual model has been translated into a simulation model the simulation model needs to be tested and validated. In the validation process two important issues are analyzed: the ability of the instrument to reflect reality and the internal consistency. In chapter 4 the question of the practical applicability plays a central roll (sub question 3). This includes the applicability of the instrument in multiple regions and for multiple project types.



Step 10: The model that was built in step 9 is now ready to be tested. It has to undergo the validation and verification process as is common for simulation models (Sterman 2000). The most important steps include:

- Boundary adequacy: tests if the behaviour and outcomes (the best policy) of the model changes under different boundary assumptions.
- Structure assessment: checks the structure of the model, does it reflect the behaviour of real actors, is the aggregation of the model well chosen.
- Extreme conditions test: will the model still make sense when inputted with extreme values.
- Surprise behaviour: does the system react appropriately to new conditions or does it show unpredicted behaviour.

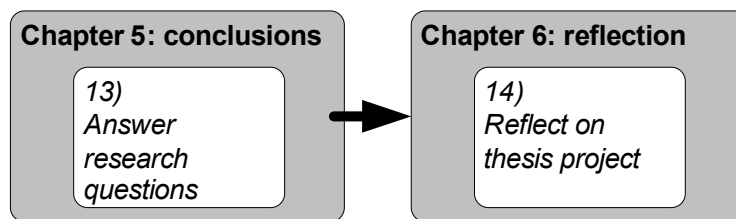
Special attention needs to be given to the sensitivity analysis of the input variables and the input parameters. Small changes in the variables that cause big deflection in the output of the model should be identified and studied. The time series model output will also be tested against output of other models; this way a comparison can be made in the relative accuracy of the model (Forrester 1980). Section 4.1 gives a more detailed description of the validation process and the different validation procedures.

Step 11: Now the model has been validated, step 11 will test the applicability of the simulation model. The instrument will be tested on the ability to represent reality and make valid claims about the development of the socio-economic indicators. For this purpose the simulation model will be run with historic data in order to check if the results actually did come true.

Step 12: In step 12 the requirements from step 4 are tested with the validated instrument. It has to be seen if all the requirements are implemented in the instrument and if the instrument performs its tasks as desired. In order couple of tests are performed with different actors. Model experts will analyze the mode structure while policy makers assess the usefulness of the instrument in their line of work. In three separate group session the dynamics of the instrument is tested on a larger group of people, like an actual consultancy assignment.

1.3.5 Chapter 5 and 6: thesis conclusion and reflection

In chapter 5 (step 13) the main research question is answered and the sub questions are elaborated. Subsequently in chapter 6 (step 14) a reflection on the project is described, what can be learned from the project and what might still be improved?



Step 13: In step 13 the research questions can be answered using the experience from performing the requirement analysis, building the simulation model and validating the results.

Step 14: The final step of the thesis project is reflecting on the thesis project. The reflection consists of two parts. The first part is a set of recommendations for further research into the use of system dynamics in economic models. The second part reflects on the developments and decision made during the course this thesis project. This will give an idea of the insights gained in the process of developing the thesis model and writing this report. The second part is a reflection on the general applicability issues of the developed model in practice and dealing with available data.

1.4 Introduction of case study: Wieringerrandmeer

The case used in this thesis is the Wieringerrandmeer (WRM) project. It is located in the North of North-Holland and concerns a small rural area with two municipalities: Wieringen and Wieringermeer (see figure 1.2). The project involves the formation of a new lake in the polder and the creation of 1845 new dwellings in the vicinity of the lake. The case will be illustrated with a very brief history and the coming about of the plan to redevelop the Wieringermeer polder. The following section will give an overview of the project that has been proposed, giving insight in the

scale and scope of the project. The timeline of key policy decisions is set out in section 1.5.2 and in 1.5.3 an actor analysis is performed.

1.4.1 From lake to polder back to lake again

The Wieringermeer polder is located in the top of the province of North-Holland. The polder was created between 1927 and 1930¹¹ as part of a large land reclamation project in the Netherlands. The



polder currently functions mainly as land for agriculture; this function however has been under discussion over the past years. The Wieringermeer polder is a rural area situated about 55 kilometres north from Amsterdam. A problem in the region is the increasing departure of younger people and the general trend of an aging population. One of the consequences of this demographic development is a fading support for services and facilities in the region. Meaning that retail, recreation, healthcare and cultural functions will retract from the region (DHV 2006). The region also has some other issues; there is a need for improved water management for the irrigation of farmland and there is an ambition of creating an ecological link between the Waddenzee and the IJsselmeer (see also figure 1.3).

Figure 1.2, province of North-Holland (Source: Google Earth)

Figure 1.3, the Wieringerrand-meer project area (Source: Google Earth)



¹¹ <http://nl.wikipedia.org/wiki/Wieringermeerpolder> (visited: March 3, 2006)

In order to solve these problems the municipalities of Wieringen and Wieringermeer and the province of North-Holland issued a contest. This contest resulted in a public private partnership that was given the task of developing new economic impulses for the region as well as solving the water management issues. These impulses were focussed on¹²:

- Red development: socio-economic development. The attraction of more and different labour and inhabitants to the project region
- Blue development: improvement of water management. More high quality irrigation water supply for agriculture activities and better water storage facilities.
- Green development: realisation of robust ecological link. Nature reserve as level crossing for flora and fauna between the North Sea and the IJsselmeer.

The Lago Wirense consortium won the design contest. This three party consortium consisting of Volker Wessels Stevin Bouw & Vastgoed Ontwikkeling Nederland BV, Boskalis BV and Witteveen+Bos BV proposed a plan that would transform the Wieringerrandmeer into a pleasant atmosphere for living and recreation (Lago Wirense 2004). The project area is indicated in figure 1.3 and illustrates the current situation. Figure 1.4 is taken from the Lago Wirense proposal and shows the lake forming a connection between the Amstelmeer in the southwest with the IJsselmeer in the northeast. The project will span some 25 years to complete with end date estimated in 2030. The dwellings that Lago Wirense intends to build are only owner-occupied houses in the mid- a higher segments. Most of the dwellings will have a lake or forest view. The intention of Lago Wirense is to draw higher incomes into the project region in order to maintain the level of services and facilities. The north side of the lake will consist of reed canes and shallow water forming the ecological link between the North Sea and the IJsselmeer. Lago Wirense also intends to improve the water sport qualities of the project region by creating yacht-basins and locks both tourist and professional opening up of the lake area. The locks will also enable passage from the Amstelmeer to the IJsselmeer for professional and recreation traffic.

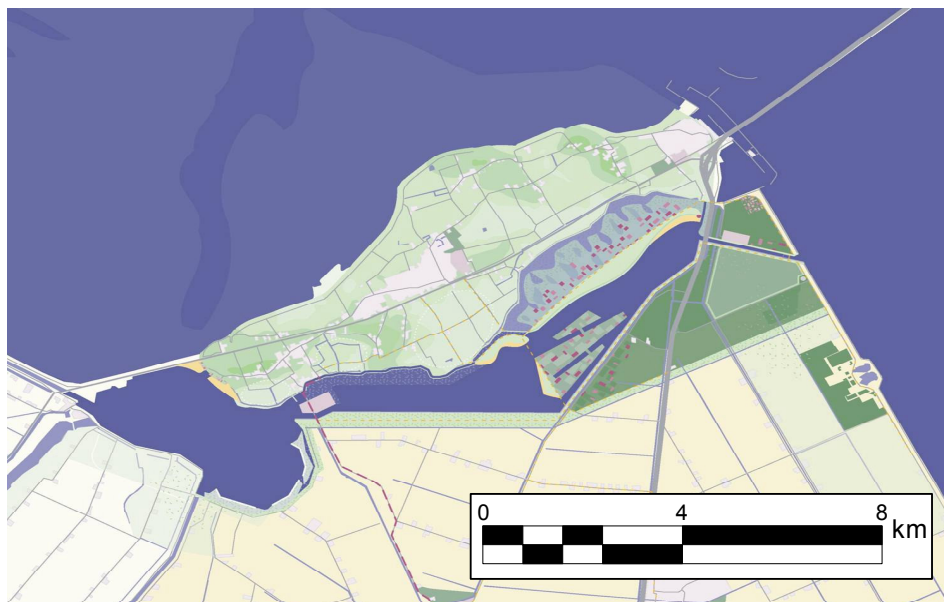


Figure 1.4, the Wieringerrandmeer project area (Source: Lago Wirense, May 2005)

¹² Stated in the consultation document from 9 April 2003. Accessible through the Wieringerrandmeer website: http://213.201.212.154/clientFiles/{A01A823B-4CC5-4779-B99C-68E25ABFA950}/PPS_consultatie.doc (visited on 01-06-2006)

1.4.2 Policy time line in the Wieringerrandmeer project

The initial idea for the re-flooding of the Wieringermeer polder has been around since the late nineteen eighties when it was proposed by a member of the Provincial States. Several researches were executed and plans were drawn up under that cover of a programme called: "Water Bindt". Eventually in 2002 the developing agency "Wieringerrandmeer" was put up, consisting of the municipalities of Wieringen and Wieringermeer, Polder board Holland's Noorderkwartier and the province of North-Holland.

The series of important events between January 2003 and June 2006 are depicted in a timeline in figure 1.5. The kick-off for the current state of play was given in May 2003 with the announcement of a contest. This announcement was sent out to a range of firms and organisations, the "Consultatie document" made the intentions for the region clear. The document also presented initial ideas for the possibility of public-private-partnership in the development of the region. The actual competition started in November of 2003 and an independent jury announced the winner in February 2004. As mentioned above, the winner was the three-headed consortium Lago Wirense. In the following period the plans of Lago Wirense were worked out in dialogue with the province and municipalities. The worked out plans resulted in an intention agreement, this agreement clarified responsibilities, a worked out project plan and a detailed public structure.

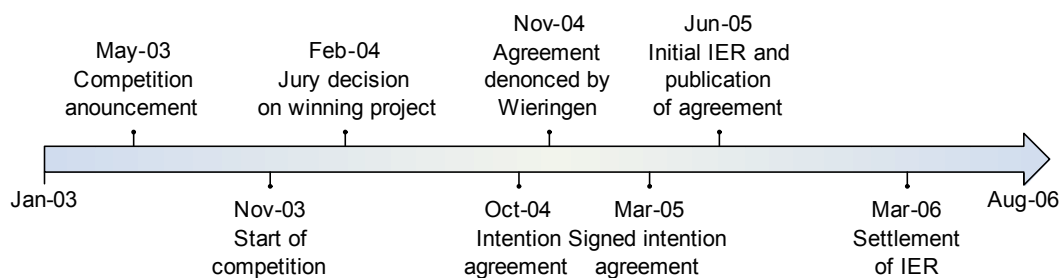


Figure 1.5, *important events in the Wieringerrandmeer policy process*

Then in November of 2004 the town council of Wieringen denounced the intention agreement. All the other parties had signed in favour of the project, including the mayor and administrators of Wieringen. After the rejection some a cooling off period was agreed between all parties. The town council of Wieringen demanded more knowledge and better-funded estimations on the financial risks for both municipalities. During the cooling off period the financial plans were clarified and Wieringen eventually signed the intention agreement in March of 2005.

The next step in the policy process was to develop and Integral Effect Study (IER) which included effects for agriculture, the economic position of the region and a social cost benefit analysis. The early findings of the IER were presented in June of 2005 and after revision of all parties the final version was presented in March 2006. According to the project planning construction should start in 2007 and will take until 2030.

1.4.3 Actor analysis of the Wieringerrandmeer project

The most important actors in the development of the Wieringerrandmeer are:

- **The province of North-Holland:** the North-Holland has great interest in improving the North of their province as it lacks in economic performance compared to the south of the province (Amsterdam and Haarlem). They acknowledge the negative side effects of the aging population in the region (see also 1.4.4). The Province of North-Holland also acts a financier of

a part of the project and is risk bearing involved in the successful implementation of the project. The province has therefore great interest in that the project is executed, preferably with funds from the central government.

- **The municipality of Wieringen:** Wieringen is a municipality situated on the old Wieringen isle (see figure 1.4) and the inhabitants are the “original” residents of the region. Wieringen is a small municipality with little over 8000 inhabitants (CBS 2005) who see the development of the new lake as the end of their beloved quiet landscape. Another part of their reluctance is the financial size of the project and risks their municipality runs. They fear that the project is too big for the small, rural municipality of Wieringen; they simply do not have the manpower or the expertise. More subjective is their stance towards the city of Wieringermeer, which they deem not “original” and intrusive (interview Stegeman 23-12-2005). The community itself is divided over this issue, which is represented in their municipal government.
 - **The city council of Wieringen:** the city council of Wieringen initially opposed the idea of the new developments but could be persuaded by their neighbouring city Wieringermeer and the Province of North-Holland. The city council acts directly on behalf of the inhabitants who are not pleased with the new developments and are concerned with the financial risks.
 - **The administrators of Wieringen:** the city administrators initially approved the new development plans and agreed immediate cooperation. They indicate that swift action is to be taken in order to prevent a deterioration of the economic situation of their municipality.
- **The municipality of Wieringermeer:** Wieringermeer is the municipality that was developed after the creation of the new Wieringermeer polder in 1930. The municipality has some 13000 inhabitants and is, compared to Wieringen, a new town. The municipality of Wieringermeer is great supporter of the WRM project as they see the necessity for change.
- **Polder board Hollands Noorderkwartier:** the polder board has to insure high quality and sufficient quantity of water in the project region. They are not part of the development team and are not financially involved. They do however act as advisory organ for the project and assist in the information provision of the consortium.
- **Lago Wirense:** the winning project team of the contest for the development of the Wieringerrandmeer. Lago Wirense consists of the three companies: Volker Wessels Stevin Bouw & Vastgoed Ontwikkeling Nederland BV, Boskalis BV, Witteveen+Bos BV. The aim of Lago Wirense is to profit from the project.

The problems that the project currently¹³ faces are reaching agreements on specific details of the basic agreement made between March and May 2006. The municipalities want to steer clear of any large risky financial commitments because that could damage their municipal funds. This means that the municipality and the central government have to bear more risks. Lago Wirense is working out more and more details of the project and is trying to avoid unforeseen costs like problems with the soil stability, ground pollution etcetera. The province remains confident that all obstacles can be overcome and that final agreement can be reached this summer (Meetings with Arjan Stegeman from Lago Wirense (11-05-2006) Wim Voordenhout from the province of North-Holland (23-05-2006). The province and Lago Wirense both will play a part in the requirement analysis in chapter 2 and in testing the model in chapter 4. The simulation model will also be tested in an environment with all actors present in a group (section 4.3.2)

¹³ Time of writing is 19-06-2006

1.4.4 Socio-economic analysis of the Wieringerrandmeer region

This section analyses the socio-economic status of the Wieringerrandmeer region. The WRM is compared to the average data from the Netherlands. Data from the CBS is used to calculate the current and historic performance of the region. For the future demographic developments data from the PRIMOS model is used. The socio-economic analysis focuses on three issues:

1. Employment in the region
2. Demographic development
3. Economic development

1. The rural character of the region sketched in previous sections can also be found in the regional industry sector structure. Employment in the production sector is heavily overrepresented compared to commercial services (see table 1.1). The share of production sector labour (agriculture, industry and construction industry) is almost twice as large as the national average. The less developed sectors compared to the national average are the Health and Wellness, Transport and Communication and Commercial Services. In total 5560 people work in the WRM region.

Employment: share of industry sectors (2004)

| | volume | percentage | | | | | | | | |
|-------------------|--------------------|-------------|----------|-----------------------|-------|-----------------------------|------------------------|---------------------|---------------------|--------------------------------|
| | Total jobs (x1000) | Agriculture | Industry | Construction industry | Trade | Transport and communication | Financial institutions | Commercial services | Health and wellness | Other, non commercial services |
| Netherlands total | 6.929,4 | 1% | 13% | 5% | 17% | 6% | 4% | 20% | 16% | 18% |
| WRM region | 5,6 | 8% | 22% | 8% | 19% | 3% | 2% | 13% | 9% | 16% |

Table 1.1, *employment industry shares in the WRM region*

2. The demographic situation in the WRM is currently not that different from the national average. In the WRM region about 21 thousand people live in almost 9 thousand households¹⁴ (CBS 2005). Table 1.2 illustrates the age distribution in the column “Share in 2005 (%)”; this is the percentage of people in an age group for the Netherlands and the WRM region. The WRM region has relatively more people between 45 and 65 and relatively less people between 15 and 44. Currently that is not a problem, however the demographic projections until 2030 show a potential problematic situation. The columns on the right side of table 1.2 show the index of predicted development of the age groups. What can be noticed in the Netherlands is the tremendous increase of inhabitants older than 65. This group will grow with 67 percent in the next 25 years. In the same time the other age groups will grow only slightly or even get smaller. The WRM region shows the about the same increase of older people. The big difference between the Dutch average and the WRM region is that all the younger age groups (0-65) will significantly decrease over the coming 25 years. This “de-greening” of the region can potentially cause problems. For instance the region might lack in providing substantial facilities and services like pharmacies, grocery stores or doctors.

¹⁴ For the Netherlands in 2005: 16,4 million inhabitants in 7,1 million households (CBS 2005)

| | | Inhabitant age developments | | | | |
|-------------|--------------|------------------------------------|------|------|------|------|
| | | <i>index, 2005=100</i> | | | | |
| | | Share in 2005 (%) | 2010 | 2015 | 2020 | 2030 |
| Netherlands | 0-14 year | 19 | 98 | 96 | 94 | 97 |
| Netherlands | 15 - 44 year | 41 | 97 | 95 | 94 | 96 |
| Netherlands | 45 - 65 year | 26 | 109 | 112 | 113 | 102 |
| Netherlands | 65 year plus | 14 | 109 | 126 | 139 | 167 |
| WRM region | 0-14 year | 19 | 96 | 92 | 88 | 90 |
| WRM region | 15 - 44 year | 39 | 96 | 91 | 90 | 89 |
| WRM region | 45 - 65 year | 28 | 103 | 104 | 103 | 91 |
| WRM region | 65 year plus | 14 | 115 | 135 | 151 | 171 |

Table 1.2, *age development in the Netherlands and the WRM region*

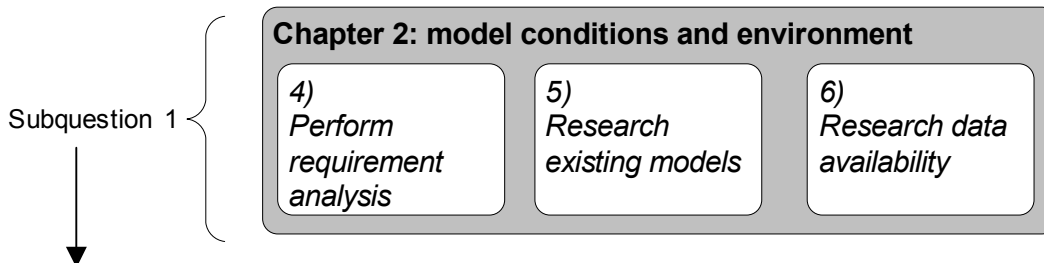
- The economic development of the WRM region is likely to stay behind the Dutch development. Partly because there is an overrepresentation of production sector labour in the region, which has less added value than for instance the commercial services sector¹⁵. Secondly because the potential labour force in the region (inhabitants between 15 and 65 years old) will decrease over the next 20 years (see table 1.2). This has two effects: first the gross added value of the WRM region will decrease, reducing the economic activities in the region further. Secondly the disposable income of the households in the region will decrease due to the fact that more people live on their pension (which is lower than regular salary). This will lead to lower spending in the region, which in turn means that even less products can be sold and produced in the region.

From the economic analysis it can be concluded that the current socio-economic status of the region is similar to the national average. However future developments predict that the region will economically suffer from the aging inhabitants. The growth in the younger age groups (0-15 and 15-30) stays far behind compared to the national average. This could have consequences for the level of services that is offered in the region as the basis for these services diminishes.

¹⁵ The CPB predicts a lower growth of the production sectors compared to the trade and commercial services sector (Huizinga 2004).

2 Model conditions and environment

In the second chapter the first sub question is worked out and supported by steps 4, 5 and 6. The focus of this chapter is therefore on attributes of other economic models and demands potential users of the instrument.



What are the leading indicators and underlying relations of an instrument for the ex-ante exploration and assessment of policy options in spatial investments in a region?

- a. *What are the user requirements of such an instrument?*
- b. *What can be learned and used from the existing models or instruments for regional economic analysis?*
- c. *What are the generally accepted data sources that can be used as input parameters for such an instrument?*

Before these sub questions can be answered a better definition must be given of the intended properties of the policy-supporting instrument. Therefore section 2.1 gives a description of what is meant with policy supporting models and the place of the instrument in the policy life cycle. The latter indicates the policy phase in which the instrument should be deployed. Section 2.2 gives a definition of the geographical scale of the instrument. The former definitions are needed before the requirement analysis can be performed in section 2.3. The requirement analysis illustrates the demands for the simulation model from different sources, both literary as user oriented. Using the outcomes of the requirement analysis a set of existing models is researched that approximates the functionality of the thesis instrument. From the existing models a great deal can be learned that might prove useful in the construction of the thesis instrument. Section 2.4 ends with a specification of why the currently existing model cannot fulfil the demand posed in the requirement analysis. This specification leads to the introduction of system dynamics in section 2.5. The basic methodology, principles, pros and con's of system dynamics are mentioned in this section, ending with the proposal to system dynamics for the thesis instrument. From studying the existing models and the user requirements a fair indication can be given on what information is needed to construct and operate the thesis model. This subject is given attention in section 2.6 where an indication is given of required data and the location of this data. Finally in section 2.7 the question is answered what the leading indicators of the instrument should be.

2.1 Policy making and simulation models

Simulation models have had large impacts on the way policy makers perceive the world and develop new policies. It was the World3 simulation model from Donella H. Meadows that was used by the Club of Rome in the 1972 resulted in the well-known publication *Limits to Growth* (Donella Meadows 1972). The simulation model helped to raise awareness with many policy

makers that economic growth was not infinite and that the natural resources would eventually run out. Another, more recent application of models in policy making are the projections made by the CPB based on the political programmes of the different Dutch political parties (CPB 2002). The JADE model calculates the effects that result from the suggested policy programmes (CPB 2003).

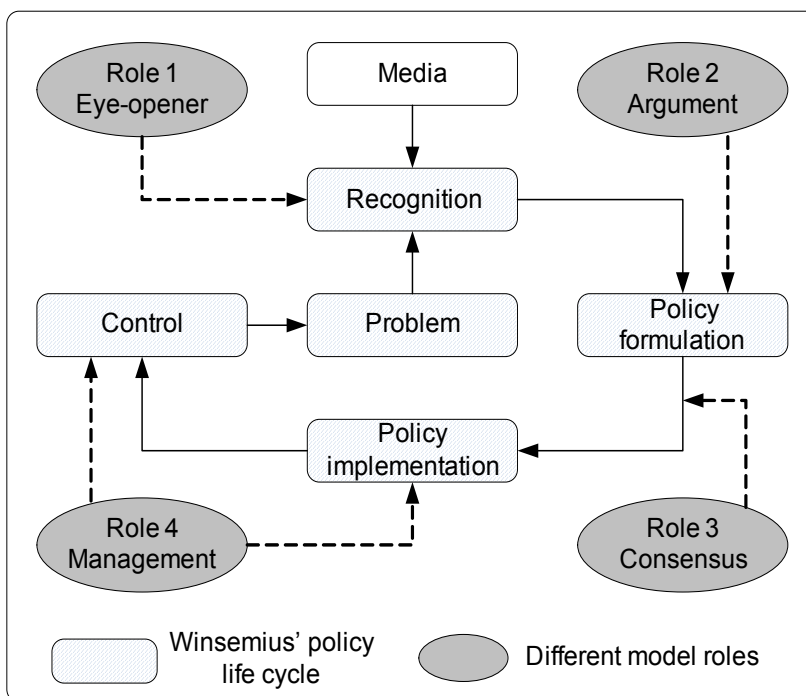
2.1.1 Policy decision models and policy supporting models

A distinction must be made between decision models and policy supporting models. A decision model specifically aids policy and decision makers in making a choice between two or three policy options. Such a model must present the outcomes in a manner that it supports a binary decision. This decision is either go ahead with the project or terminate it. Social cost benefit analysis (SCBA) is an example of a model that assists in decision-making. It evaluates all possible effects and attaches a financial compensation to each of the effects. Then in the final step of the analysis the total costs are deducted from the total benefits, the answer is either a positive or negative balance (Eijgenraam et al. 2000). SCBA will be addressed in more detail in section 2.3.4.

A policy-supporting model is aimed at aiding policy makers in gaining insight in the economic, social, demographic or environmental effects. A policy-supporting model is most valuable in the early phases of policy development. This in contrast with a decision-supporting model, which is needed right before the moment the final decision on the project is made. The value and necessity of quantified information early in the policy process is one of the recommendations of the Committee Duivensteijn (TCI 2004). The committee also noted that risks were identified too late in projects and when discovered were not discounted in the budget (TCI 2004, p 32). The thesis model will have to supply the required quantified information on socio-economic effects on a regional scale level and be able to give some idea to what risks are involved.

2.1.2 The place of the thesis model in the policy life cycle

Policy concerning multi million euro investments from both public and private parties does not come about over night. It is a painstaking process of debilitation, politics and persuasion to come



from initial idea to the final decision. A method for studying policy processes more accurately is presented by Winsemius presented over two decades ago. The policy life cycle (PLC) for environmental issues, as described by Winsemius (1986), gives an idea of how issues surface on the political agenda and eventually turn in to actual policy (see figure 2.1). Starting at the beginning: at certain moment in time a *problem* is *recognized*. The recognition can for instance occur through party politics, international agreements and media attention.

Figure 2.1, policy life cycle and modelling roles

In the second phase of policy life the problem is *formulated* in debates and research, the conditions for a possible change are set. In the next phase the policy is *implemented*, therefore the formulated policy will have to be translated into actual mechanisms and regulations. Finally, the policy execution will have to be brought under *control*, which will eventually either solve the initial *problem* or not. Winsemius' cycle was designed for environmental issues in policy development, however in this research the use of the PLC model is extended to regional development issues as well.

The relation between the PLC model of Winsemius and quantitative models has been researched and described in the article of van Daalen, Dresen and Jansen (2002). In their article they attribute four different roles to models within the policy life cycle:

1. Models as eye-openers: models are used to put certain issues on the political agenda, the best example of such a model is mentioned above: the World3 model. World3 led to the Limits to Growth report (Donella Meadows 1972).
2. Models as argument in dissent: in this role the model functions as an argument in a debate. The outcome of the model can also be used as counter expertise to challenge the outcome of another model, however this effect is unwanted. In some cases the term "report war" (rapporten oorlog) was used by the TCI (2004). In this phase however an effect model can render poor policy propositions obsolete in an early stage or promote other that have prospering effects.
3. Models as vehicles in creating consensus: in this phase a model can assist in creating political consensus. This could for instance happen by creating shared knowledge (Richardson 2004) in a group model building session. Shared knowledge can be used in discussions where two parties try to reach an agreement based on the same data.
4. Models for management: a management model gives insight in the effects of implemented decisions and helps to identify concrete policy decisions. An application mentioned in the text is finding the optimal level of source extraction (van Daalen 2002).

This PLC provides a basis for the positioning of the thesis model in the policy life cycle. The aim of the model is to assist policy makers in an early phase and to develop a policy-supporting model. This would implicate that the thesis model should support the policy formulation and policy implementation phase. Thus, model role 2 and 3 become the focus roles for the thesis model. Role 4, management does implicate the policy implementation phase, however this role is more associated with decision models and therefore not included in further research.

When the Wieringerrandmeer project is analysed in terms of the policy life cycle, it has to be concluded that project is currently between phase 2 and 3¹⁶. Almost all the development plans are worked out in the policy formulation phase and a management organisation has been set up for the control of the project. The final decision for the project awaits a final analysis on the social benefits of the project that Witteveen+Bos and DHV are currently working on.

¹⁶ Time of writing is 19-06-2006

2.2 What are regional investment projects?

The model that will be developed has to evaluate regional investment projects. The question is how big is this region or project? This section will clarify the term regional investment project and try to illustrate the type of effects that occur on this level and that are important for the policy makers.

2.2.1 Geographical scale and the project region

For this thesis project the Wieringerrandmeer case study is used as an example of a regional investment project. The scale of this project however does not fit exactly in the commonly used geographical levels. The scale levels that are universally used are:

- Neighbourhood level (radius approximately 0,1 kilometre): this is the level of small groups of streets that have similar characteristics
- District level (radius approximately 0,5 kilometre): the level consists of a group of neighbourhoods that typically have a (small) centre.
- Municipality level (radius approximately 3 kilometre): the municipal level is a collection of districts; this can also mean a set of dispersed smaller municipalities. The municipality of Wieringen consists for instance of 8000 inhabitants.
- COROP level (radius approximately 20 kilometre): the Netherlands is divided in 40 COROP regions each consisting of roughly 350.000 inhabitants and 150.000 jobs. A COROP level is constructed from the summation of the set of municipalities within the COROP region.
- Provincial level (radius approximately 50 kilometre): a province is a part of the country and consists of a set of COROP regions
- National level (radius approximately 150 kilometre): a nation

The thesis model focuses on a level between that of the municipality and the COROP level. Statistics Netherlands has more data available as the geographical scale level increases, meaning that for data usage a COROP level will have more data available than the municipal level. Because the thesis model is focused on a multi municipal level, data from the COROP level will be used when municipal data is lacking.

2.3 Finding the model requirements

The development of the simulation model is started with a requirement analysis. The general idea that functions as point of departure for this requirement analysis is based on the concept of a simulation model. This model supports policy makers in the development and testing of policy alternatives in spatial issues (non-infrastructure). The model is able to test the effects of different policy options/alternatives under different economic scenarios. The model can be seen as an instrument for providing quantified data, early in the policy life cycle. The instrument as developed in this thesis is only applicable for spatial planning projects on a COROP and multi-municipal (> 20.000 inhabitants) scale. Furthermore it supports interaction between consultants and policy makers through an interactive user interface. From this viewpoint the requirement analysis takes off.

For the thesis model interviewing has been chosen as requirement trawling technique. Interviews can be executed from remote locations via telephone; furthermore they do not (as work shops do) require complex meeting arrangements or long introductions. The interviews follow an open line of questioning to promote the respondent to think of unconscious and undreamed requirements. Interviewing is also the best way to reach respondents that are situated at different locations, as group brainstorming requires all people to be in the same room. Some interviews with policy makers and consultants who were familiar with model building resulted in discussions and brainstorming about the requirements the model should have. More information on the decision to use interviewing can be found in appendix 2. In this appendix information about requirement trawling are also included, it also explains where, during the interviews special attention was paid to.

2.3.1 Creating structure: a requirement analysis framework

Now a requirement trawling technique has been chosen and it has been made clear that both consultants and the policy makers should contribute to the requirement trawling process a framework is presented. The framework has three *requirement sources* and three *dimensions* that will provide structure and help to streamline the process. The requirement sources are the sources of information that contribute to the final list of requirements. The three dimensions stress the important issues concerning the development of the simulation model. Figure 2.2 shows the framework of requirement sources and dimensions. Using this framework two questionnaires were made to function as a guideline during the interviews (see appendix 3 for the questionnaires).

The requirement sources are:

- *Policy makers*: the role of the policy makers during the interviews is to convey how they see possibilities for a simulation model to aid them in improving policy development. Furthermore policy makers have a better understanding of where to use a simulation model in the policy life cycle. Should it be used as persuasive argument in a dispute or as facilitation of bringing about a change in the public opinion?
- *Consultants*: consultants have to see the simulation model as an instrument that is to be used in providing advisory services. They have to indicate if and how they want to change input parameters, add variables and calculate different scenarios. Consultants will be asked for their requirements concerning the development of a simulation model and the use of the model with policy makers.
- *Policy issue*: requirements that stem from the policy issue are specific for each case the simulation model is used for. As each case is different each case requires different steering variables and different socio-economic effects. For instance, for the Wieringerrandmeer case the simulation model must indicate the growth of the housing stock and the effects that has on the demographic composition of the municipalities.

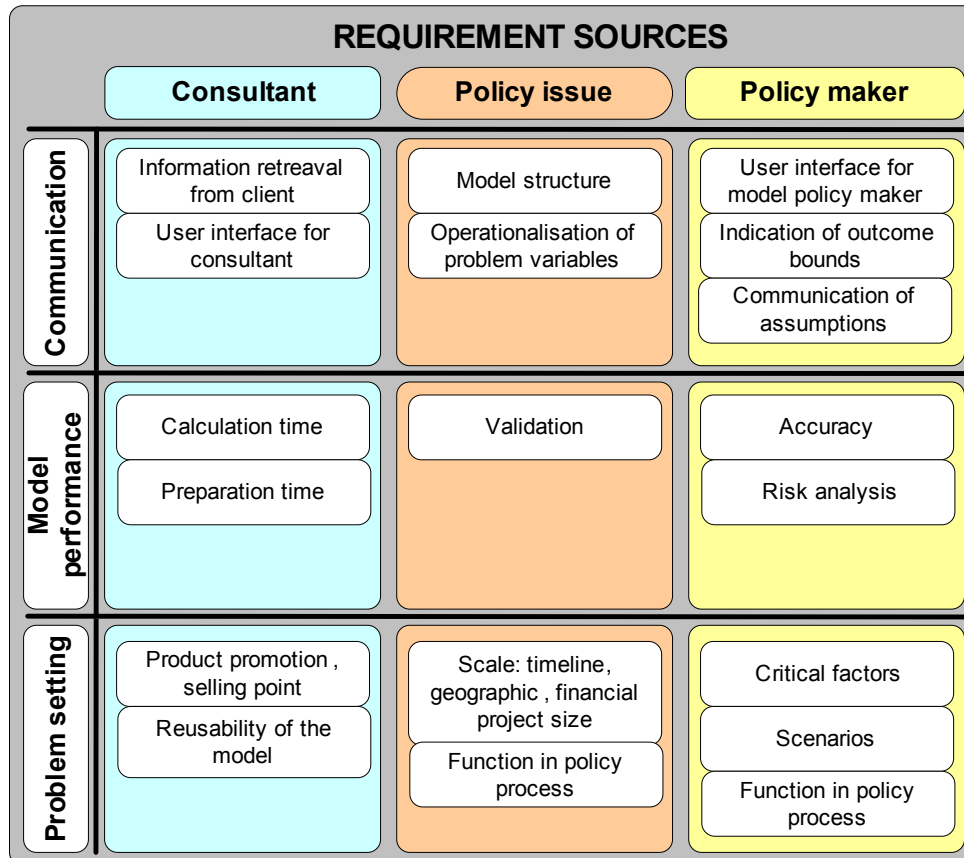


Figure 2.2, requirement analysis framework

Next to the three sources of requirements (vertical axis), three dimensions are identified (on the horizontal axis in figure 2.2). These dimensions cover the most important aspects of the simulation model and will form the basis for the line of questioning during the interviews. For each different requirement source these aspects entail different issues. The list below clarifies the dimensions further:

- *Communication*: the aspect communication is important for the transfer of information both from policy maker to consultant as visa versa. For instance for the consultant this means that he or she has to consider the background of policy makers, and policy makers must be open to a new policy-supporting instrument. The structure of the model must on the other hand support the complexity of the problem and the level of detail of the policy maker’s issues. An important goal of the thesis model is to convey information to the policy maker concerning assumptions and premises that precede the model construction in chapter 3. These assumptions can vary from economic scenarios to assumptions on the power of attraction of the region. Requirements that follow from the policy issue are given in terms of factors that are important for that specific issue. In case of an investment in regional employment, detailed factors concerning employment will need to be incorporated in the simulation model.
- *Model performance*: from the model performance follow requirements that indicate limits of model concerning sensitivity, calculation time and risk analysis. The quality of the input data that is used also plays a role in the performance of the model and has implications for the use of the outcomes. For the policy maker it is important to have some insight in the bounds and the accuracy of the model.

- *Problem setting*: the problem setting also is a source of requirements. For consultants the fact that the simulation model must be a profitable product is important. The use of simulation models in policy formulation must have unique selling point for them. As for the policy makers, they need to recon with their political arena and alliances. They have to be aware of the model use: do they require the model for project appraisal or for scenario development or do they seek justification for a specific investment they are interested in? The policy issue and the problem setting give an overview of requirements that can stem from the specific policy issue in a larger political setting.

2.3.2 Setting up the interviews

With the requirement analysis framework as a basis, two questionnaires are formulated, one for the policy makers and one for the consultants (see appendix 3). The content of both questionnaires is generally the same and both use the three dimensions from the framework as guideline. They differ on specific issues like the perception of information, usability of the instrument and performance requirements. The interviews are conducted in an open line of questioning in order to promote creative thinking during the interviews. The average time for an interview is 1 to 1,5 hour. Each interview is divided into 3 parts:

1. The interview starts with some general questions to test the respondents' knowledge of simulation models and mathematical modelling in general. Some respondents have used financial models or have worked with the outcomes of mathematical models. Due to the open structure of the interviews an experienced model user can give input and requirements on a higher level. Other respondents that are for instance more focussed on the implications of a simulation in a multi actor setting focus more on that particular subject.
2. The general questions are followed by a short explanation of the simulation model that will be developed. This will give the respondent some idea of what the intended model is capable of and what it can be used for.
3. The next part of the interview is a series of detailed questions on requirements of the simulation model. The questions are grouped so that they fit the three dilemmas from the requirement analysis framework. Starting with communication followed by questions on the model performance and the problem setting.

In total ten respondents with different backgrounds have been interviewed (see appendix 4 for list of respondents). This group of ten respondents is divided three groups. The first groups are three policy makers related to the WRM case study. The second group is a selection of five consultants with an expertise varying from risk management, cost benefit analysis to economic modelling and environmental effect analysis. Finally two model experts were interviewed to put the requirement analysis in perspective and shed light on possible pitfalls in the construction of the model.

After the interviews the answers, quotes and remarks are grouped together in a long-list (see appendix 5). This list gives an indication of the broad bandwidth of ideas and modelling concepts put forth during the interviews. The long-list is screened for actual requirements; quotes and general remarks are taken out and included as clues for the development of the model. These remarks give information on the background of requirements or illustrate personal issues of the respondents. This extra information led in most cases to the discovery of more requirements if

more detailed questions were asked. After the screening a long-list with requirements remained that could be used for further processing.

2.3.3 Results: the requirements for the simulation model

The long-list of requirements resulting from the interviews described in the previous section includes over 150 entries. Because not all of these entries are feasible requirements, a selection needs to be made. This selection will be based on need-to-have and nice-to-have requirements. Based on the intended functionality of the model (see section 1.2), the long-list is scanned and the demands are grouped in need-to-have and nice-to-have requirements. The need-to-have requirements will form the basis for the concept model in section 3.1. The nice-to-have requirements should be kept in mind, it might be possible to include some of these requirements relatively easy. An example of a nice-to-have requirement is that the model should be able to calculate the financial return on investment for a private investor. This financial requirement does not concern socio-economic effects and therefore it will not be incorporated in the concept model (it remains a nice-to-have requirement). A second selection that is made originates from contradicting requirements that can be found in the long-list, these contradictions are design dilemmas. Special attention will have to be paid to dilemmas that exist between the requirements of the policy makers and those from the consultants. A striking example is the statement of policy makers that most of the data should be presented in graphs while the consultants prefer presentation of information in tables. How to deal with contradicting requirements is discussed in section 2.3.4.

The final list of need- and nice-to-have requirements is fully stated in appendix 7. The key need-to-have requirements are selected and included in the main text below. The selected requirements below are important because they illustrate a conceptual choice or because they are very challenging requirements. The requirements are grouped in the requirement sources from the framework:

- Policy maker requirements
- Consultant requirements
- Problem setting requirements

A second differentiation is made in the requirement analysis. For each of the three requirement sources, three dimensions are specified. These dimensions are also used during the interviews. The dimensions of communication, model performance and policy issue can also be found in the requirement framework in figure 2.2. Finally an additional requirement source is added. Literature requirements are included as an extra requirements source that originally fell out of the scope of the requirement framework. However literature requirements appeared to be very useful in delineating the model concept and in structuring the design process.

Policy maker requirements

During the interviews with policy makers several issues kept coming up. Issues that could not directly be translated into requirements but could prove important in the implementation of the model in a political situation. Each interviewed policy maker made a remark concerning the level of detail of information that is given to the policy maker in different actor settings. Some remarks that were made:

- *“The model must be able to deal with multiple levels of complexity in communication”*

- “It must be able to change presentation styles, from comprehensive to simple”
- “The outcomes of the model must connect to peoples common sense in order to reach residents in smaller municipalities”

These remarks point at the same issue: adapt the presentation of outcomes of the model to the level of policy maker. In order to resolve this issue different interfaces must be built to make it suitable for different actor groups. What becomes clear is that for the interactive use of the model, the background and interests of the policy makers should determine as also the level of detail that is presented to them. The time that is given for the interactive session must constrain the level of detail. If for example only two hours are available, small details are irrelevant. Multiple interfaces or levels of detail would make the simulation model broader applicable. Table 4.1 lists the other policy maker requirements. The simulation model must:

| <i>Policy maker: communication</i> | |
|---|--|
| 1 | Avoid using tables and use at the most 2 variables per graph |
| 2 | Be able to change presentation “styles”: comprehensive to simple |
| 3 | o Include a "Jip en Janneke" version explainable to laymen |
| | Include the following factors |
| 4 | o Housing market and inhabitant development |
| 5 | o Employment |
| 6 | o Show 4 year policy cycles and economic growth |
| 7 | Not require more than 5 minutes on theory of system dynamics |
| 8 | The interactive session with client must not take longer than 2 hours |
| <i>Policy maker: model performance</i> | |
| 9 | Include new variables (region specific) and remove obsolete variables |
| 10 | Only use averages in the presentation of outcomes |
| 11 | Communicate reliability and the status of the model outcomes |
| 12 | Present uncertainties and assumptions in complete but orderly fashion. |
| 13 | Offer the possibility to calculate different policy scenarios |
| <i>Policy maker: policy issue</i> | |
| 15 | Support gut feeling of policy makers |
| | Communicate different stakeholders: |
| 16 | o The residents of a region (they will influence local government) |
| 17 | o Other governments (for the creation of support) |
| 18 | o Other political parties for the (creation of support) |
| 19 | Be used in early phase of policy life cycle |
| 20 | Give indication of effects on provincial scale |
| 21 | Give indication of effects between small municipalities |
| 22 | Show result on a time scale between < 30 years |

Table 4.1, list of policy maker requirements

Consultant requirements

The interviews with consultants appeared more structured compared to the interviews with policy makers. In more than one situation the consultants contributed undreamed¹⁷ requirements while this occurred less with the policy makers. The consultants also pointed out that it would be very important to include an understandable manual with the model in order for them to work with it. It should

¹⁷ When a requirement is undreamed the respondent sees it as impossible while in fact it is a very important requirement (see appendix 2).

furthermore not be a requirement to be a mathematician or system dynamics expert in order to work with the model. The interviewed consultants and the policy makers agree on the subject that the simulation model can contribute more to the policy process if it is used in the start-up phase. A consultant mentioned: “Research should foremost be executed to create clarity in fuzzy situations” and “generation of alternatives that can immediately be quantified is a powerful tool”. The rest of the consultant requirements can be found in table 4.2. The simulation model must:

| Consultant: communication | |
|--|---|
| 1 | Be suited for the use with different actors and different regions |
| 2 | Present results in graphs with a maximum of 3 variables |
| 3 | Show relationship between input and output variables |
| 4 | o Highlight the policy steering variables |
| 5 | Show visual representation of model relations |
| 6 | The interactive meeting should take a half to a full day |
| Policy maker: model performance | |
| 7 | Display additional variable information on demand: |
| 8 | o Standard deviation of outcomes. |
| 9 | o Input variable sensitivity. |
| 10 | o Reliability interval and model bounds. |
| 11 | Show distribution of uncertainty on output values. |
| 12 | Use sensitivity analysis for uncertain input variables. |
| 13 | Make use of known modelling techniques like the PRIMOS model and the shift-share method for estimating employment development. |
| 14 | Clarify the relation between the thesis model and available models and methodologies: Social Cost Benefit Analysis, REGINA etc. |
| 15 | The model outcomes must be reproducible results. |
| 16 | Store time-series outcomes in spreadsheet (Excel) |
| Consultant: policy issue | |
| 17 | Present model outcomes in simplified “Jip & Janneke” versions. |
| 18 | Give insight in the “mitsen en maren” of a project → show the model assumptions. |
| 19 | Scale of the project the model should be suited for: |
| 20 | o Financial: > 10 million euro. |
| 21 | o Time span: 10 - 30 years. |
| 22 | One input screen for all the regional variables. |
| 23 | Use the model to gain insight on a provincial scale. |

Table 4.2, list of consultant requirements

Policy issue requirements

The requirements that are obtained from the policy issue concern the case for which the instrument is used. In this case the case the WRM project. For the analysis of the socio-economic effects in the Wieringerrandmeer the emphasis lies on the changes in the housing market and recreation facilities that will affect production structure and the labour market. During the interviews the respondents involved with the WRM project were asked specifically on detail of the WRM project. The other respondents answered the questions on simulation models for supporting policy development on spatial investments in general. The most important policy issue for the WRM project is the exploration of the effects that extra tourism has on the region. Table 3.1 lists the rest of the requirements. The simulation model must:

| <i>Policy issue: communication</i> | |
|---|---|
| 1 | Very simple model interface |
| 2 | Understandable for laymen |
| 3 | Model must be able to deal with local communities and government |
| 4 | Give insight in the effect of tourism |
| 5 | o Day tourists and long holiday |
| <i>Policy maker: model performance</i> | |
| 6 | Indicate the risk and uncertainty involved in the project |
| 7 | o Make a difference between Wieringen and Wieringermeer |
| 8 | o Uncertainty with respect to economic scenario |
| <i>Policy issue: prolem setting</i> | |
| 9 | Illustrate the effect of stopping the project half way |
| 10 | The model should facilitate a setting that will lead to a closer relation between Wieringen and Wieringermeer |
| 11 | The model must show growth in retail, social services and recreation |

Table 4.3, list of policy issue requirements.

Literature based requirements

A requirement source that is not explicitly included in the requirement analysis framework is the literature used in the initial phase of this thesis project. Studying existing models that support spatial decisions resulted in a range of issues that have to be dealt with in the simulation model. The important requirements from the literature study are listed below in table 4.4. The simulation model must:

| <i>Literature requirements</i> | |
|---------------------------------------|---|
| 1 | Make a choice in the theoretical predicament of job-follow-people or people-follow-jobs (Vermeulen & Verkade 2005). |
| 2 | Differentiate a set of production sectors to indicate economic and employment growth in these sectors (Heida 2002) |
| 3 | Include the following factors (Armstrong & Taylor 1993) and (Koops (2005): |
| 4 | o Labour market: working labour force, unemployment, jobs in region, vacancies. |
| 5 | o Demography: household size and composition, age, migration, birth/death rate. |
| 6 | o Gross added value. |
| 7 | o Attractiveness of region (through labour, residential or income advantages). |
| 8 | o Income: Regional wage level, consumption, average income. |
| 10 | o Real estate and land: supply of dwellings, demand of dwellings, price levels. |
| 10 | Include limited capacity of growth factors to prevent interpretation errors with extrapolation (Nijkamp & Reggiani 1998). Major, one time events in the past may have had a large effect on the historic growth. Extrapolating this growth without indication of such an event happening again would be unjust and therefore growth (and decline) bounds should prevent excessive growth. |
| 11 | The model must be able to indicate potential risks early in the policy phase (TCI 2004). |
| 12 | Show underlying assumptions of the modelling technique (Meadows 1976). |
| 13 | The model must not predict the future but give direction to the effects that a decision has in the far future under different economic scenarios (Handbook of Knowledge Society Foresight 2003). The model should be interpreted more as giving direction opposed to providing a prediction (Koops & Muskens 2005). |
| 14 | Always include expert opinions of non model-makers for specific regions (Forrester 1980). |
| 15 | Develop the model in such a manner that it is possible to include other interesting (unconventional) economic relations (Glaeser et al. 2001) and (Florida 2002) |

Table 4.4, requirements of the literature study

2.3.4 Sorting out dilemmas and contradicting requirements

Because of the variety of respondents and the enormous size of the long-list with requirements requirement some contradictions between requirements occur. These contradictions are treated like dilemmas and will have to be solved before the conceptual design is made. Dilemmas do not only indicate a contradiction between two requirements, they can also show the tip of a larger “iceberg”. Some simple dilemmas can have huge design implications and can point out weaknesses in the simulation model or concept. To make sure that these problems are not encountered during the design of the model, dilemmas will be resolved in the following fashion:

1. First look for the underlying meaning of the dilemma. If indeed an iceberg is present at the basis of this dilemma more attention should be given to the design choice.
2. The next step is to look for a simple solution that can make the issue go away. For instance including both requirements if that is possible within the model and within the given time constraints.
3. If the dilemma has not been resolved after the second step. The requirement with the predicate need-to-have will get priority over the nice-to-have requirement.
4. When the conflict still has not been resolved the requirement will be chosen that is least time consuming because the development of the simulation model is constrained by time.

Requirement dilemmas

- *The duration of an interactive setting, 4 hours or 2 hours:* this dilemma relates to the application of the model with the end user. Depending on the setting, the time limit should be different. In case of a presentation of the model outcomes, the time required should not be more than 2 hours. On the other hand, in an explorative setting, where policy makers are looking for alternative solutions the required duration of the meeting can easily be 4 hours, even a day. A solution to this dilemma would be to facilitate the model for short presentations and also for more complex policy questions. This would mean that the model should be equipped with multiple user interfaces with different levels of complexity. This requirement is already recorded in the analysis.
- *Displaying information on the meaning of the combination of two factors:* a requirement from the policy makers is to display the meaning of two factors in relation to each other. For example: take two regions, both with low labour participation. A region with low income and low labour participation indicates impoverishment and is therefore not considered a prospering region. On the other hand a region with low labour participation and high income indicates the presence of early retirees and can be considered a prospering region. The requirement to make these relations clear should not be implemented. Model users should always analyze these types of relations, as computers cannot judge them. A nice-to-have feature however would be a “red flag” systems, that warns for unwanted combinations.
- *Do or do not give information on variable bounds:* policy makers tend to deem the indication of variable bounds less important than consultants. The bounds of the outcomes can contribute to better policy decision and should therefore be included in the model. The bounds should only be displayed on demand, as the information is not relevant for all the model users.
- *Keep the model presentation as simple as possible or present all uncertainties and assumptions:* this dilemma relates, just as the previous dilemma, to the level of detail of information that is given. It should be possible to change this level and therefore both a simple presentation as a more complex one should be provided.

Use the model on a provincial or small municipality level: the desire to apply the simulation model on varying geographical scales is understandable. The requirements put forth by the respondents to apply the model on a provincial or small municipality scale is not possible though. On a provincial scale the model should incorporate more complex variables like province competitiveness, the model is too simple for this scale. On a small municipal level the necessary information is not available. Furthermore, on a small scale, small changes (for instance the departure of a local grocer) present large deflections in the model that are not justified. The geographical scale of the model will remain on a multi-municipal and COROP scale.

2.3.5 Reflection on requirement framework

The use of a framework for the requirement analysis proved useful for structuring the questionnaires and the interviews (see figure 2.2). The framework gives some grip in thinking of possible requirements. However, not all the requirements found during the interviews fitted into this framework. Furthermore the literature requirement sources are not mentioned in the framework and neither are the useful additions model experts. The literature requirements should be explicitly included in this framework; this will also promote the use of existing list with requirements. Interviewing model experts should also be included in the framework. Experienced model builders in the field of regional economic modelling or system dynamics add value to the relevance of the model. They can also warn the model builder for possible pitfalls and known drawbacks of certain design assumptions and requirements.

During the development of the thesis model the use of a case study was chosen to make the model more concrete. The issues for this specific case are dealt with in the “policy issue” in the framework. These requirements are specific to that case only and should not be regarded as general requirements. The specific case issue makes the requirements more focussed on the effects of house-construction and recreation development. For new cases a short requirement analysis should be performed on the policy issues. Using these case specific requirements the simulation model can be tailored to fit the specific policy makers demands.

2.4 Existing spatial, regional economic models

This section will give a brief impression of existing regional economic that are relevant for this thesis. An effort has been made by van Oort, Thissen and van Wissen (2005) in “A survey of spatial economic planning models in the Netherlands” to create an overview of all the available models. This wide range also includes models specifically for the assessment of infrastructure issues on a national level like the RAEM model. Other models like PRIMOS produce forecasts on a municipal level on the future development of population and household composition. The REMI model is developed by the University of Massachusetts and domiciled by Ecorys. It claims applications in infrastructure, main port, labour market, energy and environmental issues (van Bork & Treyz 2005). Four models are described in more detail in the following sections. The aim of this exercise is to learn from these models and see if concepts and ideas from these models can be used in the thesis model.

Section 2.4.1 - The PRIMOS model because it is the only Dutch demographic model and it functions as input data source for other models.

Section 2.4.2 - The REGINA model, it focuses on regional economic projections and has both a municipal and a COROP geographical scale.

Section 2.4.3 - The regional labour market model because this model illustrates the relation between jobs, income and population growth in an orderly fashion.

Section 2.4.4 - The Social Cost Benefit Analysis because it has become a benchmark methodology for assessing large projects both in infrastructure as in other spatial projects.

2.4.1 The PRIMOS model

The PRIMOS model makes long-term demographic projections for all Dutch municipalities. It accounts for life cycle changes in households and household behaviour by matching housing demand to individual households (Blok et al. 2005). The model produces prognoses in annual time series from 2002 to 2040 on a wide range of demographic data. The most main model factors are:

- **Housing:** the PRIMOS model includes several housing variables like desired housing supply, expansion demand, building efforts, housing shortage, housing supply. These variables indicate the need for new dwellings or the excess of existing dwellings.
- **Household types:** indicate the composition of households. The classification in child living at home, single, living together no kids, living together with kids, single parents is generally accepted. The development of household types over the years is an important indicator for the housing demand. The for instance aging population in the Netherlands leads to more single living persons, which decreases the average household size. A decreasing household size and equal or growing population means an increasing demand for new dwellings.
- **Demography:** the demographic data for each municipality consists of birth, death, emigration, immigration, departure and settlement (see figure 2.3). When studying the data from the Wieringerrandmeer case it become clear that the region suffers both from an aging population while at the same time the younger people move to larger agglomerations.

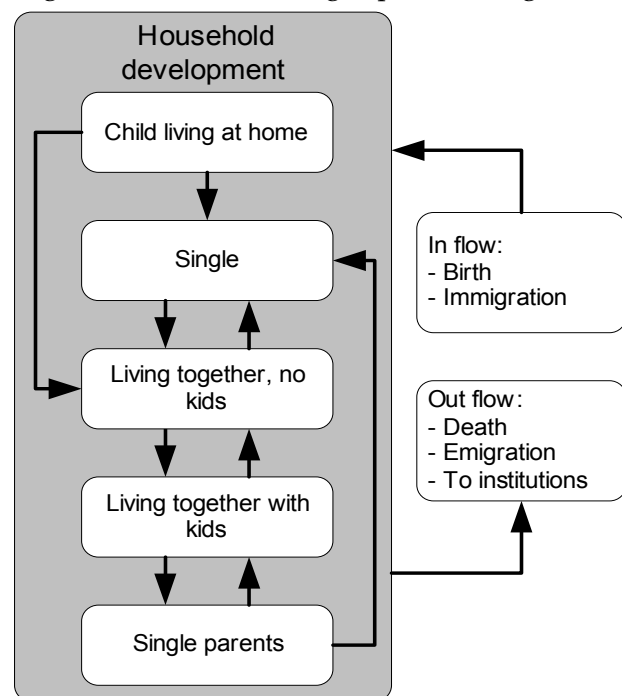
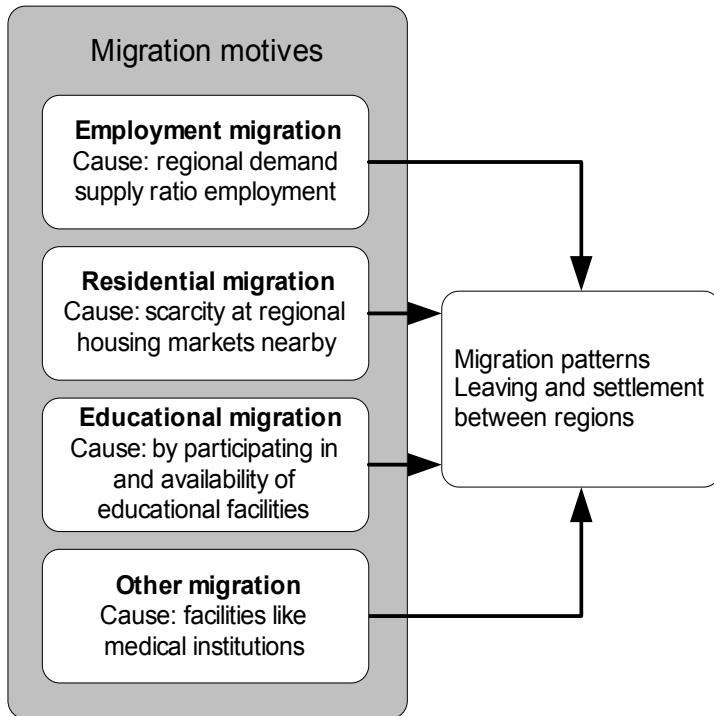


Figure 2.3, demographic development¹⁸.

A vast number of combinations is possible between these factors: age groups cross tabulated with housing demand or household types and desired housing supply. As the PRIMOS model is the only model in the Netherlands that makes demographic forecasts for all geographical scale levels the output data of the model is often used in other models like REGINA.

¹⁸ Illustration from Heida. (2002), page 4

The demographic projections are calculated through four key processes in the PRIMOS model: demographic and household developments, regional migration, housing market dynamics and housing production. All the processes take place on a geographic scale of municipalities. This would also make it relevant for the use as input data for a model that has a multi municipal scale like the thesis model. PRIMOS analyses inter and intra regional migration of persons. The model



deals with four migration motives that together result in the total net migration per region (Heida 2002, Blok et al. 2005) (see figure 2.4). From these four motives, employment migration is the most important and significant factor for migration. The PRIMOS model deals with these migration motives by including a factor that determines if a change of job will lead to a migration move based on the distance from the current residence location and the new job location. As this distance increases the probability of migration increases also. Residential migration takes place if there is a mismatch between the current and desired housing situation, for instance in case of addition to the family.

Figure 2.4, *migration motives*.¹⁹

Residential migration occurs when the demand for a type of dwelling in a region exceed the supply. Inhabitants will in that case start looking for dwellings of their desired type in other regions. Educational migration is based on data from the “Referentie raming” from the Dutch ministry of education, Culture and Science (OC&W). The Referentie raming predicts first year student inflows in different educational bodies based on previous enrolment and city of origin of the first years. Finally there are also some other migration motives. Some examples are institutional homes and health care, cultural and leisure activities and landscape bound motives.

The PRIMOS model illustrates how models can deal with migration and demographic development on a municipal level. However it fails to identify important economic functions like the development of the gross regional product or the increase in jobs in the healthcare sector. A model that does provide more economic data and still functions on a municipal level is the REGINA model.

2.4.2 The REGINA model

The REGINA²⁰ model is used to explain differences in employment and economic sector growth between regions by analyzing the national growth, regional industry mix and other regional factors. The REGINA model is developed by the Netherlands Organisation for Applied Scientific

¹⁹ Illustration from Heida (2002) page 5

²⁰ REGINA is an acronym for Regionaal-Economische Groei Indicatie

Research (TNO), it uses the time series data from the PRIMOS model as forecast for the demographic developments in all the municipalities of the Netherlands (Koops 2005). The REGINA model is focused on forecasts of regional employment and the growth or decline of production sectors in the Netherlands. Compared to the RAEM and PRIMOS model, the REGINA model is relatively easy to comprehend. The mathematical basis that stands at its roots is called shift-share analysis. Shift-share analysis extrapolates growth in production sectors through a shift and a share part. The share part consists of the national growth indicators predicted by the CPB (Huizinga & Smid 2004). The shift part consists of multiple variables with historical performance as most important indicator (see also section 3.3). If, at regional level a sector performs admirably compared to the national performance, an over-representation of that sector in a region will lead to higher growth rates in the future (Armstrong 1993, Koops 2005). This compact theory is extended by TNO to include other explanatory factors for industry and employment growth. As explanatory variables for the over or under performance of a region the model uses the following factors next to the industry mix:

- Labour supply: population growth increases the potential labour supply (age: 15-65), it also increases the potential sales market.
- Agglomeration effects: from the New Economic Geography literature. REGINA includes an explanatory variable for the proximity of concentrations of employment.
- Accessibility: as important attractor for firms to settle in the region.
- Proximity of economic main ports: the model takes Amsterdam Airport Schiphol and the Port of Rotterdam into consideration.
- Sector representation: takes growth in economic sectors with different size into consideration (using the Hirshman-Herfindahl index).
- Other factors: available space for economic activities, suburbanization.

The primary function however remains identifying differences in economic growth between regions or municipalities, not the ex-ante calculation of regional investments. The use of the PRIMOS model for the provision of demographic forecasts proves useful in the REGINA model. If the model would also include a demographic module the relation would become exponentially more complicated. And it would not be a guarantee the model would produce better results. The REGINA model fails however to give policy makers insight in the inner workings of their model. This would prevent the policy makers from understanding the effects of their decisions and the consequences of their policy proposals.

2.4.3 The regional labour market model

The regional labour market model is built by the CPB focuses on the regional distribution of population and employment (Verkade & Vermeulen 2005, Vermeulen & van Ommeren 2005 & 2006). The aim of the model is to provide long-term scenarios for policy development on infrastructure projects and business development areas. The author uses the model to challenge the popular believe that people follow jobs with the statement that the opposite is true; jobs follow people. For both directions the causality theoretical explanations exist. Through a local comparative advantage in production it is possible that wages increase, attracting migrants as they start to rise, hence people follow jobs. The other way around indicates that as people move to areas with high amenities (e.g. high quality services, attractive environment and consumer goods) they supply labour, which attracts firms, hence jobs follow people (Vermeulen & van Ommeren 2005). The regional labour market model acknowledges the fact that neither employment nor population growth develops exogenous. Therefore the relations between them should be dynamic. The

geographical scale on which data is used in the model is on COROP level. For the model equations are estimated on time series data from the 1970 – 2000 period. This makes the model more econometric than other more theoretical derived model.

The two most important equations in the model are that of the net domestic migration (NDM) and the employment growth (Δemp). NDM indicates the effects that the housing market, employment and region specific amenities have on the migration in a region (see equation 1). The increase or decrease in the housing stock seems to be the most important indicator for the NDM. The increase of the housing stock with a 100 dwellings will lead to the increase of approximately 80 inhabitants through migration based on the housing supply only. The negative 4% $pop_{i,t-1} - hou_{i,t-1}$ indicates the deviation from the equilibrium that occurs when the housing stock deviates from the national average. Finally there is a positive impulse from employment growth in the region (Δemp). Note: this factor is more than 26 times smaller than the effect from housing stock increase.

$$(1) \quad \frac{NDM_{i,t}}{POP_{i,t-1}} = C_i^M + 0.8\Delta hou_{i,t} - 0.04(pop_{i,t-1} - \overline{hou_{i,t-1}}) + 0.03\overline{\Delta emp_{i,t}} + \alpha_k X_{i,t}^k$$

- NDM: net domestic migration
- POP: population in age group 15-65
- HOU: number of housing units
- EMP: employment (employees in labour years)
- C: region-specific fixed effect
- X: other explanatory variables

The other basic equation of the labour market model is that of the growth in employment (see equation 2). The employment growth in the region is largely based on the population (age group 15-65), which is an outcome of the hypothesis that jobs follow people. A smaller and negative effect is attributed to the employment density ($emp_{i,t-1} - \overline{pop_{i,t-1}}$). Under other explanatory variables the regional labour model accounts for more significant effects. For instance the growth that would be predicted based on the industry composition in a region, much like the sector shift factor in the REGINA model. Furthermore the model includes the accessibility of input and output markets and the ratio of regional added value through employment. Fact remains that the increase in population remains the most important factor in the growth of employment in the region.

$$(2) \quad \Delta emp_{i,t} = C_i^E + 0.3\Delta \overline{pop_{i,t}} - 0.09(emp_{i,t-1} - \overline{pop_{i,t-1}}) + \beta_k Y_{i,t}^k$$

Compared to the REGINA, the CPB model does not relate the employment growth to the sector breakdown of a region. The shift-share analysis, as used in the REGINA model, links a growing industry on national level to regional prosperity. However according to Verkade and Vermeulen (2005) the major growth has not presented itself in the Randstad (as a shift-share analysis predicts). They proof in their work that growth is stronger in the intermediate zone.

2.4.4 The social cost benefit analysis

The use of cost benefit analysis is widely spread and commonly used by economists. Social Cost Benefit Analysis (SCBA) has become obligatory for large projects since the OEEI-guidelines were

introduced in 2000 (Eijgenraam et al. 2000). The TCI stressed the importance of SCBA and the thorough assessment of costs and benefits and focused even more attention on ex-ante valuation of large infrastructure projects (TCI 2004). Compared to the models in this section the SCBA is more a methodology than it is an econometric model or even a computer model.

The methodology can be described in four steps (see figure 2.5)

1. First a list must be drawn up with all the relevant costs and benefits of the policy option. The OEEI-guide gives some direction in the selection of the effects. Not all effects are allowed in the due to the possibility of double counting. Double counting can occur when two or more effects are strongly correlated and have the same influence on the welfare. The effect of extra employment due to an investment cannot be accounted for if the respective rise in regional income is also included in the SCBA. The extra employment results in the increase of the regional income.
2. The effects from step 1 must now be made monetary by the process of determining the market value of the effects. For example the loss of one acre of agriculture land costs 15.000 euro per year. Guidelines that support the process of expressing the effects in monetary values are not present in the OEEI-guide and still under development.
3. The third step is assessing the quantity of effect and multiplying this with the monetary value of the effect of step 2. This will result in a list of monetary values representing the costs and benefits of the project.
4. Finally total costs and total benefits must be subtracted from each other to find out if the policy option has either a positive or negative effect on the welfare.

| Effect in own unit | Monetarized effect | Quantity of effect | Total effect |
|---------------------|--------------------------|--------------------|-----------------------|
| - Costs | - Costs | - Costs | - Costs |
| loss of agriculture | 15.000 euro / ha / year | 100 ha | 1.500.000 euro / year |
| | | X | = |
| - Benefits | - Benefits | - Benefits | - Benefits |
| jobs | 30.000 euro / job / year | 100 jobs | 3.000.000 euro / year |

Figure 2.5: overview of SCBA approach

The great value of SCBA is its chosen policy goal: the aggregate welfare of a group of citizens in a region or country (Heyma & Oosterhaven 2005). This means that underlying, lower policy goals are implicitly incorporated in the SCBA. Furthermore, the use of this single criterion provides a solid basis for the comparison of different policy options. Before the SCBA can be properly performed the effects need to be inventoried first. These effects studies are usually preceded by individual effect studies (see figure 2.6) When an SCBA is put into perspective with other research and reports the integral function becomes clear once more. The SCBA follows from multiple studies that are – often – executed before the SCBA is made. The SCBA then uses the information and by the set of double counting rules combines all welfare effects. The other studies included are the:

- Strategic environment assessment (SMB): aims to involve environmental considerations in policymaking, it furthermore contributes to sustainable developments in large projects.

- Environmental impact analysis (MER): provides insight in the environmental effect for a specific part of a project. For specific projects a MER is required.
- Agriculture impact analysis (LER) predicts the effect of changes function of the planned area and the effects these changes have on agriculture
- Socio-economic Effect Study (SEES): provides insight in socio-economic factors. SEES does not consider double counting effects, on the other hand it does not accumulate these effects and can therefore legitimately be used. The SEES gives a broader perspective on socio-economic effects than a SCBA.

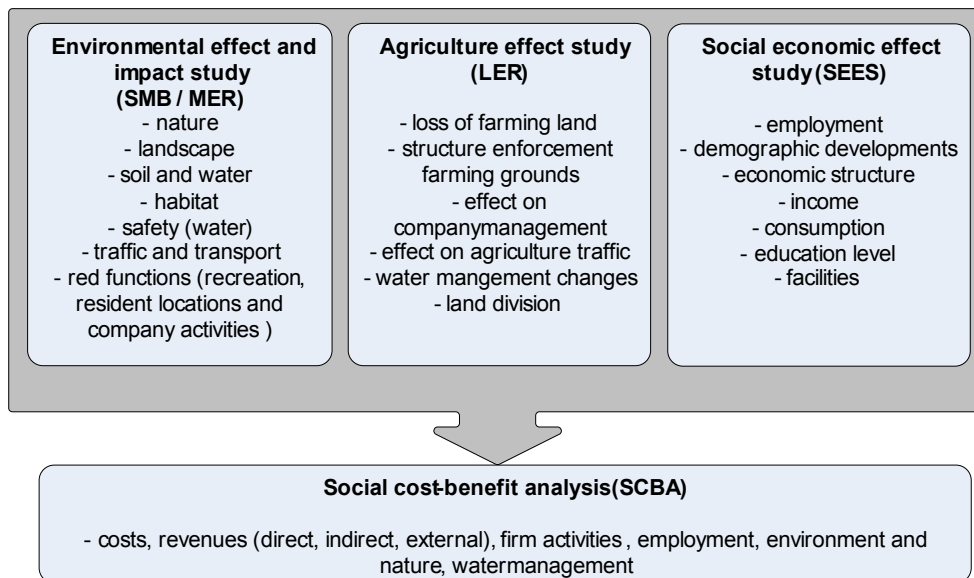


Figure 2.6, relation between different studies

2.4.5 Shortcomings of existing methodologies and models

The models addressed in the previous sections all have the aim of supporting the decision making process and assessing policy proposals. They all try to make a projection of things to come, under different scenarios and different policy options. What they fail to do is providing policy makers with the understanding of why their policy proposal pushes economic growth. A general notion from studying the existing models is that none of them is intended for interaction with policy makers or understanding policy makers for that matter. Key factor in this issue is that most models present the value of the effect variables at the end of the forecasting period. They do not show the behaviour of this variable over time. By omitting the behaviour over time, a learning effect dissipates because policy makers are not able to grasp the behaviour of the economic system.

Next to this flaw in presentation of outcomes there are three other critical points that make the models mentioned above less suited for economic effect modelling in smaller regions. The first problem is these models are not well suited for the intended use as policy supporting instrument in interaction between the consultant and policy maker. Especially the regional labour market model, the RAEM model and the REMI model, are difficult to comprehend. For a policy maker and even for a model expert these models are not easily understood and therefore cannot be used to as a tool supporting the general understanding of economic effects. The complexity of these models prevents a clear interface with the policy maker and obscures a learning effect.

The second issue that needs to be dealt with is that of uncertainty in forecasting models for long term planning (10 to 30 years). Real predictability is not realistic, as one cannot account for unexpected events or technological advances that might occur in the future (Nijkamp 1998, Don 2004). Therefore it is important that policy makers who work with (the results of) forecasting models are aware of these inaccuracies and receive proper instructions on the bounds of the model outcomes. The outcomes of PRIMOS model are often used as input data for other models, however the uncertainties of the outcomes are not judged. The outcomes of the model are copied without consent of the attached uncertainty of the outcomes.

The third issue that makes the available models less suited for the thesis model is the geographical scale of these models. There are models, like REGINA, that are capable of explaining why one region has a higher income than another region, however the focus is never put on a specific region alone. Other models account on a nation wide scale and do not include specific regional details like the RAEM model. This puts a strain on the assumptions made in the national model and a regional model that does only account for regional effects that are not distributed across the country. For the thesis model this will not form a problem as it only looks at a specific region and is not interested in the effects that the region has on the environment surrounding the region. Finally the costs of the use of the models mentioned above are sizable. Performing a SCBA or running the REMI model can cost up to €25.000. The RAEM and TIGRIS model even exceed €50.000 for one application (RWS 2005)

To sum up the shortcomings are:

- Models are not intended for interaction with the policy maker.
- The models are very complex.
- The uncertainty in the economic models is not expressed explicitly enough.
- The currently available models are not suited for economic analysis on smaller regions.
- The models are very costly.

To overcome these problems a new model needs to be developed using a new methodology. A model that can provide a projection of a new economic regional situation that occurs after an investment. This model will provide insight for policy makers and must – partly – be developed in cooperation between the model builder (consultant) and the policy maker. The intended users of the model are the consultant and the policy maker together. If the consultant would create the model without the help of the policy maker, some vital information of the policy maker may not be included in the model. The mental database of the policy maker should be regarded as a resource of information that cannot be found in databases with numerical data (Forrester 1980). On the other hand the policy maker should not use the model by itself, as he or she is less aware of the mathematical foundation on which the model is built. The danger exists that the policy maker would use the model, change variables and parameters so that the model is no longer valid.

2.5 The potential of system dynamics

Another way to approach policy makers with policy supporting models is to create smaller insightful models that support the exchange of knowledge between the model builders and the policy makers (van Daalen 2002, Mészáros-Komaromy 2003). This way model validation takes place parallel with a learning effect towards the policy makers. Don (2004) describes a similar approach and mentions that simulation models will support both consultants as policy makers in

getting grip on the dynamics surrounding a certain – spatial – policy decision. This in turn will lead to better understanding of the problem situation and hence better policy solutions. A methodology that is able to cope with smaller insightful model is system dynamics (SD). SD is based on cause and effect relationships also called causal models. If SD is applicable for the problem at hand will be assessed in section 2.4.1, a more detailed description is given in 2.4.2 and section 2.4.3 gives a critical view on the use of system dynamics.

2.5.1 Why use system dynamics?

The choice to use system dynamics as a modelling instrument for this thesis model can be supported by a set of indicators. These indicators determine the nature of the problem at hand and the intended use of the model (van Daalen & Thissen 2003).

- *Continuous or discreet time*: the events that occur in the model are strictly speaking discrete event. The completion of a house in the Wieringerrandmeer can be seen as a discrete event. However the size of the project and the course of time in which the project is realized allow the use of continues time.
- *Closed or open system*: the system is open because influences from the environment affect the system but are not affected by the system (exogenous variables). For instance the development of the gross regional product, the growth of inhabitants and the development of jobs in the region. These variables can be seen as assumptions of the economic system described by the model.
- *Deterministic or stochastic behaviour*: systems that are completely determined by the historic events are called deterministic. A system or model where events happen incidentally and are not predetermined is called stochastic. In the thesis model the behaviour of the model should be reproducible and therefore stochastic. However the introduction of stochastic elements is used in testing the sensitivity of the model.
- *Linear or non-linear behaviour*: the model is part linear and part non-linear. The non-linearity plays part when for instance the housing price increases with 50% the inhabitants will not decrease with 50%. Linearity is visible in the relation between gross regional product and jobs in the region. When the jobs in the region double, so does the gross regional product.
- *Static or dynamic*: the economic system is dynamic because the output variables (effect variables) are dependent on other variables in time. The growth of jobs depends for instance on the historic performance and the availability of potential labour force.
- *Constant or time dependent*: the system is time dependent. The construction of the new dwellings in the Wieringerrandmeer influences the growth of the economy and the demographic structure.

The indicators above certainly point towards the use of system dynamics; the problem is continuous, open, deterministic, partly non-linear, dynamic and time dependent. The problem and the system in which the problem has to be solved also appeals to system dynamics. The problem can be described in causal loop diagrams and the patterns of behaviour are more important the exact values. This latter statement relates to the function of the model to elucidate policy makers of the concepts of economics. Furthermore changes occur in time and flows and level can be recognized. Levels are stocks of goods, persons, houses etcetera and flows make these levels either increase or decrease. In the economic system the amount of jobs, houses, households and inhabitants can be regarded as levels. The analysis takes covers a longer period and finally feedback loops can be expected. These issues are discussed in more detail in the rest of this section.

Economic effect modelling, simulation, forecasting and model building all revolve around the same thing in this paper: predicting the future. This thesis focuses on the prediction of regional economic effects of investments in that specific region. The approach that will be used for the determination of economic effects in this paper will be based on simulation through System dynamics (SD), a technique developed at the Massachusetts Institute of Technology (MIT) in the sixties (Forrester, 1969). SD is based on causal relations and causal feedback loops between stocks, exogenous and endogenous factors. Causal relationships are extracted from causal arguments; these arguments are valid, logical rationales that are – often – part of our own “mental” models of reality. Causal loop diagrams form the basis for a SD model; an example of a simple model of an urban area developed by Forrester is shown in figure 2.7. Forrester developed three SD models, the Industry Dynamics model, showing the interaction between companies and a World Dynamics model showing intercontinental flows. The model that is most important for this research is the Urban Dynamics model, giving insight in the dynamics of a city or urban area. It might prove useful to use this model as a starting point for the model in this thesis (Forrester, 1969).

In figure 2.7 each number between two arrows and two factors indicate the specific relation between the two factors in a specific region. Take for example relation 1 between *Population* and *Job availability*; the arrow with the minus sign indicates that if the population increases, job availability will (logically) decrease as the new inhabitants fill in a part of the available jobs. The ‘plus’ arrow indicates that if the available jobs would rise this would attract people from outside the modelled region, and therefore increasing the population. Arguments can also be made between more than two factors. When – for example – a municipality decides to develop new *Houses*, the *Housing availability* will increase (see loop 4). The available houses will attract *Population* in loop 2. Then, under the assumption that all residents work in the modelled area and that no extra jobs are created, the *Job availability* will decrease (loop 1). The decrease in jobs will in turn reduce the rate of population that settles in the area leaving the municipality with an excess supply of housing²¹.

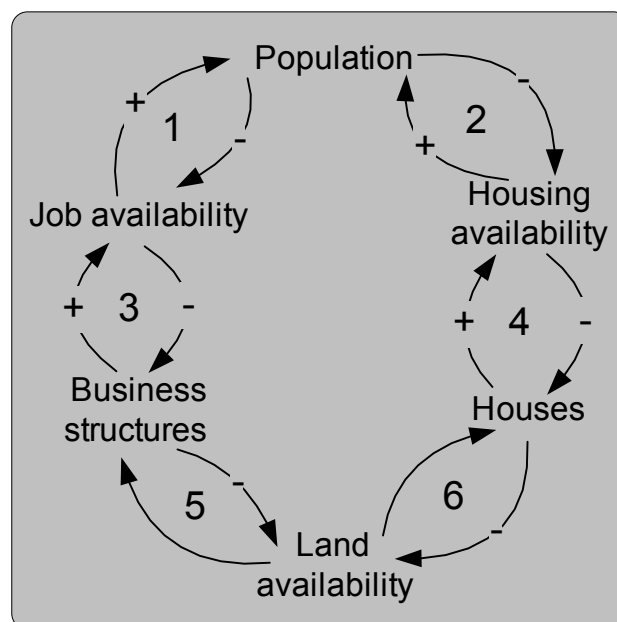
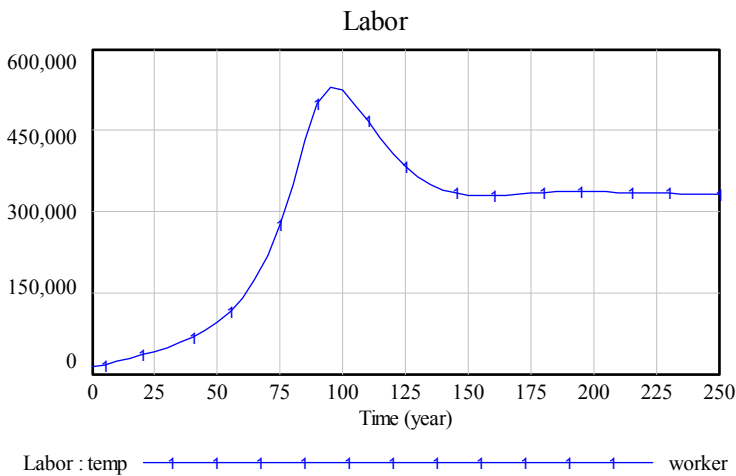


Figure 2.7, causal loop in urban dynamics model

²¹ Assuming that people follow jobs and therefore people will move away from regions that have a relative small supply of labour (van Ommeren & Vermeulen 2005).

This example is a very short-sighted model of reality, packed with assumptions; it would be too simple for the purpose of the thesis model. What it does illustrate is the relative ease of understanding the model, it relates very closely to our own mental models of reality. It corresponds with the feeling that real systems are non-linear, multivariable, time-delayed and disaggregate (Meadows, 1976). Most people are capable of logically deducting these causal relationships between two factors and so creating a visual model from their mental model (like figure 2.7). With this visualised model feedback loops can be identified that would have been obscured in a mental model due to the complexity and non-linearity of the real-life system. The ability of transforming complex, mental models into tangible and quantifiable models is a great strength of the system dynamics approach.

Another big advantage of using SD and simulation is that it provides a time series output of the long-term effects (10 – 30 years). Thus, SD provides insight in the development of different



variables over time; figure 2.8 shows an example²². In this way the model provides insight in the behaviour of the system. From figure 2.8 it becomes apparent that at t_{100} a peak occurs in labour supply, and that later at t_{150} the labour supply reaches equilibrium at around 300k jobs. This insight helps policy makers in determining their planning and timing of expected returns of certain investments.

Figure 2.8, labour supply in the “urban dynamics” model

2.5.2 Why not use system dynamics: drawbacks and criticism

The models that Forrester and his followers developed have met with a lot of criticism. One of the most important critiques, which will also be an issue in this thesis research, is the fact that the Urban Dynamics model was developed without empirical data. The model of Forrester describes a hypothetical city and therefore the nonlinear functions that are present in the model cannot be validated. Garn and Wilson mention that too little empirical data exists to support the assumptions on the range and shape of the critical non-linear functions (Garn, 1972). The SD community responded with the argument that it is better to include an estimation of important variables than it is to omitting the variable and denying its influence in total (Forrester, 1969). This was also pointed out by Meadows who compares SD with econometric models and attributes more explanatory value to SD models. Due to the rigorous statistical testing methods that econometricians apply, their models exclude variables that might invoke numerical biases as a result from covariance that increases the error term (Meadows, 1976). The value of SD models thus lays not the minimization of the error term but in the explanatory power that the models exert and

²² Example taken from the “Urban Dynamics” models of Forrester (Forrester 1969), this particular example is extracted from the VenSim simulation package. It represents the *labor* stock in a specific region.

the insight they provide. Therefore and SD or UD user is not interested in a specific value in a specific year, but more in the behaviour of a system over time and the occurrence of unexpected oscillation, growth, decline and equilibriums.

Because it is important to have some insight in the outcomes of the model compared to for instance the future explorations of the CPB (Mooij & Tang 2003), the numerical time series output of the thesis model can be used to check if the outcomes align with the outcomes of other planning models when using a neutral scenario (Forrester, 1980).

Criticism was also passed on the subject that urban dynamics assumes that the behaviour of cities is endogenously driven. Meaning that the model within the system boundary does not influence its environment and visa versa. In my opinion this criticism is right, and in the thesis model this issue will have to be dealt with. An example can be given with respect to commuters; in the original model from Forrester, the assumption is made that all people who work in the city reside there as well. This creates a problem because as commuters that work or live outside the region cannot be accounted for. In the thesis model this will have to be worked out, for instance by giving a distribution of residents who work outside and inside the region. Other problems that occur due to the endogenously driven system will be worked out in a similar fashion. The fact that the urban dynamics system is endogenously driven also poses advantages, as only few exogenous variables are necessary to run the model. Exogenous or input variables are usually very hard to find and depend for a large part on the geographical scale of the model. For the development of the thesis model, data on the COROP agglomeration level will be used. The COROP data is provided by Statistics Netherlands (CBS) and available through the StatLine website²³. It is the intention of the thesis model to deviate from the original urban dynamics model on the subject of city scale. The original model focuses on a city with a defined suburban area, the thesis model will look more on a regional level, including multiple smaller municipalities if necessary.

The third issue that the UD models were criticized on is their assumption of a limitless environment. For example, there is an endless supply of residents in the UD model. As long as the local environment is more attractive than the outer environment residents will flow into the model. This means that only the local environment is optimized instead of a national optimization. Because the aim of the thesis model is to focus on a specific region and not on the external environment, this will not pose a problem. This also deals with the problem that existing models have towards the geographical scale: because the thesis model is only focusing on one region, the effects that occur only have to affect that specific region.

A decisive advantage of simulation models based on SD are relative comprehensible and transparent; this makes them well suited for policy maker and model builder interaction. As Meadows points out: "System Dynamicists instinctively admire simple models and reject complex ones" (Mead1976). As we are trying to create a clear / tangible model, understandable for layman, this simpleness is appreciated and even necessary (Meadows, 1976). This interaction is vital for knowledge exchange, as was demonstrated in the chapter 2 by van Daalen (2002) and Mészáros-Komaromy (2003).

There are some points that require more attention in the SD approach. The instrument is supposed to be used by the consultant and the policy maker together. Without the input of regional

²³ <http://www.CBS.nl/statline>

knowledge and experience of the policy maker the consultant lacks insight in the region to create a suitable model. On the other hand the policy maker is not aware of the model boundaries that occur due to the mathematical properties of the model and could therefore use the model outside its correct bounds. This would result in unrealistic outcomes that cannot be validated and that might be (mis)used to justify the model toward a higher governmental power. A second point of attention is the explanatory power of the model in different situations. It has to be seen if it is possible to use the same model for different regions, in order to test this multiple cases will have to be simulated. One case should then represent a “simple”, rural region and the other a more complex urban centre.

2.6 Available data for model input variables

For the construction of the simulation model a wide range of input variables must be filled with valid data. These data have to be extracted from databases, economic forecasts and research in socio-economic phenomena. The thesis model that is presented in chapter 3 requires about 50 input variables, all for which a valid source had to be found. This chapter will give an overview of data sources that are widely used and generally accepted in the field of regional economic modelling. The two largest sources of data are the PRIMOS model and the CBS StatLine database. PRIMOS provides forecasts of the demographic developments on a municipal scale. The CBS database contains historic data that is also used for the historic validation in section 4.3.2. The list below gives an overview of data sources that can be used,

- The PRIMOS model provides time series predictions between 2005 and 2040 for a set of demographic data (Heida 2002). These forecasted data are available for each Dutch municipality, COROP region and province and can be used as input parameter for an economic model:
 - The composition of the population classified in different distributions
 - Distribution of household types
 - Distribution of age
 - A forecast of the supply and demand for dwellings in a municipality
 - A distribution of households per municipality and living environment (woonmilieus)
 - A forecast of births, deaths, immigration and emigration
- The CPB provides forecasts for a large array of economic variables. The forecasts are based on the work of Huizinga & Smid (2004) who apply their economic models to the scenarios “Four Futures of Europe” of Mooij and Tang (2003). The CPB does not provide time series data like the PRIMOS model but give indication either per 20 years or for the period of 2005-2040.
 - Forecasts per industry sector for the development of jobs per sector. The growth indicators are given for 2005-2020 and 2020-2040.
 - Forecasts for the unemployment until 2040
 - An estimation of the development of the gross national product per inhabitant
 - A forecast of the development of productivity until 2040
- The SCP provides forecasted data on the participation level of people. This is the amount people of the potential labour force that are actually working.
- The CBS is the largest database on historic economic data in the Netherlands. It contains thousands of table’s worth of information from unemployment levels until level about social

safety. The data that can be used from the CBS is either used to extrapolate data or to indicate starting values of basic model variables. Below only the selection of data that is used in the thesis model is illustrated²⁴.

- The start value of: dwellings in the region, jobs per industry sector in the region, jobs per industry national, unemployment, working labour force, labour force, disposable income of households, average spending on daily, non-daily and leisure.
- The habitat quote
- The Locatus retail explorer (Locatus 2004) gives an indication of the demand for retail in a region.
- The retail yearbook (HDB 2004) provides data on the size of retail per COROP area and is updated on a yearly basis. The yearbook also gives information on different retail sectors and the demand for retail in a region.
- The “Koopstroomonderzoek” of Goudappel Coffeng (KSO 2004) gives information on the distribution of regional spending by inhabitants of a region.

2.7 Conclusion of model conditions and environment

In chapter 2 the first thesis sub question formed the departure point for the search for the most important indicators and underlying relations of the instrument that has to be built. By executing step 4, 5 and 6 the sub questions can now be answered in the conclusion of this chapter.

What are the leading indicators and underlying relations of an instrument for the ex-ante exploration and assessment of policy options in spatial investments in a region?

- a. *What are the user requirements of such an instrument?*
- b. *What can be learned and used from the existing models or instruments for regional economic analysis?*
- c. *What are the generally accepted data sources that can be used as input parameters for such an instrument?*

Chapter 2 started with exploring the environment where the instrument should be able to work in. From studying the policy life cycle in chapter 2.1.2 it can be concluded that the place of the thesis simulation model in the policy life cycle comes best to justice in the policy formulation phase. This is supported by the intention to develop a model that is able to answer what-if questions in the coming about of policy proposals. The geographical scale of the simulation model is the COROP level, for COROP regions relatively much information is available. The COROP classification also provides a fine meshed division of the Netherlands in 40 regions. Within these regions it must however be possible to assess individual municipalities or groups of municipalities.

The requirement analysis has led to the answers of another sub question of the thesis and also forms a basis for the simulation model construction. By interviewing policy makers, consultants and model experts the important requirements were discovered and categorized. Some of the most important requirements are that the model must:

- Offer different sets of complexity, some actors are interested in highly detailed information, while others prefer a so-called “jip-and-janneke” version.
- Include the regional demographic, employment and housing market developments.

²⁴ All the data is available online through the StatLine website: www.statline.cbs.nl

- Differentiate the production sectors in order to indicate economic and job development per industry sector.
- Show a distribution of the uncertainty of the outcomes and the sensitivity of the input parameters early in the policy process.
- Provide a clear indication of the assumptions that were made during the model construction.
- Show the socio-economic effects of different policy options under different economic scenarios.
- Export the outcomes of a simulation run to an Excel file so it can be used for later analyses.

Specifically for the Wieringerrandmeer case the simulation model must show the effects of tourism, the model must assist in quantifying the risk for both Wieringen and Wieringermeer. The model must also be able to show the effects of stopping the project halfway.

From the requirement analysis and the research into existing economic models it can be concluded that the three most important indicators for the socio-economic instrument are:

- 1) Demographic data
 - a. Age and household distribution
- 2) Employment data
 - a. The development of jobs in different industry sectors
- 3) Economic data
 - a. Spending in the region
 - b. Gross regional product

These indicators need to have a prominent place in the outcomes of the instrument that is presented to the policy makers.

The *raison d'être* of the thesis model is based on shortcomings of currently available models for assessment of regional investment projects. These models either have a wrong geographical focus (mostly national), they do not correctly convey the uncertainty of the outcomes or they are too difficult to function in a dynamic group session. The current models are also quite costly (more than €25.000) and for that price a competitive product can be developed. As stated already in the introduction, the shortcomings of the other model leave possibilities for the system dynamics methodology. The non-linear, dynamic and time dependent behaviour of the regional economy also leads to this conclusion. Another and perhaps more important reason for studying other economic models is looking at possibilities to use concepts, equations and data from these models.

- The PRIMOS model is a complex demographic projection model. It might be helpful to use the PRIMOS time series output data as input for the model that has to be developed (Heida 2002). Furthermore PRIMOS supplies some excellent insights in how demographic development comes about and what motivates inhabitants of a region to migrate to another region (see figure 2.3 and 2.4)
- The REGINA model from TNO shows that a relatively simple technique like shift-share analysis can be extended to make it more realistic in presenting economic and labour market developments.
- The regional labour market model from the CPB is useful because it has examined, based on empirical data, the relationships between housing, employment and migration. These issues are particularly important for the thesis model. The quantified relations might prove helpful during model construction.

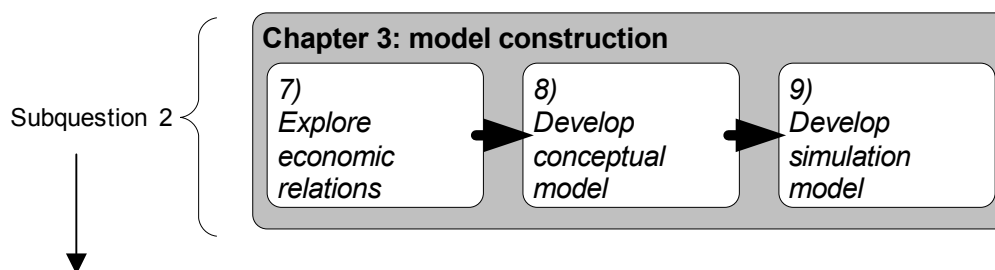
The third and final aspect of the first sub question concerns the data sources that are available and accepted and that are required for the input variables of the instrument. The following most relevant data sources have been identified:

- The PRIMOS model provides time series predictions between 2005 and 2040 for a set of demographic data (Heida 2002). These forecasted data are available for each Dutch municipality, COROP region and province and can be used as input parameter for an economic model:
 - The composition of the population classified in different distributions
 - Distribution of household types
 - Distribution of age
 - A forecast of the supply and demand for dwellings in a municipality
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 - Forecasts per industry sector for the development of jobs per sector. The growth indicators are given for 2005-2020 and 2020-2040.
 - Forecasts for the unemployment until 2040
 - An estimation of the development of the gross national product per inhabitant
 - A forecast of the development of productivity until 2040
- The CBS is the largest database on historic economic data in the Netherlands. It contains thousands of tables worth of information from unemployment levels until level about how safe people feel. The data that can be used from the CBS is either used to extrapolate data or to indicate starting values of basic model variables. Below only the selection of data that is used in the thesis model is illustrated²⁵.
 - The start value of: dwellings in the region, jobs per industry sector in the region, jobs per industry national, unemployment, working labour force, labour force, disposable income of households, average spending on daily, non-daily and leisure.
 - The habitat quote.
- The “Koopstroomonderzoek” of Goudappel Coffeng (KSO 2004) gives information on the distribution of regional spending by inhabitants of a region.

²⁵ All the data is available online through the StatLine website: www.statline.cbs.nl

3 Model construction

In this third chapter the second sub question of the thesis forms the basis of the research. Now the preliminary phases have been executed the real model building can start. As step 7 the economic relations will be explored first based on the knowledge from the requirement analysis and the study of literature and existing models. Then as a step between the actual model and the requirement analysis a concept model needs to be developed. Chapter 3 thus shows two transformations; first the results from the requirement analysis, the exploration of economic relations and literature study are transformed in the concept model. The second transformation is that of the concept model in the actual mathematical model. The key assumptions and decisions of the design process are worked out in detail and the SD theory is tested on its applicability in the final model.



How to construct an instrument for the ex-ante exploration and assessment of policy options in spatial investments in a region?

- a. *How are the notions from the requirement analysis, literature study and existing models translated into a conceptual model?*
- b. *How is this conceptual model translated into a mathematical simulation model?*

The leading indicators identified in the previous chapter and the theoretical framework form the starting point for the design of the concept model. In section 3.1 the general concept is given, basic decisions and assumptions are explained. Section 3.2 deals with the causal and empirical relationships that appear in the concept model. Then in section 3.3 the transformation of the concept model into the final simulation model is described. The assumptions that were made during the complete design process are described in section 3.4 and the model specifications can be found in 3.5. An aspect that is placed high on the list of user requirements is the interface, how the interface communicates with the model user is described in section 3.6. And finally in 3.7 the conclusion is given based on the insights gained during the development of the simulation model.

3.1 The simulation model concept

The simulation model must provide insight in the socio-economic developments that will take place in a certain region; the region in this case is a set of municipalities within a COROP area. A requirement states that for this region the model must be able to calculate different scenarios, both economic and policy scenarios. The policy scenario discloses the available policy options and external policy events; for instance the delay of the investment project. The economic scenario illustrates the effects on the project region of either a growing or declining economy. The economic scenarios are based on the commonly used CPB scenarios (Huizinga & Smid 2004). The case in which the investment project is not executed is called the autonomous policy scenario; it illustrates

the effect of the base case or 0-option. The impulse policy scenario gives an indication of the socio-economic effects in the region when the investment is made. The effects in the impulse scenario illustrate also if the project requirements are met and if the desired political goal is reached. Figure 3.1 is taken from the simulation model and illustrates the development of jobs in the region over a period of 25 years. The impulse scenario is presented in pink against the autonomous scenario in blue. The striped section between the lines indicates the extra jobs created by the investment project. Having a visual representation of the economic effects is another model requirement.

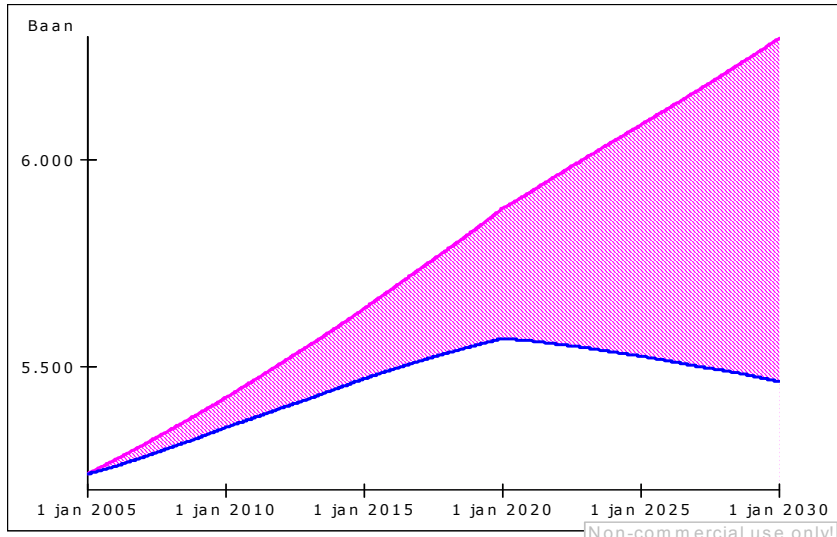


Figure 3.1, jobs in the autonomous (blue) and impulse (pink) scenario

The general concept of the simulation model is that it combines theoretical relationships found in system dynamics with empirical data from other models and prognoses. Why this combination is necessary is explained in the following section. The input data, or data that is required to run the model comes from a variety of sources. The CPB delivers economic forecasts in the form of growth percentages, the SCP provides participation levels in the workforce, and demographic data comes from the PRIMOS model etcetera. To comply with the model requirements the key input factors of the model are (see figure 3.2):

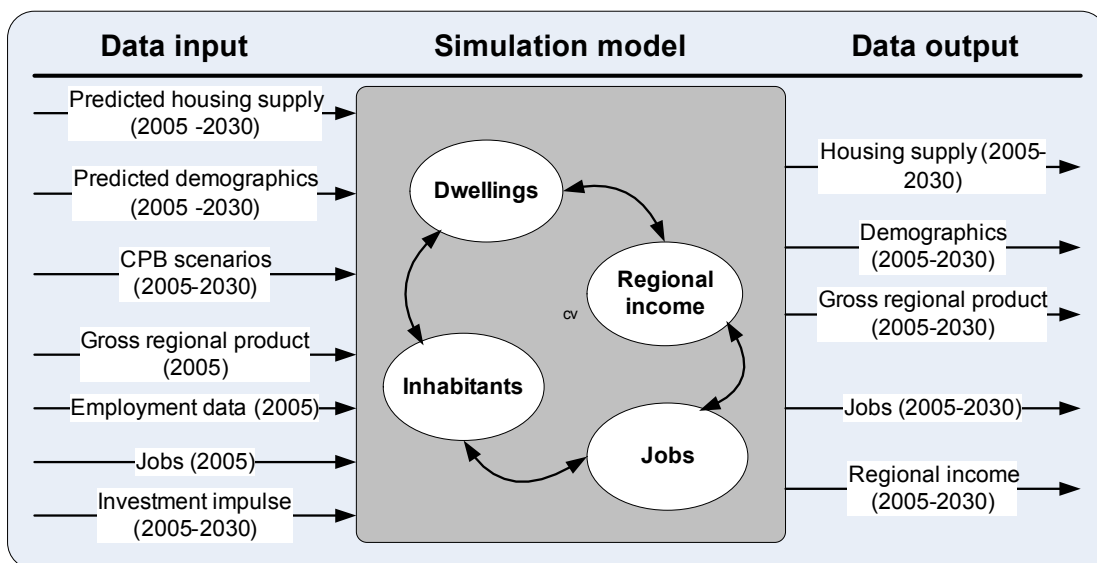


Figure 3.2, the core variables of the simulation model and the important in- and outputs

- The predicted housing supply and demographics by PRIMOS. The demographic data consists of inhabitants in age groups and household types.
- The CPB economic scenarios for the Netherlands until 2040 (Huizinga & Smid 2004), in the model only used until 2030.
- Data that describes the current situation: the jobs in different industry sectors, regional income and regional productivity.
- The proposed investment project that is translated into a growth in the number of houses and facilities in the project region.
- The present supply of recreational and other facilities to comply with the requirements from the case study Wieringerrandmeer.

The four most important simulation model variables are the number of dwellings (houses) in the project region, the inhabitants, the regional income and the development of jobs in different industry sectors. The data generated by the model is exported to MS Excel spreadsheets for analysis and further processing. The output of the model is focused on the regional socio-economic factors and is in correspondence to the requirements from step 4:

- The total housing supply including the investment impulse until 2030.
- Developments of demographic variables (households types and age groups) until 2030.
- The development of the gross regional product until 2030.
- The jobs per industry sector in the project region until 2030.
- Developments in the regional income and spending in the region until 2030.

3.1.1 Using exogenous data to keep the model manageable

Initially Forrester's Urban Dynamics model was intended as the basis of the thesis simulation model (see section 2.4.1). The Urban Dynamics model however is a completely theoretical model without empirical data (Garn 1972); this means that most of the variables in Forrester's model are endogenous. A completely endogenous model would also require the development of a demographic and labour market model component. Looking at the size, complexity and quality of existing demographic models like PRIMOS it is almost impossible to replicate such a model in a system dynamics environment. A model of such complexity would compromise the requirement to develop a manageable model and would furthermore exceed the given time for this thesis project. This leaves the option of using the time series projections of PRIMOS as input for the model. There are more indications that using external data is better than developing an endogenous model that does not inhibit the properties of Forrester's UD model:

- First, if only theoretical assumptions constitute the model the description of for instance the demographic developments require a far more complex model. This complexity would contravene the goal of the thesis model to be comprehensible and manageable. Through the introduction of empirical data from existing models the complexity of the model can be kept within limits.
- The second argument for not only using theoretical relations is the relevance of the information that has to be presented towards the end user, the policy maker. The Urban Dynamics model has never been validated on an empirical case and would be hard to ex-ante verify the correctness on an actual situation. The actual data derived from the Wieringerrandmeer case study cannot be implemented in the UD model. The outcomes of the UD model do not comply with the user requirements. For instance, it is not possible in the UD model to attribute

different industry sectors, neither is it possible to give insight in demographic effects like age or household distribution.

Using the urban dynamics model as starting point for the thesis model becomes impossible if the user requirements are to be met. There are two more arguments for *not* using UD that give the decisive proof.

- The time span of the UD model exceed by 10 fold the intended time span of the thesis model (Forrester 1969). Forrester's model describes the growth of a small town that, over a period of 250 years evolves to a major metropolis (see also figure 2.7). The time span for the thesis is only 25 years.
- Finally, the geographical scale of Forrester's model is that of one urban area, a small town, which grows to be a large metropolis over a period of 250 years. The geographical scale that is required for the thesis model is that of several smaller municipalities and the using data from COROP regions.

Does this then mean that all the theoretical concepts of the UD model will have to be abandoned? No, some key concepts of the urban dynamics model can be used in the concept model. For instance the concept that disposable income can be deducted from the quality (in this case price) of a house. This concept is used in the simulation model to estimate the disposable income of the new inhabitants of the project region. Also the concepts of attractiveness of a region remain important for the construction of the model.

As mentioned before, causal feedback loops are one of the major properties of system dynamics. The concept model presented in figure 3.3 does however not show any causal feedback loops. The question then comes to mind if the concept model is a true system dynamic model? All the other conditions surrounding the problem and the development of the model are evidence of and approve of the use of system dynamics. The model's properties (time dependent, dynamic and non-linear) all justify the use of system dynamics. Why the feedback loops are not present in the concept model can be explained by the exogenous data itself. The exogenous data "breaks up" the feedback loops in the system. More attention is given to this subject in section 5.1.

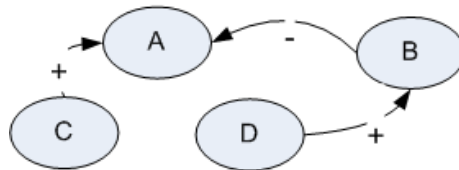
3.2 Cause-and-effect relationships as basis for the concept model

The causal relationships in the concept model form the basis for the design of the simulation model. Figure 3.3 depicts this basic causal model. The "Housing impulse" and "Leisure impulse" are the steering variables where that determine the policy plan. The impulse variables will influence the entire system over time as each variable is connected to the economic system in the simulation model. The remainder of this section provides an overview of all the individual relations. The numbers on the relationships lines correspond to the descriptions that are summed up in the remainder of this section. The numbers inside the ellipse shaped variables in figure 3.3 indicate the source of data that is used as input for that particular variable. De numbers correspond respectively to:

- 1) PRIMOS model data
- 2) Data from the Social and Cultural Planning Office of the Netherlands (SCP)
- 3) Base data for shift-share analysis stems from Statistics Netherlands (CBS)
- 4) Different sources (Locatus, Detail Handel Jaarboek, Koopstroomonderzoek)

Reading a causal model

A causal model describes the relations between multiple variables. The variables that are connected by an arrowed line have a cause and effect relationship. If the level of the sender of the arrow increases there will be a positive or negative effect in the level of the variable at the receiving end. For instance if the disposable income of a households increases, their spending in their city of residence will increase because they can afford more luxuries. To read a causal model start at variable of interest "A" and see by which variables "A" is influenced or which variables it influences. If for instance an increase in "B" decreases "A" a negative relationship is established. Then it is possible to see to what variables "B" is connected etcetera.



Textbox 1, reading a causal model

(1) Final GO → Housing impulse

Before the actual development of the investment project can start a series of political, procedural and sales activities have to be undertaken. These activities can cause project delays. The effect of a delay is translated in a prolonged period of autonomous economic development, a delay in the inflow of new inhabitants and hence a delay in the economic effects in the region. To illustrate the effects of such a delay the “final GO” is included in the causal model, indicating the final starting date of the investment impulse.

- A political delay can be caused by disagreement about the project on multiple political levels or between political levels (municipal, provincial and national level).
- Procedural delay can occur when the required documents are not in order and the project cannot be started. For instance a missing development license or zoning plan mismatch.
- A delay can also be caused by a lack of interested buyers of the new dwellings. Usually when about 70% is sold, construction starts for a part of the project.

The WRM case study is already affected by a delay. Due to a political delays caused by uncertainty of the project goals, the Wieringerrandmeer currently suffers a delay of about a year (initial starting date half 2006 (WRM 2004)). Further delays might lead to an increasing sector breakdown of the region and a continued outflow of younger people (DHV 2005).

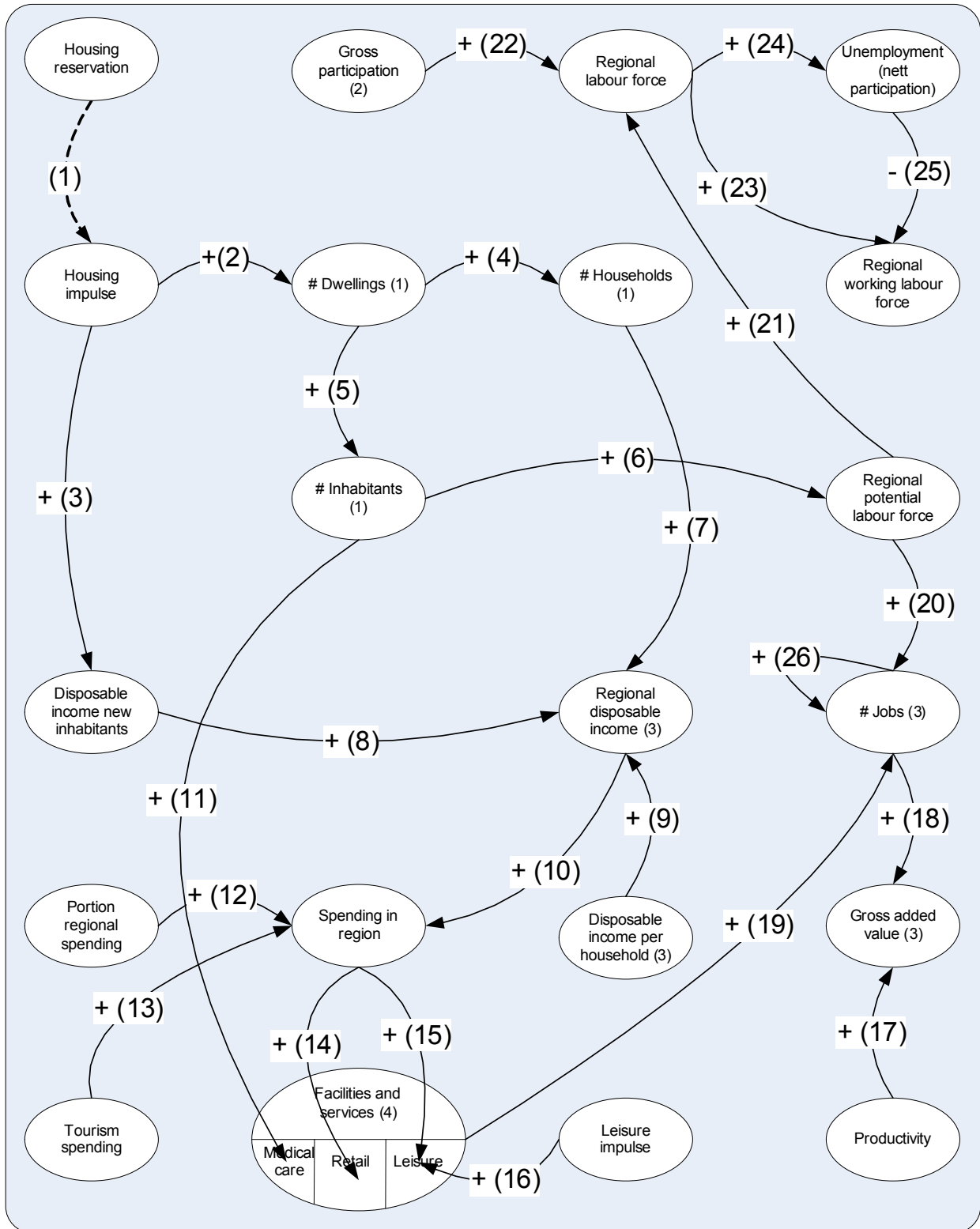


Figure 3.3, concept causal model

(2) *Housing impulse* \rightarrow *Dwellings*

The housing impulse starts the construction of the dwellings in the region. Through a delay that compensates for the building time the number of dwellings increases directly the number of dwellings in the project region.

The WRM project consists of four building phases, each of these phases delivers a set of dwellings with a grand total of 1845 dwellings (Lago Wirense 2004):

Phase 1: 150 dwellings over a period of 5 years

Phase 2: 355 dwellings over a period of 6 years

Phase 3: 760 dwellings over a period of 5 years

Phase 4: 580 dwellings over a period of 9 years

(3) Housing impulse → Disposable income new inhabitants

An attribute of the housing impulse is the average price of the new dwellings in the project region. The disposable income of the new inhabitants of the project dwellings will be proportional to the average house price of the project. This is based on the assumption that people spend on average the same percentage of their disposable income on the costs of housing. Using the average housing price, the mortgage and “woonquote²⁶” the disposable income of the new inhabitants can be estimated. In general this means that if the prices of dwellings are higher the disposable income of the inhabitants is higher. (CBS StatLine: woonuitgaven 1990 - 2000)

The situation in the WRM region is such that the newly build project dwellings have a higher value than the existing dwellings currently present in the region. This means that the new inhabitants have a higher disposable income, hence more spending in the region, which in turns results in an improved regional economy.

(4) Dwellings → Households

There is a one on one relationship between the number of dwellings and the number of households because a new household occupies each new dwelling. The households are divided into four basic household settings (CBS compliant):

- Single parents
- Living together with kids
- Living together no kids
- Living alone

This distribution of the types of households of the new inhabitants can be determined in two ways. Either beforehand, during the input of new data into the simulation model or the new household distribution is similar to the current household distribution.

A strong increase in the number of single households can be observed in the Netherlands. The WRM project region is subject to an increased effect of single household increase due to the over performance of aging in the region compared to the Netherlands. The WRM housing project is partly aimed at reducing the level of single households and lowering the aging rate.

(5) Dwellings → Inhabitants

The development of inhabitants in the project area is controlled by two variables. The first variable is controlled by the PRIMOS forecasts and provides a null-scenario, hence the autonomous growth of inhabitants in the region (Heida 2002). The second variable controls the inhabitants of the newly

²⁶ Woonquote: the total costs of housing (including municipal charges and public utility expenses) expressed as percentage of the disposable income.

built project dwellings. By multiplying the average household size of the new households with the number of households the amount of new inhabitants is calculated. The inhabitants grow according to an age distribution in four age groups (PRIMOS compliant):

- 0 – 14 years old
- 15 – 29 years old
- Lago Wirense (2004). 30 – 64 years old
- 65 and older

Just like the distribution of household types the distribution of age of new inhabitants will either be appointed during the input of new data into the simulation model or be similar to the current age distribution.

The current predictions for the WRM forecast a fast growing elderly population (faster than national) and a reduction of births and therefore young people. In general the population will shrink in the WRM area. In the end this causes the foundation for services and facilities to diminished and gradually dissolve. The WRM project aims at reducing the rate of aging and shrinking of population in the project region.

(6) Inhabitants → Regional potential labour force

A selection of the inhabitants based on age belongs to the potential labour force. Using the distributions from the age groups the inhabitants between 15 and 65 years of age make up the regional potential labour force (CBS compliant).

The effect of the increasing aging population in the WRM region leads to a decrease in the people in the regional potential labour force. A reduction of the potential labour force will lead to a reduced growth of jobs in the region.

(7)(9) Households and disposable income per household (of current inhabitants) → Regional disposable income

In order to obtain the value of the regional disposable income the number of households in the region is multiplied with the disposable income per household. The regional disposable income controls part of the spending in the project region, which in turn influences the facilities and services. The data from the disposable income per household is derived from the CBS StatLine website.

The current level of disposable income per year is € 30.500 per household, which lies above the national average (CBS StatLine)! However the total disposable income in the WRM region is currently at a sustainable level but diminishes significantly the coming 20 years (DHV 2005).

(8) Disposable income per new household → Regional disposable income

The disposable income of the new residents in the project region is calculated separately from the disposable income of the existing residents (relation 9). If the dwellings of the WRM project are more expensive compared to the existing dwellings, the disposable income of the new inhabitants will also be higher (see also relation 3). This effect is explained in more detail in section 3.3.3.

Currently only estimations can be made on the price of the new dwellings in the WRM project. The latest estimation is an average price of €300.000 per dwelling (meeting with Arjan Stegeman 11-05-2006) which leads to an disposable income of €48.000 per household (with "woonquote": 25% and interest rate: 4%. However a more detailed market study should be performed in order to get a more precise indicator of the average dwelling price.

(10)(12) Portion regional spending & Regional disposable income → Spending in Region

Households do not spend all their disposable income in their home region or municipality. For instance, when an inhabitant of a rural town needs to purchase non-daily products (furniture, electronic appliances etcetera) he or she has to go to a larger, more urban city to find a furniture or electronics store (Koopstroomonderzoek Randstad 2004). This means that if an area is more rural, a smaller portion of the disposable income is spent in the region. The opposite holds for inhabitants of large urban regions. They do not have to go to other regions for non-daily purchases, simply because the supply of non-daily products in their home region is sufficient. To correct this effect in the concept model the portion of regional spending is a percentage of disposable income spent in the home region. Because the rate of regional binding is different for different types of products three sources of spending are identified in the simulation model (Koopstroomonderzoek Randstad 2004):

- Daily spending: Grocery stores, small clothing stores.
- Non-daily spending: Electronic-, Hardware-, Furniture-, specialized clothing stores
- Leisure spending: Daytrips, spending in bars, restaurants

The WRM region can be classified as rural and therefore has a relative small regional binding factor. For the daily spending 85% is spent in the region, for non-daily this is 40% and for leisure 30%. By increasing the amount of inhabitants and amenities in the region the binding factor will increase as inhabitants do not have to go to other regions for their groceries and other purchases.

(11)(19) Inhabitants → healthcare → Jobs

A direct effect from the increase in residents is the additional need for healthcare services and facilities and hence healthcare jobs. This makes the healthcare services a non-basic sector, controlled directly by the healthcare demand from the inhabitants (Armstrong 1993). This non-basic effect is not calculated through the shift-share analysis. In stead, the average employment in healthcare services per inhabitant is multiplied with the number of new inhabitants and added to the present level of jobs in healthcare (A more detailed description in section 3.3.1).

The public administration of the WRM region fears that the combination of an aging population and the decrease of younger people in the region will further reduce the foundation for professional healthcare services. They argue that this will lead to a further decrease of population in the region (from meeting with Lago Wirense Project Management Team in October 2005).

(13) *Tourism spending → Spending in region*

An increased impulse of tourism will lead to higher tourist spending in the region. Tourist spending is allocated in two sectors: the hotel and restaurant sector (sub sector of commercial services) and the trade sector. An increase of tourist spending must be preceded by an investment in tourist facilities (hotel, restaurant, boat rental etcetera).

An important aspect of the WRM project is increasing the tourist attractiveness of the region. The new lake is supposed to attract different water sport activities like sailing, fishing and beach tourism. The environment around the lake will be equipped with cycling- and footpaths to attract nature tourism. The supply of hotel and camping facilities will also be expanded (Lago Wirense 2004). Currently the income from tourism is less than 1% (DHV 2005).

(14) *Spending in region → Facilities and services / Retail*

When the spending in the region increases as a cause of more regional disposable income, higher regional binding or higher tourist spending the foundation for retail and leisure facilities also increases. The Dutch board for retail trade (Hoofdbedrijfschap detailhandel) and Locatus²⁷ provide data for the effects of higher spending in the region on the level of services. When commercial and non-commercial services in the region increase the jobs in those sectors will also increase (relation 19).

The supply of a (large) range of retail facilities is important for the attractiveness of the WRM region, both for inhabitants as for tourists (VNG 2006). The WRM project strives to increase the spending in the region by increasing the level of retail facilities. Attracting more inhabitants through the housing project and more tourists by developing new facilities around the lake.

(15) *Spending in the region → Facilities and services / Leisure*

(16) *Leisure impulse → Leisure*

Like relation 14, more spending in the region increases the level of services and facilities of for leisure. Extra disposable income in the region as a result of new inhabitants has a direct effect on the available space for leisure facilities. The Dutch board for retail trade (HBD) and Locatus provide data for the effects of extra inhabitants on both the level of leisure activities in a region as the added effect for the employment in the region. When the investment project is executed new leisure will be developed which is expressed in square meter of working accommodation.

Currently tourism and leisure facilities in the WRM region are almost negligible, therefore spending by both tourists and local inhabitants is very limited. The WRM project causes a leisure impulse that is supposed to kick-start the leisure facilities in the project region.

(17)(18) *Jobs and Productivity → Gross regional product*

Productivity indicates the sector specific added value per employee in a region (data from CBS StatLine). When the productivity is multiplied with the current jobs in the region the gross regional product can be derived. The gross regional product or regional income is an important indicator for the economic health of a region. When the regional product diminishes the indicator is often a decreasing amount of jobs or an increase of jobs with a lower added value (lower productivity) (Armstrong 1993). Note that the jobs in the region do not necessary have to be

²⁷ Locatus: company supplying retail trade, services and hotel and catering industry information

fulfilled by the inhabitants of the region this separates the spending income of the region from the gross added value.

The gross added value of the WRM region has the potential to increase with 20% if the project is executed. The WRM region does cope with a relative low productivity compared to the Dutch average. This is mainly due to the high portion of jobs in the primary sector where added value per job is lower compared to other sectors (DHV 2005).

(19) *Facilities and services / Leisure and Retail → Jobs*

The level of services and facilities of leisure and retail is calculated in square meters of working accommodation per sector (square meter floor space). The HDB specifies ratios of employees per square meter for the leisure and retail industry (HDB 2005). Using these ratios and floor space area's the employees in these sectors can be calculated. Spending in the region will lead to an increase in square meter floor space, which in turn will lead to an increase in jobs through the employee per square meter ratio.

The WRM currently has a small range of leisure facilities, most of them being bars and small hotels (SCBA Lago Wirense 2006). These facilities make up less than 2 % of the total jobs in the region. Under the WRM project the jobs in these sectors can increase more than 5 % (DHV 2005).

(20) *Potential labour force → Jobs*

The relation between potential labour force and the jobs in a region has been disputed over time. There are two theories that support both directions of the causality between potential labour force and jobs (see also section 2.3.3). The paradigm is that either people-follow-jobs or jobs-follow-people.

- *Jobs → Potential labour force*: this directionality can be theoretically funded by assumptions that migrants come into a region when wages in that region are higher compared to adjacent regions. The economic agglomerations effects will (in this line of thought) drive up wage levels as employment becomes scarcer. The higher wages in the region will attract people to the region that eventually will settle in the region. Hence, people follow jobs.
- *Potential labour force → Jobs*: supporters of jobs follow people make the point that people do not move to other areas for higher wages but for more and better amenities. The amenities are in that case the most important factor in population growth. The people that move to high amenity locations demand consumer goods and supply labour. In turn the people that move to a region supply labour that attracts firms, hence, jobs follow people (Vermeulen & van Ommeren 2005, pp. 3). In the thesis model the latter relation is used: jobs-follow-people because it is more accepted than people follow jobs. Vermeulen and van Ommeren (2005) proof in their paper that jobs follow people.

The growth of jobs in the WRM region is currently based on the historic performance of the production sectors in the region. However over time, using the jobs-follow-people principle, the job development will partly be determined by the availability of labour.

(21..25) Inhabitants and labour force

Some of the relationships in the concept model are standardized and come directly from other models. Figure 3.4 shows the deduction of the working labour force from the total inhabitants of a region. Only a part of the inhabitants belongs to the potential labour force, these people are of working age (15 to 65 years old) this classification is also used by Statistics Netherlands. Because not every person in the potential labour force is working the gross participation²⁸ indicates which percentage of the potential labour force is actually working or looking for work. The former and the latter combined make up the labour force, the inhabitants of a region that have a job are grouped in the bottom category of figure 3.4; the working labour force. These indicators together illustrate the amount of inhabitants that are currently working, unemployed or not of working age. The indicators do not however give information about the jobs that are available in the region. The inhabitants that are part of the working labour force could work outside of the region and not contribute to regional employment.

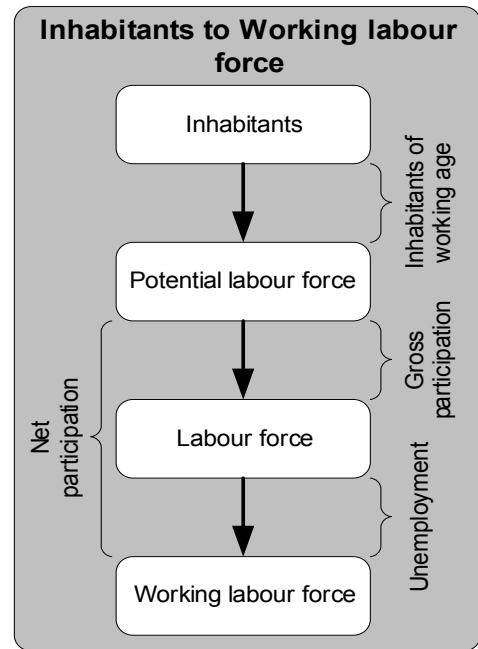


Figure 3.4, labour force

The current age distribution in the region is fairly equal to the national average with a slightly older population. This results in a potential labour force that comprises of 67% of the total population. The forecasts show a decrease of potential labour force compared to the national average, which indicates economic decline over a longer period (DHV 2005).

3.3 Translation of the concept- into the simulation model

Section 3.3 describes the translation of the concept model into the quantified simulation model. This translation is actually a sophistication of the concept model. The relations presented in section 3.2 are often not as simply implemented as presented in the concept model. This section therefore elaborates on the relations as they have been implemented in the simulation model. Section 3.3 describes the specific implementation of the concept model in the software programs PowerSim and Microsoft Excel. The simulation model is presented in set of 11 sub-models in figure 3.5. The sub models fall into three categories and will be discussed accordingly.

1. Labour market developments in the basic and non-basic industry sectors
2. Regional spending and disposable income
3. Inhabitants and available labour force developments

The tripartite division of the model will also be used in the discussion of the model assumptions in section 3.4 and in the sensitivity analysis in section 4.2.

²⁸ Participation level data available through the Social and Cultural Planning Office of the Netherlands (SCP). Historical data available on a COROP level, predicted values available only on national level.

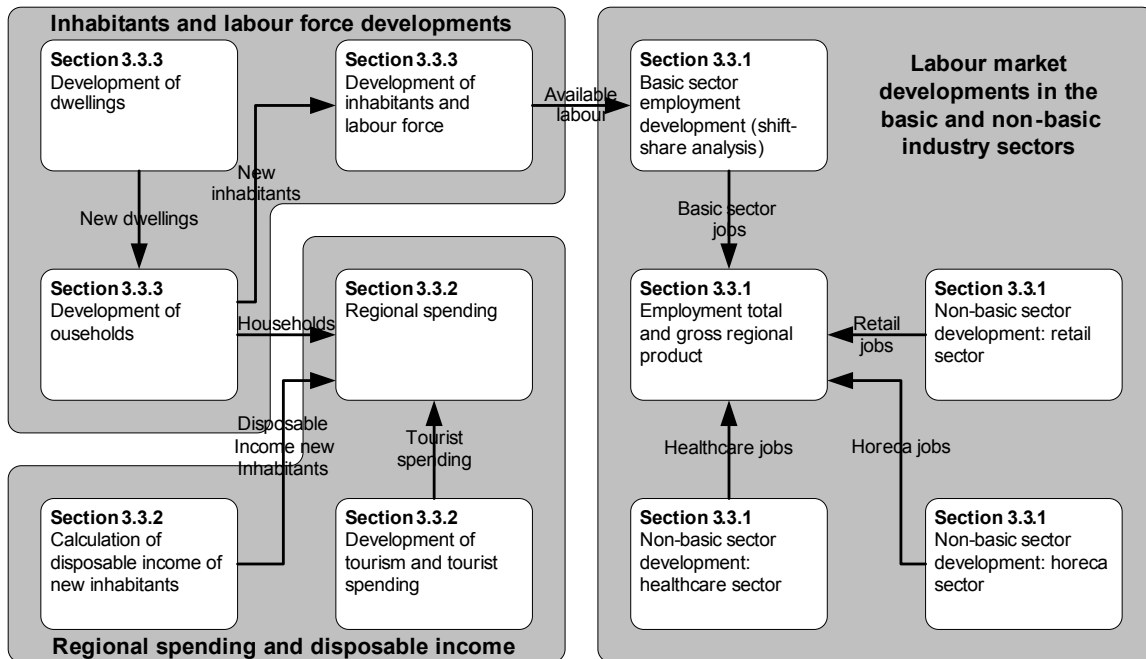


Figure 3.5, components of the simulation model

The sub models are described and discussed in more detail in the rest of this section. Special attention is given to relations that are not worked out in detail in the concept model of figure 3.3.

Section 3.3.1: Labour market developments in the basic and non-basic industry sectors

- Figure 3.6: shift share analysis in PowerSim. This is the calculation of the job development in the basic sectors in the project region.
- Figure 3.8: the healthcare sector developments of a non-basic sector and the influence on the job development in the project region
- Figure 3.9: the retail sector developments (non-basic sector) and the influence on the job development in the project region

Section 3.3.2: Regional spending and disposable income

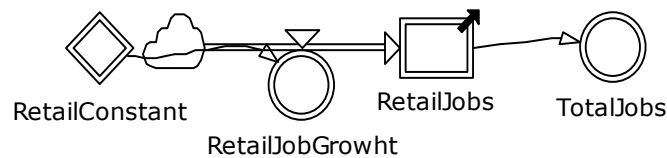
- Figure 3.10: the summarized spending in the region (daily, non-daily, leisure and tourism sector).
- Figure 3.11: detailed description of the tourist spending in the project region
- Figure 3.12: the deduction of disposable income of inhabitants of the project dwellings

Section 3.3.3: Inhabitants and available labour force developments

- Figure 3.13: the inhabitants and labour force in PowerSim

Reading a PowerSim diagram

PowerSim is a system dynamics modelling program. It allows the user to implement simple and complex causal relations in a relatively simple fashion. There are four basic building blocks used in PowerSim (called the Stella notation). Each of the blocks will be described shortly to help understand PowerSim diagrams. The diamond shape on the left in the figure below indicates a static model variable or constant. These are used to input data that does not change over time. In this case the “RetailConstant” is linked to “RetailJobGrowth” which controls the increase or decrease of retail jobs (this is called a rate). The large arrow passing “RetailJobsGrowth” indicates that it is controlling the in and outflow of the stock of “RetailJobs”. This stock variable indicates the total amount of jobs currently active in the retail sector. The stock value of “RetailJobs” is linked by again a small arrow to “TotalJobs” which indicates the total amount of jobs currently taken. The last block is called an auxiliary variable and it is used to calculate values that change over time.



Text, reading a powersim diagram

3.3.1 The labour market development in basic and non-basic industry sectors

The development of jobs in a region is different for basic and non-basic sectors. Furthermore, the entire labour market is too complex for a simple one on one relationship that increases jobs along the increase of inhabitants in the region. Jobs in the non-basic sectors do develop as a direct consequence of and in- or decrease of the population. While the basic sectors developed lagged over time and are more dependent of the economic developments (Armstrong 1993) and the availability of labour. These effects have to be incorporated in the simulation model. After long discussion the shift-share analysis was chosen as basic modelling tool for the development of jobs in the basic sectors (see also appendix 7). Shift-share analysis is chosen because it is relatively easy to use and understand. This appeals to the requirements that the simulation model must be easy to understand and reduce complexity as much as possible. Furthermore a fairly little amount of data needed to make the shift-share calculation. The decisive factor to use shift-share analysis comes from Koops (2005) who demonstrates with the REGINA model that it is possible to use multiple variables to explain the development of jobs in a region. With this functionality it is possible to include the effect of jobs-follow-people from Vermeulen & van Ommeren (2005, 2006). Shift-share analysis extrapolates growth in production sectors through a shift and a share part (Koops 2005, Armstrong 1993). The share part consists of the national growth indicators predicted by the CPB. The shift part consists of multiple variables with historical performance and available labour force as most important indicators. For the shift-share analysis the regional performance is matched to the predicted national performance. If the shift indicators outperform the national indicators the region will develop proportionately faster than the nation. For the non-basic sectors another solution has been tailored to accommodate a more direct link with the growth of the population. These relationships are illustrated in figure 3.8 and 3.9 and will be dealt with later.

Basic sector employment development

Figure 3.6 illustrates the implementation of the shift-share analysis in PowerSim. As mentioned there are three basic ingredients (1 to 3) for calculating the shift share factor (4):

- 1) The first ingredient is the standardized shift factor that illustrates the performance of the region with respect to the available labour force according to the jobs-follow-people principle (Vermeulen & van Ommeren 2005, 2006). This part of the shift factor is calculated by comparing the national ratio inhabitants per jobs to the regional ratio of inhabitants per job. The two ratios translate either into a positive factor (over performance, the project region has a relatively large supply of available labour and is therefore more attractive) or negative factor (under performance, the project region has a relatively small supply of available labour). This variable (“shift factor labour force”) then has to be standardized to become usable in the simulation model. If the variable would not be standardized interpretation errors can occur in the extrapolation of the historic data (Nijkamp & Reggiani 1998). Major, one time events in the past may have had a large effect on the historic growth. Extrapolating this growth without indication of such an event happening again would be unjust and therefore growth (and decline) bounds should prevent excessive growth. The standardization occurs by assigning a maximal and minimal value of the shift factor and normalizing the old value to prevent erratic data output when approaching zero. The maximal and minimal values that are set to the over and under performance are respectively plus and minus one time the standard deviation of the national job growth in the Netherlands (CBS 2005).
- 2) The historic performance of the region is deducted from CBS data from time period 1993–2004. The historic performance is measured, just as labour factor above (1), relative to the national performance. The 1993-2004 period is chosen because in 1993 the production sectors were regrouped into the current sector division and the most recent data is from 2004²⁹.

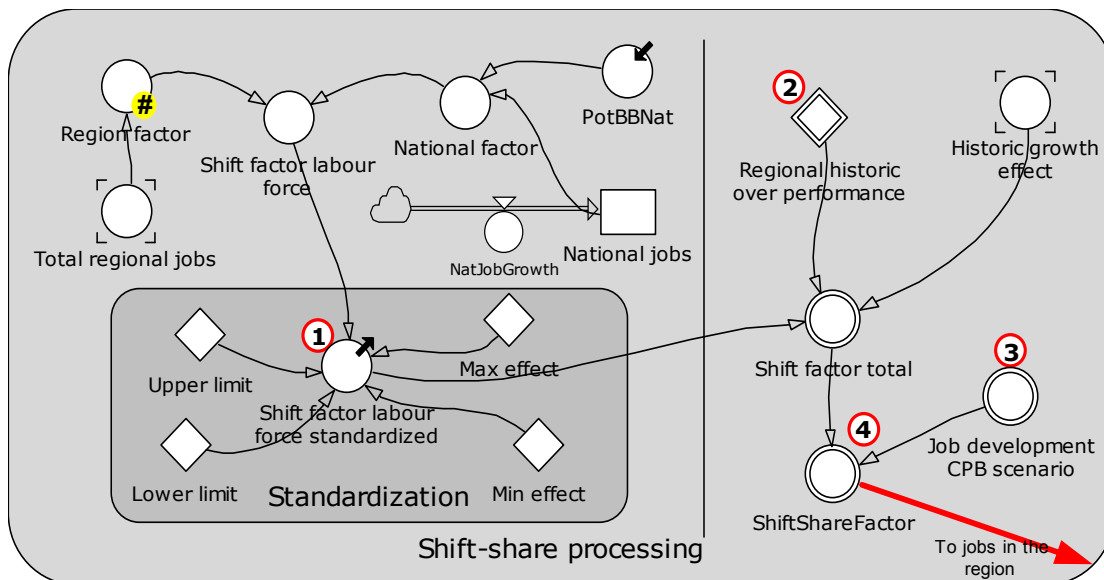


Figure 3.6, *shift-share processing in PowerSim*

²⁹ 2005 data will become available later in 2006 (CBS StatLine website)

- 3) The CPB predicts job growth per sector for the Dutch economy in two stages (Huizinga & Smid 2004). The first stage 2005-2020 and the second stage 2020-2040 together comprise the CPB scenario development. Because not all 18 sectors of the CPB scenarios have been incorporated into the model the growth predictions have been tailored to fit the simulation model.
- 4) The final shift-share factor is a combination of the variables 1, 2 and 3. The shift-share factor is the growth percentage per industry sector per year that can now be used for the calculation of jobs in the region. The red arrow in figure 3.6 indicates that the growth indicators are used for the development of jobs in the basic sector in the project region. The shift-share factor is multiplied with the current level of jobs, hereby ensuring fault-free inflow (or outflow) of jobs.

The values of factors 1 to 4 from figure 3.6 are visible in the graph in figure 3.7. What immediately becomes clear is the non-continuous step in 2020 (3), which is caused by the change in the (CPB) predicted economic growth from 2020 to 2040³⁰. This of course has an enormous discontinuous effect on the shift-share factor (4).

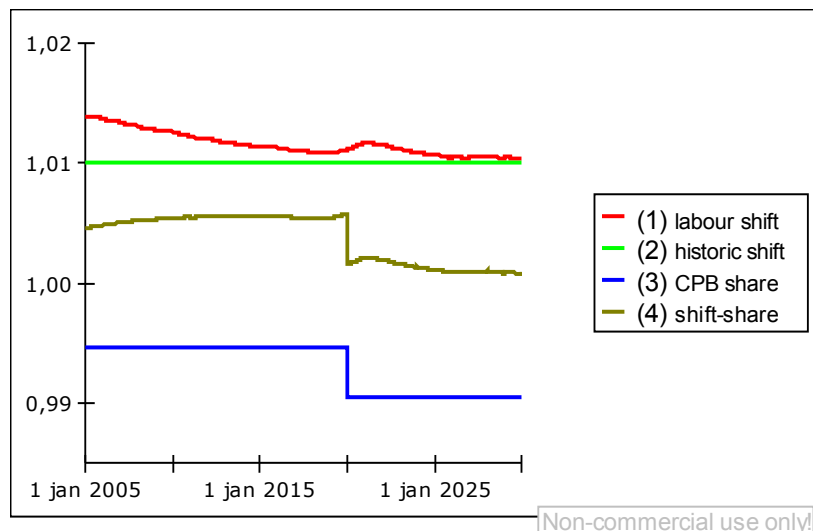


Figure 3.7, time graph of development of the shift and share factors

Non-basic sector development: healthcare sector

The shift share analysis is only able to calculate the developments in the basic sectors (agriculture, industry, construction industry, trade (partly), transport and communication, commercial services and non-commercial services). The non-basic sectors (healthcare and retail) increase not as part of historic performance or available labour force. These sectors increase gradually as the population in a region develops. In the simulation model jobs in the healthcare sector increase as a consequence of three factors (see figure 3.8):

1. The direct effect between the population and healthcare jobs comes into expression when the ratio of “healthcare jobs per inhabitant” is multiplied with the “inhabitants growth”. This direct effect of a non-basic sector contributes for a large part to the extra healthcare jobs in the region.
2. In the same way as the CPB scenarios have influence on the jobs in the basic production sectors the scenario predictions influence the jobs in healthcare. The primary reason for including the

³⁰ Calculation in figure 3.6 is made with the Regional Communities scenario (Huizinga en Smid 2004)

CPB scenarios is that they consider the effect the aging population has on the demand for healthcare jobs (Huizinga en Smid 2004). These jobs will grow more than the economy's average because the population keeps becoming older hence requiring more medical attention³¹

3. Because the Socio-economic Effect Study (DHV 2005) illustrated that the population ages faster in the WRM region compared to the Dutch average a "Grey pressure performance" variable has been included. This variable corrects the healthcare jobs if the percentage persons older than 65 years old exceed that of the Dutch average. The percentage it exceeds will be included in the healthcare job development.

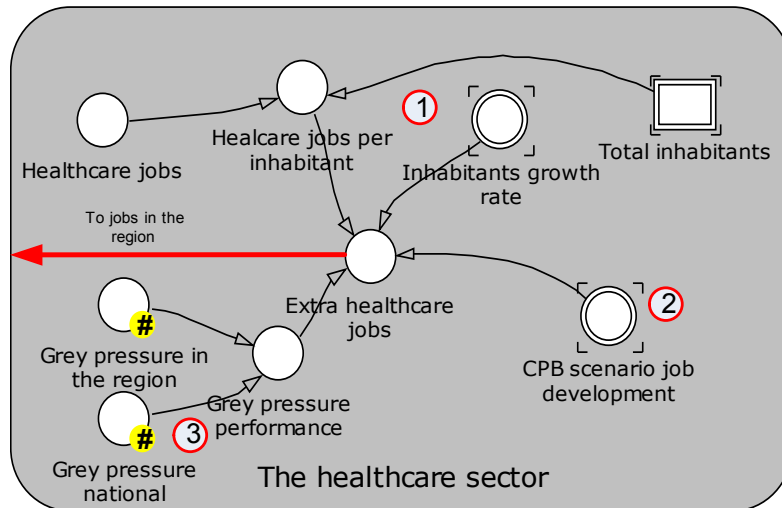


Figure 3.8, *healthcare sector development in PowerSim*

The red arrow in figure 3.8 connects the extra jobs in healthcare to the total job development in the project region.

Non-basic sector development: retail sector

Another sector that develops in line with population growth is the retail sector. The retail sector is not explicitly incorporated as an industry sector in the simulation model but is part of the trade sector. Later versions of the simulation model will perhaps use a more detailed distribution of the production sectors. Then the retail and hotel and catering industry can be included as separate sectors. As mentioned the regional spending in the retail sector is divided in daily and non-daily retail facilities (VNG 2005). The volume of the daily and non-daily sectors is specified in square meters of floor space (Source data from HDB 2004). To calculate the jobs in the sector the floor space is multiplied with the average amount of employees per square meter floor space (Locatus 2004) (see figure 3.9). The WRM project includes an impulse of retail sector. The effects of this impulse are translated in square meters and added to the total amount of floor space with the variable "Retail impulse". The red arrow in figure 3.9 connects to the total job development in the project region.

³¹ For a detailed description of the healthcare sector see the Ministry of Health website on industry reports: http://www.brancherapporten.minvws.nl/object_document/o273n392.html. The reports illustrate that someone over 65 requires triple the amount of medical care then someone

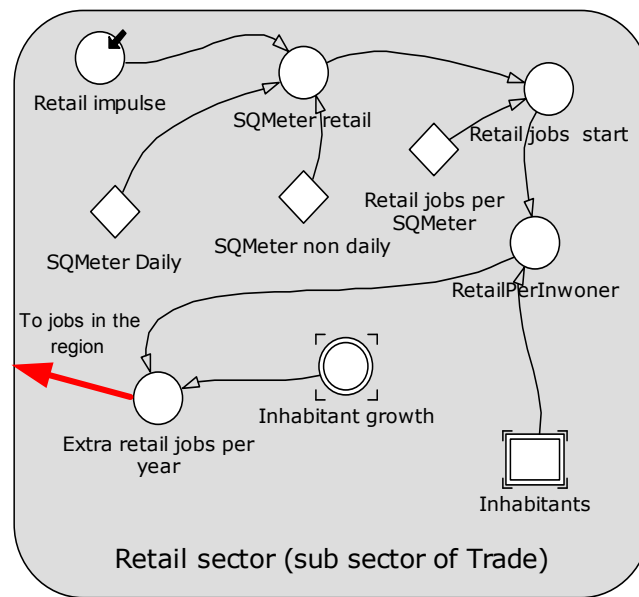


Figure 3.9, the retail sector in PowerSim

The development of the leisure jobs in the hotel and catering industry (horeca) is calculated in similar fashion as the retail sector. The square meters of horeca are multiplied with the average jobs per square meter, and the effects of the investment impulse are added to the floor space. Data on the volume of the hotel and catering industry from the HDB (2004) and the VNG (2005) report are used. Similar like the retail sector, the hotel and catering industry is not recognized as an individual sector. Therefore the job development in this sector is discounted in the commercial services sector.

3.3.2 Regional spending and disposable income

Regional spending

The source of spending in the project region basically comes from inhabitants and tourists. These spending sources might change over time as a result of the WRM project, as the tourism development will attract more tourists that in turn spent more money in the region. The spending in the region is also influenced by the disposable income of current and new inhabitants. In total there are five variables controlling the regional spending (see figure 3.10):

1. Spending in the daily sector by inhabitants:
2. Spending in the non-daily sector by inhabitants
3. Spending in the horeca by inhabitants
4. Spending by tourists
5. The new inhabitant spending factor

For the calculation of the regional spending of the inhabitants (1, 2 and 3) the regional daily, non-daily and horeca spending is multiplied with a “regional binding factor” (see figure 3.10). This regional binding factor corrects for the amenities available in a municipality (KSO 2004). The regional binding factor indicates the percentage that resident households spend in the daily, non-daily and horeca sector *in* the project region. Large cities (urban centres) provide sufficient amenities with respect to stores, shopping malls and large supermarkets. Hence an inhabitant of a

highly urban area spends most of his or her income in the region itself, while a rural inhabitant is forced to shop outside its residential region. The data from a regional spending research (Koopstroomonderzoek 2004) is used to determine the percentages. The WRM project also aims at attracting more tourists to the region. The tourist spending is included by adding it to the total regional spending of the inhabitants (4). Figure 3.11 in the section below will give a more elaborate explanation how the tourist spending comes about. Finally a correction is made based on the expected higher disposable incomes of the inhabitants of the new project dwellings (5). These higher disposable incomes of the new inhabitants lead to higher spending in the region (HBD bestedingen en marktaandeelen 2005). The increased level of disposable income of the new households is indicated by the variable “new inhabitant factor”. This variable added to the spending in the different spending sources. The higher disposable income cannot be translated one on one to more spending in the region. The variables “Elast daily”, “Elast non-daily” and “Elast horeca” control for the elasticity that belongs to these patterns of spending (RIZA 2004)

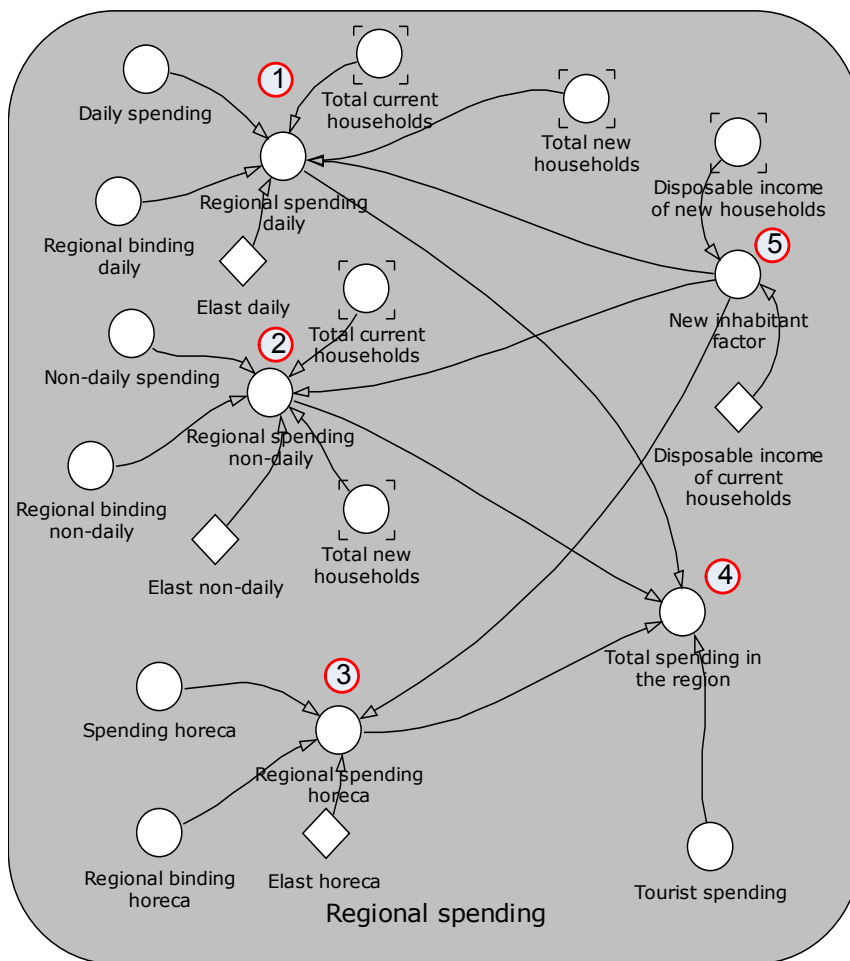


Figure 3.10, regional spending in PowerSim

Development of tourism and tourist spending

Figure 3.11 illustrates how the “Tourist spending” in figure 3.10 is calculated. Basically the simulation model recognizes two categories of tourists that each contributes to the tourist spending. The development over time of the extra tourist attractions is also included in the model through the variable “tourism development time”. Proportionately to the completion of the development of tourist amenities tourists will visit the WRM region. If the tourism facilities are

only 50% finished only 50% of the tourist potential will come to the region. The two tourist types are:

1. The “day tourists” who visit the region for only one day (data from CVO 2004). The number of day tourists depends on the amenities in the region. This can be the quality of the nature, swimming water, sailing docks, a beauty centre, hotels and restaurants or a museum. The CVO measures the spending patterns of tourists and based on this information a daily sum of money can be attributed to each tourist. Hence multiplying the daily spending and the amount of tourists gives “total spending of day tourists”.
2. The holiday tourists who visit the region for multiple day’s using accommodation in the region. Just as the day tourists what holiday tourists spend on average is multiplied with the total number of holiday tourists. The amount of tourists in the region also depends on the “ambition level” and the progress of the project. The ambition level gives the model user control over the flow of tourists into the region. Standard the ambition level is set to receive half a percentage of the total tourism in the three adjacent tourist regions Waddenzee, IJsselmeer and Noordzee badplaatsen (Alterra 2005).

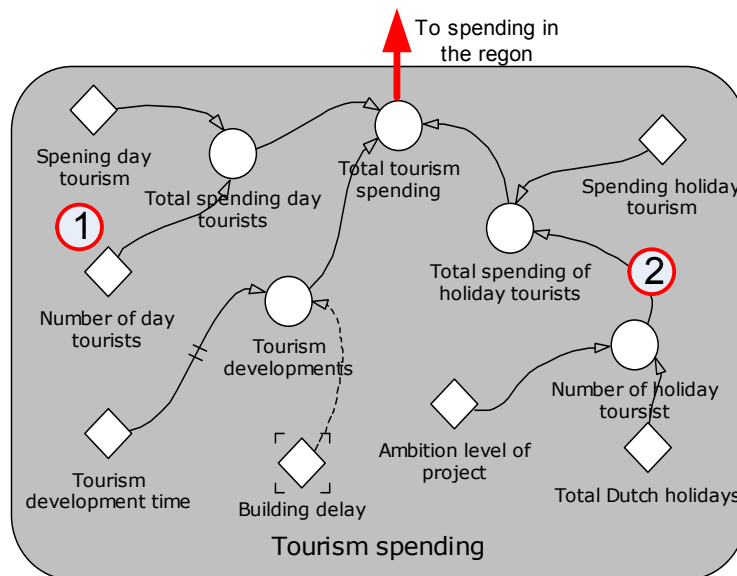


Figure 3.11, *tourism spending in PowerSim*

Calculation of disposable income of new inhabitants

On order to get an estimate for the disposable income of the new inhabitants the average price of the new dwellings in the project region is coupled to the disposable income (see figure 3.12). By calculating the costs of owning a house (“average housing costs”) from the “average project house costs” and the “interest” level a measure is given for the disposable income. The average housing cost is finally divided through the average percentage people spend on their house compared to their disposable income, the “Habitat quote” (Woonquote, CBS).

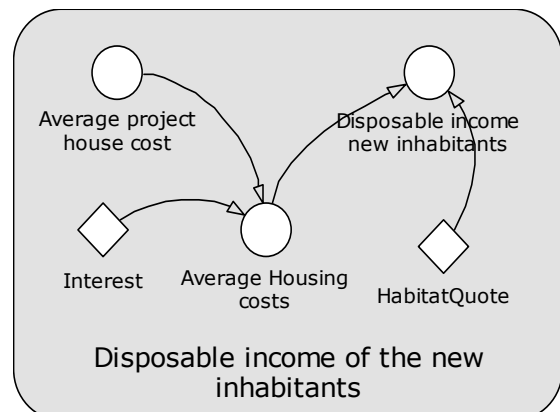


Figure 3.12, *disposable income of new inhabitants*

3.3.3 Inhabitant and available labour force developments

Development of inhabitants and labour force

The development of inhabitants in the simulation model is depicted in figure 3.13. Through the “Inhabitant rate” (1) the predicted population development by the PRIMOS model (Heida 2002) serves as input for the “inhabitants growth rate”. The variable “new inhabitants” indicates the new residents in the region that are caused by the Wieringerrandmeer project. The stock of inhabitants (“inhabitants in the region”) represents all the residents in the project area. The inhabitants are divided into four age groups (0-15, 15-30, 30-65, 65+). The PRIMOS model provides an age distribution that follows these four age groups. The “new inhabitants” automatically receive the age distribution that is present in the region at time of entrance. However it is also possible to manually adjust the age distribution with the “new inhabitants age distribution” variable. This gives the model user the opportunity to see the effects on the region if for instance only senior inhabitants are attracted to the WRM. The age groups are also used to deduct the “potential labour force” for the calculation of the labour force in the region (3). The latter variable is used to select only the age groups 15-30 and 30-65, which in the shift-share analysis functions as indicator of the supply of labour in the region (see figure 3.6). More information on how PowerSim copes with age and household distribution can be found in appendix 8

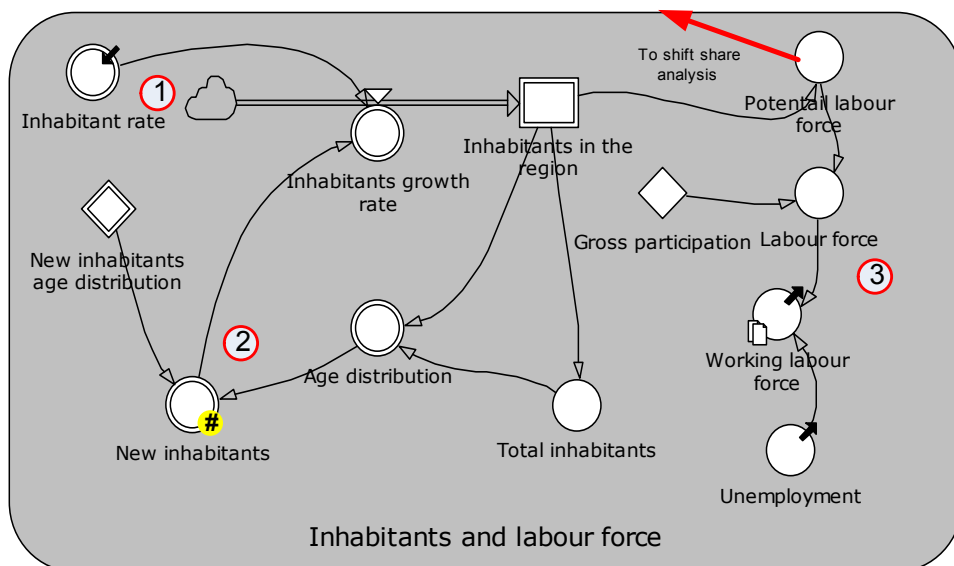


Figure 3.13, *inhabitants and labour force in PowerSim*

Just as the age distribution does the composition of the households also consists of four categories (single, single parent, living together no kids, living together with kids). And in similar fashion when nothing is done the model increases the households with the same distribution as currently present in the model. This method is also used for the development of the households in the region.

3.4 Assumptions made during the development of the simulation model

During the development of the concept model and the translation to the actual simulation model, several assumptions have been made in order to come to the instrument presented in section 3.3. Sections 3.4.1 to 3.4.3 describe for each model component what the most important assumptions are. The model components are divided in similar fashion as section 3.3 and elaborate on statements made in that section:

3.4.1 Labour markets in the basic and non-basic sectors

3.4.2 Regional spending and disposable income

3.4.3 Inhabitants, available labour force and housing developments

Each assumption that is discussed is also analyzed on its effects on the model outcomes with respect to sensitivity. A more elaborate sensitivity analysis is referred to in chapter 4 where the model is validated.

3.4.1 Assumptions: labour markets in the basic and non-basic industry sectors

Jobs-follow-people

Theoretical evidence can be found both for the hypothesis that people-follow-jobs as for jobs-follow-people (see section 2.3.3). In the thesis model the latter hypothesis is chosen for two reasons. First, empirical evidence can be found for jobs-follow-people and not for people-follow-jobs. Vermeulen, Verkade and Van Ommeren (2005, 2006) have shown this empirical proof in a series of publications based on historical data. Second in a recent publication Derks et al. (2006) mention that the Dutch population growth is gradually grinding to a halt. Already in the next decennium, less people will be available on the labour market. Derks predicts that from 2035 the Dutch population will shrink. This development makes labour an even more important and scarce production good and if firms want to maintain in business they have to settle where labour is still available. This means that if relatively a lot of people (potential labour force) live in an area compared to work a region, that region becomes more attractive for employers to locate. This leads to an – higher than – average increase in jobs. This effect is included in the shift-share analysis that is used for the calculation of jobs in the project region.

Decreasing importance of the historic over-performance in the shift-share analysis

The previous assumption that job-follow-people is incorporated in the model through the shift factor. This is similar to the way that Koops & Muskens (2005) describe the inclusion of different variables in the shift in the REGINA model. The shift-factor of the shift-share analysis depends both on the historic performance as on the jobs-follow-people theory. The historic performance however diminishes over the years while at the same time the availability of labour factor increases (see figure 3.14). The slope in the model is currently set to reach 0% historic performance value in 15 years according to a linear function. The model includes the possibility to change the linear function into an exponential and logarithmic function. It is also possible to adjust the 15 years historic performance influence. This assumption is not overly sensitive to changes in the decay time of 15 year.

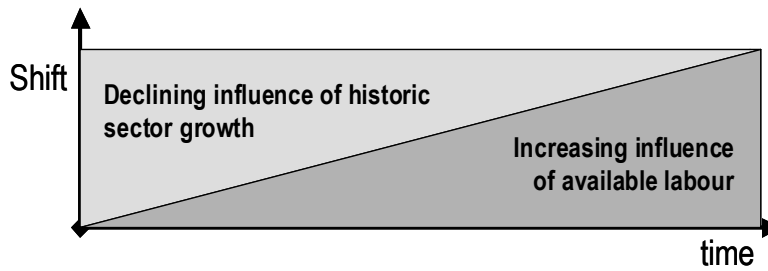


Figure 3.14, *adaptive shift factor for determining job development*

The maximum and minimum values of the available labour component of the shift factor

The regional performance factor in the shift-share analysis of available labour is calculated by comparing the national with the regional average available labour. The number that is obtained from this equation is dimensionless and has to be linked to a growth indicator (see also figure 3.6). To prevent one-time historic events from influencing the extrapolation of data to extreme values, the maximum value of the available labour component has been set on 1 time the standard deviation³² of the national job development (Nijkamp & Reggiani 1998). This prevents extreme, and irresponsible, growth in jobs in the region. The same is done for the minimum value. This assumption does not show irresponsive outcome bounds.

Lack of sector specification in working labour force in region

Ideally the “Working labour force in the region” is modelled the exact same way as the “Jobs of employees in the region”, however due to a lack of data this is not possible (CBS data not available). The data available for “Jobs of employees in the region” stems from the CPB scenarios and is used to calculate the gross region product through shift-share analysis (Huizinga & Smid 2004). The “Working labour force in the region” on the other hand is derived from the PRIMOS and does not include information that is specified on an industry sector level. Therefore the “Working labour force in the region” is given only in total sector working labour force output.

Older population requires more healthcare

Because the autonomous scenario of the Wieringerrandmeer shows a higher increase of “old” inhabitants compared to the Netherlands the jobs in healthcare in the region will rise faster. In order to correct this error a variable is included that attributes twice the amount of healthcare jobs when the population ages more than the national average. This is in accordance with a market study of the healthcare industry executed by the ministry of Health (Branche rapport zorg sector 2005). Sensitivity analysis showed that the amount of twice as much healthcare for population over 65 is not overly sensitive.

3.4.2 Assumptions: regional spending and disposable income

Production sector reduction

The Dutch production sectors are divided into 15 major groups, this is visible on the left side of figure 3.15. These 18 sectors are not all included in the simulation model for two reasons. First, including 18 sectors will make the model more complex, decreasing the usability. Second, not all the data for all the sectors are known. The data from sector C (mineral extraction) and E (e.g.

³² From discussion with Michiel Pellenburg

energy sector) for instance are often not publicly available and can therefore not be used³³. By subtracting data from other sectors, it is possible to combine sectors C, D and E into one industry sector. The effect of this assumption on the model is that a less detailed description can be given of the production sector in matter of financial performance and employment.

| | | |
|--------------------------------------|---|--|
| A Landbouw, jacht en bosbouw | → | Landbouw |
| B Visserij | | |
| C Delfstoffenwinning | | |
| D Industrie | → | Nijverheid (excl. bouw) |
| E Openbare voorzieningsbedrijven | | |
| F Bouwnijverheid | → | Bouwnijverheid |
| G Reparatie consumentenart; handel | → | Handel |
| I Vervoer, opslag en communicatie | → | Vervoer en communicatie |
| J Financiële instellingen | | Financiële instellingen |
| K Verhuur; zakelijke dienstverlening | → | Zakelijke dienstverlening |
| H Horeca | | |
| L Openbaar bestuur; soc verzekering | | |
| M Onderwijs | → | Overige niet-commerciele dienstverlening |
| O Cultuur, recreatie; ov dienstverl | | |
| N Gezondheids- en welzijnszorg | → | Gezondheids- en welzijnszorg |

Figure 3.15, *production sector reduction*

Disposable income of inhabitants of the project dwellings

The dwellings in the WRM project are expected to be far more expensive compared to the existing housing prices in the WRM region. Therefore it can be expected that the inhabitants of these new dwellings will have a higher disposable income compared to the existing inhabitants. The assumption that lies at the basis of this theory is that, on average, each household spends 25% of their disposable income to their housing costs³⁴ (Woonquote, CBS). Using this “habitat quote”, the house price and the mortgage interest rate the disposable income of new inhabitants can be calculated (RIZA 2005).

Elasticity in disposable income

A higher disposable income changes the amount of money that people spend in their region. To calculate the development in the increase of spending in the region the increase of disposable income has to be corrected for product elasticity. For the daily sector this is 25%, for the non-daily sector 50% and for leisure 100% (source: RIZA 2004). The elasticity percentages are relatively sensitive as they directly control the consumption in the region.

Regional binding as factor for determining regional spending

The regional spending can be calculated by multiplying the average income with the households in the region. However, depending on the properties of the region only a portion of this income is spent in the residential region. Inhabitants of regions with high amenity levels (mega stores, shopping centres and large supermarkets) spent more of their disposable income in their residential region than inhabitants of low amenity regions (KSO 2004). This translates into a factor controlling the regional (economic) binding of inhabitants to a region. Based on the

³³ Because the government is/was shareholder of a lot of the NUTS companies in the Netherlands the data on these economic activities is classified.

³⁴ Only for home owners, the habitat quote for rental homes is about 30%

Koopstroomonderzoek three region sizes are accounted for: small, middle and large regional city types (see table 3.1). There are also three different factors for binding: the daily sector (general daily groceries), the non-daily sector (electric appliances, furniture, etcetera) and Leisure (pubs, hotels, restaurants, bike rent). The inhabitants of the Wieringerrandmeer spend 85% of their daily shopping, 40% of their non-daily shopping and 30% of their leisure expenses in the project region.

| City type | Inhabitants | Percentage of income spent in region | | |
|--------------------|----------------------------|--------------------------------------|-----------|---------|
| | | Daily | Non-daily | Leisure |
| Small town (rural) | < 15.000 | 85% | 40% | 30% |
| Medium sized city | between 15.000 and 200.000 | 90% | 70% | 65% |
| Large city | > 200.000 | 95% | 80% | 85% |

Table 3.1, *the regional spending index*

3.4.3 Assumptions: inhabitants, available labour force and housing developments

Households are equal to the amount of dwellings

A house cannot be empty therefore a one on one relationship between the amount of dwellings and the amount of households. This also means that institutional households are not taken into account. This leads to an error percentage that is less than 0,1% and is therefore neglected (CBS, inhabitant data 2005).

Transition from "Potential labour force" to "Labour force"

In order to translate the potential labour force into labour force a variable is needed that indicated the gross participation. The Social and Cultural Planning Office of the Netherlands (SCP) provides both current participation degrees as predictions on participation. The former is available on COROP region level, and the latter only on national level. The national prediction has to be differentiated to regional values based on the current participation (Sociaal Cultureel Planbureau, 2004). Gross participation is derived from historical data and is assumed in most scenarios to converge to 63%. Sensitivity analysis did not show that the gross participation is unacceptable sensitive.

Transition from "Labour force" to "Working labour force"

The factor unemployment expresses the relation between the labour force and the working labour force. Unemployment differs per region and will generally not be based on the production sectors due the fact that the potential labour force data is not sector specific. The estimation of the unemployment stems from the CPB scenarios where in the best scenario the unemployment reaches to 4% and in the worst case more than 7% (Huizinga & Smid 2004). Sensitivity analysis did not show that the unemployment factor is unacceptable sensitive.

No building delay during the project

The assumption is made that if the project starts there will be no further delays. This also means that there are sufficient buyers for the new dwellings and that and that new households move in directly into the new dwelling. This in turn means that a new dwelling can never be empty

No inclusion of rental homes

The simulation model does not include the possibility of differentiating between an owner occupied house and a rented house. This assumption based on the Wieringerrandmeer case where all the new housing projects are commercially sold to homeowners.

3.4.4 Simulation model settings

- *Run length*: the current plans for the Wieringerrandmeer have an execution time of more than twenty years. The run length is therefore set on 25 years.
- *Start time*: the start time of the simulation model is 2005. This means that all the values that are used in the simulation models are discounted to match the price level in the year 2005.
- *Time step*: the time step controls for a large part the speed of a simulation run. When set very small, one simulation run can take minutes. However when the time step is set too large the model outcomes are less accurate. Taking into account the user requirements and the fact that the run length is 25 year a time step of 10 days is taken.
- *Calendar*: in PowerSim the bank calendar is used. This calendar has 12 months consisting each of 30 days; hence a year has 360 days.
- *Integration settings*: the most accurate integration method is used for the calculation of the thesis model, 4th order, Runge-Kutta (fixed step).

For the sensitivity analysis of the input variables several other settings were used:

- *Risk analysis method*: the most detailed risk analysis method is used in the simulation model for sensitivity analysis. The Latin Hypercube method correlates each different simulation run to the previous runs that are executed. This makes this method more effective than for instance Monte Carlo simulation and therefore less iteration steps are necessary.
- *Run count*: the run count is the number of simulation runs that is used to calculate the predictability intervals. The higher the number of simulation runs the larger the power of the statement on the predictability bounds of a variable. Unless specified otherwise the standard run count setting is 40 runs.
- *Seed value*: the seed value determines the kick-off value of the random number generator. Fixing the seed value ensures that model results can be repeated. The standard PowerSim setting is 100 and this value is always used.

3.5 User interface: communicating with policy makers and consultants

Because a lot of requirements revolve around the presentation of outcomes this section elaborated on the user interface of the simulation model. The user interface is basically what the model user is able to see when working with the model. Working with a simulation model is difficult enough and therefore the model output should be served in ready to eat packages. The requirement analysis demands in the *communication* issues that the following problems have to be “solved” by the user interface (see also section 2.5):

- Avoid large tables, use graphs, limit graphs, information of input and output variables.
- Facilitate novice and advance user options (the “Jip & Janneke” version).
- Display projections of: housing market, employment, regional economy and economic scenarios.
- Understanding what to do should take no more than 5 minutes.
- Give an indication of the variable bounds.
- Visualize model relations.

3.5.1 A standardized layout for simple understanding

To improve the user-friendliness and keep an easily adjustable format for the interface a standard layout is chosen that can be adjusted for each purpose. In figure 3.16 this standard format is illustrated. The basic page consists of a header displaying the main fields of interest: housing, working and the regional economy. The fields of interest are underlined, as that is the regular format for illustrating hyperlinks. Figure 3.16 specifically shows the housing page and the inhabitants grouped by age sub-menu. The header is always visible and never leaves the screen, just like an Internet Explorer does with the address bar. The tablet on the left side shows the possible options in the housing menu. In this case dwellings, inhabitants and age (depicted in figure 3.16) and inhabitants and household type. By pressing on the hyperlinks in the tablet a new page is called that illustrated the requested information. What also is standard is the large graph in the middle, a tablet on the right for additional options and the advanced menu. The table at the bottom can illustrate different extra information or remain blank. The autonomous scenario is always depicted in blue while the WRM GO scenario is always pink. The central graph shows different variables depending on the chosen sub-menu and so does the table at the bottom. The options tables let's people work with the model, make small adjustments in the assumptions or choose a different economic scenario. The advance option is in this case the possibility to adjust the composition of the households that move to the region as a result of the investment project. By clicking on the hyperlink another page is called with the advanced option.

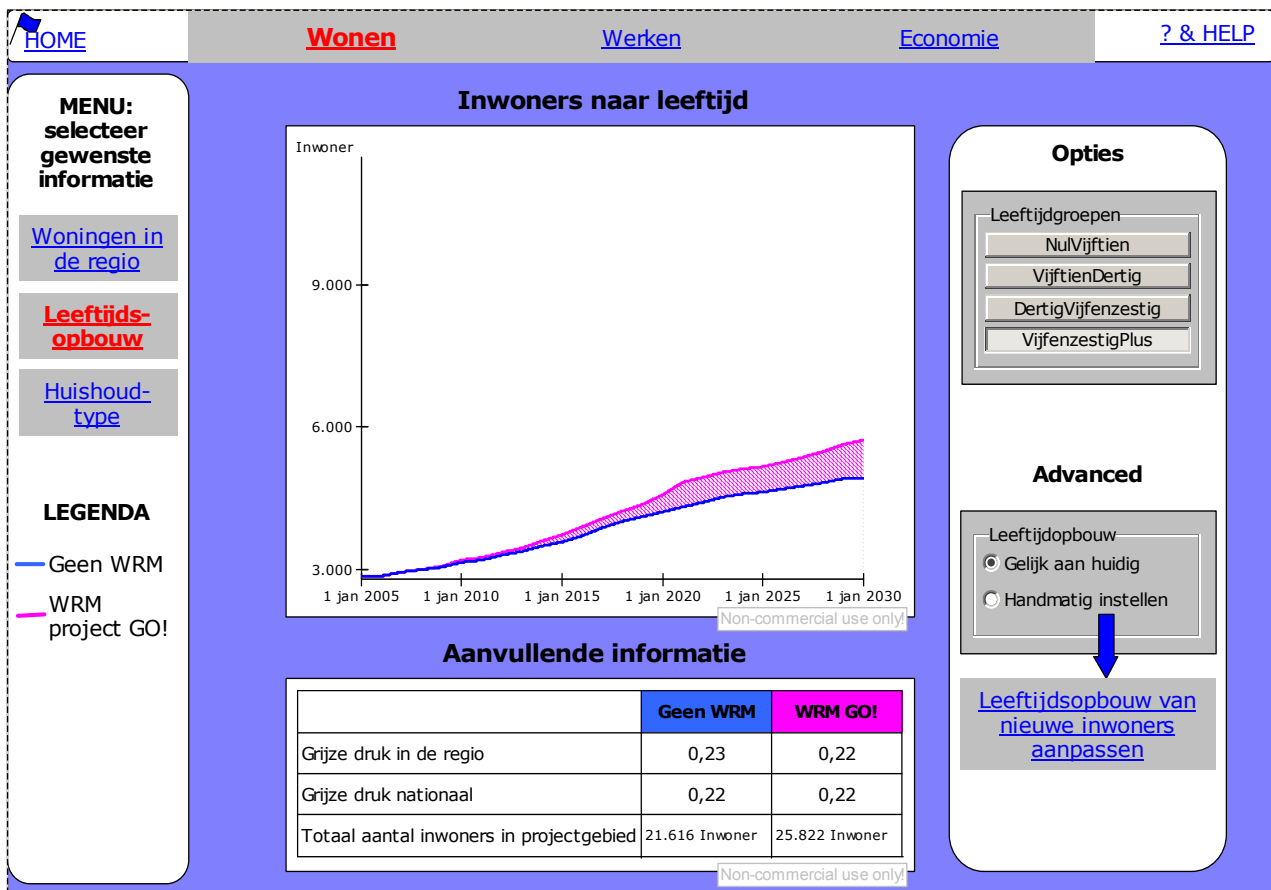


Figure 3.16, the standard layout for the model interface (the housing page)

Each sub-menu has its own help file, assisting model users in coping with the model or finding information about the variables (see figure 3.17). Again the header bar remains similar and with the sub-menu on the right different subjects can be chosen. The help menu also contains information concerning the project (about) and the basic principles of system dynamics.

The user interface offers the possibility of novice and advanced users and by only showing 1 graph approximates a “Jip & Janneke” version. Besides it still remains possible to adjust the entire model and add components in the PowerSim construction mode. With respect to constructing the interface, PowerSim is not the most convenient program to work with. Because PowerSim does not use an object-oriented manner of working, each page that is shown in the interface has to be built individually. This makes adjusting it more complex and more prone to faults.

HOME **Modelhulp** About System Dynamics ? & HELP

MENU: selecteer gewenste informatie

Wonen HELP

Werken HELP

Economie HELP

Begrippen

Bruto regionaal product

De grafieken

De grafiek "ontwikkeling van woningen in de regio" geeft een voorspelling van het aantal huizen dat in de regio gebouwd gaat worden. De x-as geeft de tijd in jaren weer en de y-as geeft het aantal woningen weer.

De grafiek "inwoners naar leeftijd" geeft een voorspelling per leeftijdsgroep van het aantal inwoners dat in de regio woont. Door rechts, onder "leeftijdsgroepen" op de verschillende knoppen te drukken worden verschillende leeftijdsklassen zichtbaar. De x-as geeft de tijd in jaren weer en de y-as geeft het aantal inwoners weer.

De grafiek "inwoners naar huishoudtype" geeft een voorspelling van het aantal huishoudens dat in de regio woont. Door rechts, onder "Huishoudtype" op de verschillende knoppen te drukken worden verschillende huishoudens zichtbaar. De x-as geeft de tijd in jaren weer en de y-as geeft het aantal woningen (huishoudens) weer.

Aanvullende informatie

Bouwvertraging

Bouwvertraging geeft de mogelijkheid to het instellen van een verlating van de ingangzetting van het project. Met de schijfcontroleer kan de bouw 2000 dagen (5,5 jaar) uitgesteld worden.

Advanced: Leeftijdopbouw aanpassen

Het model biedt de mogelijkheid tot het aanpassen van de leeftijdsopbouw van de nieuwe inwoners van het project gebied. Standaard is ingesteld dat de leeftijdsopbouw van nieuwe inwoners gelijk is aan de huidige opbouw. Door de knop "handmatig instellen" aan te zetten is vervolgens via de onderstaande hyperlink de opbouw handmatig te regelen. Volg verdere instructies aldaar.

Advanced: Huishoudtype aanpassen

Het model biedt de mogelijkheid tot het aanpassen van het huishoudtype van de nieuwe inwoners van het project gebied. Standaard is ingesteld dat de huishoudtype- verdeling van nieuwe inwoners gelijk is aan de huidige verdeling. Door de knop "handmatig instellen" aan te zetten is vervolgens via de onderstaande hyperlink de verdeling handmatig te regelen. Volg verdere instructies aldaar.

Figure 3.17, the standard layout for the model help interface (housing help page)

3.6 *Conclusions of the model construction*

In chapter 3 the second thesis sub question formed the departure point for the construction of the thesis instrument. Two translations had to be made to come to the final simulation model. The translation of the requirement-, literature and other regional economic model studies in a concept model first and then the translation of this concept model into the final simulation model.

How to construct an instrument for the ex-ante exploration and assessment of policy options in spatial investments in a region?

- a. *How are the notions from the requirement analysis, literature study and existing models translated into a conceptual model?*
- b. *How is this conceptual model translated into a mathematical simulation model?*

The requirements found in the literature and in the requirement interviews (see chapter 2) formed the basis of the concept model. By identifying the important model variables from the requirement interviews the literature handed the relationships between these variables. Then the existing models showed some interesting characteristics or insights that provided useful in the second translation (concept to quantified model). When the conceptual model was finished it had to be translated into the actual simulation model using PowerSim and Excel. The interaction between these two software programs is not optimal; the communication between them can be called clumsy and slow (see appendix 9). Initially the model was intended to incorporate a lot of aspects and causal relationships from the Urban Dynamics model from Forrester. However when the first translation started it appeared that the user requirements were hard to match with some of the properties of the UD model. The geographical scale of the model of Forrester was hard to extract because it is based on a small town that grows into a metropolis. This growth period was also a problem because the UD model was made to calculate the developments of a city over a period of 250 years while the thesis project is only interested in a ten times smaller runtime.

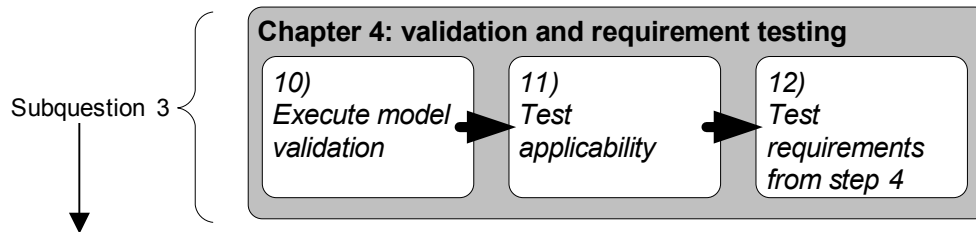
During the development of the concept other assumptions had to be made as well. Because it is not realistic to extrapolate the historic performance in the shift-share analysis indefinite a control mechanism is built in. The availability of labour gradually replaces the overrepresentation of the industry sectors (the jobs-follow-people theorem). The translation of the concept model to the simulation model also required a series of assumptions. In the model it is for instance not possible for dwellings to be uninhabited. Uninhabited dwellings make up an insignificant part of the total supply of dwellings. By leaving the empty dwellings out the model became much less complex because households and dwellings could be coupled to each other. Another assumption that is made for the sake of simplicity is the reduction of the 15 basic industry sectors to only 9.

The fact that an actual case model had to be developed meant that actual data was going to be needed for the input of the model. This meant that the basic structures of the UD model could not be used, as the variables of the UD model did not match the required outcomes. The fact that actual data had to be used also meant that the UD model could not be validated, as it is a theoretical model. Furthermore, it became clear that the model components that had to be developed to display system behaviour (like demographic development) would become very complex. The complexity was of such extent that the requirement to create a small model had to be left. In order to solve the latter problem exogenous data was used to replace the model

components that caused the extreme complexity. Other economic models also used this principle and the required data was available through PRIMOS (Heida 2002). The system dynamics methodology however appears to have some side effects with respect to the use of exogenous variables. This causes the model feedback loops to collapse defying the purpose of the system dynamics model from the beginning. It must be said however that the other concepts of system dynamics still hold and that providing insight with a system dynamics interface is still possible. See section 5.1 for a more elaborate explanation.

4 Model validation and requirement testing

In the previous chapter the concept model was constructed from literature sources and the requirement analysis. This concept model was then translated into an actual set of equations in a simulation model in section 3.4. In chapter 4 the third sub question and research steps 10, 11 and 12 of the research framework form the central issue.



What is the practical applicability of the developed instrument?

- a. *What is the robustness of the model in terms of predictability?*
- b. *Can the instrument fulfil the requirements that were initially set at the start of this research?*
- c. *Is the instrument applicable for regions with different characteristics?*

The simulation model from chapter 3 is tested in this chapter on validity, the fit of the model in problem situations and the match of the end product with the set of requirements from step 4. This chapter will start with the validation of the simulation model through a series of tests. The sensitivity analysis receives special attention in section 4.2 because it also functions as an uncertainty measurement technique. Section 4.3 is devoted to the applicability of the simulation model. In this section the model is validated with historic data and the relation between the model outcomes and the actual problem situation is analysed. After the series of validation steps the model is exposed to user groups and (model) experts in section 4.4. The model is tested in different settings on applicability and robustness; a group of individual model experts will contribute their findings concerning the model. Finally in section 4.5, based on the validation, model experts and group sessions the user requirements from that where found in step 4 are tested (see section 2.5.5).

4.1 Steps in model validation

In order to validate the model a series of tests is executed. Some are intended to analyze the appropriateness of the structure of the model and the correctness of the input values. These the model structure tests are executed in section 4.1.1 If the model structure tests are performed and structure errors are filtered out of the model a series of model behaviour tests is executed in section 4.1.2. A behaviour test analyzes if the behaviour expressed by the simulation model is in concurrence with the behaviour that is expected in the real life system. A part of behaviour tests that deserves special attention for this research is sensitivity analysis. Using sensitivity analysis the steering instruments of the policy makers can be analyzed on effectiveness and input parameters can be assessed on sensitivity. A very sensitive parameter might require more (market) research to confirm the correctness of the variable in order to use it safely in the simulation model (Sterman 2000a).

4.1.1 Model structure tests

Model structure tests assess the simulation model on structural errors that could have creped in during model construction. If any errors are detected they are dealt with immediately, unsolvable errors are reported in the text and should be considered when using the model. In total 6 structure tests are performed. The first three focus on the translation of the concept model into the simulation model and the correctness of data that is used as input parameter. Test 4 to 6 tests if the model responds to abrupt changes in the system as it is supposed to react. Test 6 is specially intended to see if the chosen integration method and step is appropriate for this model (Sterman 2000a).

- 1) *Parameter assessment* is a method for checking both the real life meaning of the input variables and the correctness of these variables. In the assessment of available data in the thesis project in section 2.6 different information sources have been identified. Most of the input values have been either deducted with statistical methods or estimated from literature or other available model. Most of the input data has already been described in the assumptions of the simulation model in section 3.4. The following list gives an overview of the input parameters that might require more attention and that will have to be tested in the sensitivity analysis
 - a. The regional binding factors that have been deducted from the “Koopstroomonderzoek” (KSO 2004) are not available for the WRM region. Therefore special attention should be paid when using these input parameters.
 - b. The elasticity of the income of the new inhabitants of the project region has been collected from the RIZA (2004). However more complex elasticity equations and perhaps also estimation are available.
 - c. The input data for the autonomous development of the inhabitants, dwellings and households in the project region comes from the PRIMOS database (Heida 2002). If newer versions of PRIMOS would make better estimations of these parameters, these new values should be used.
 - d. Special attention should be given to the parameters in the calculation of the tourist spending. The estimation of day tourists is based on the Socio-economic Effect Study (DHV 2005) while more accurate data might be available from sampling in the project region.
- 2) *Structure assessment* is a method for checking whether the model corresponds to the knowledge of the real world system and if. The level of aggregation between the sub models of the simulation model is a little bit skewed. This means that some parts of the model are worked out in more detail compared to the rest of the model. This is mainly caused by two items in the simulation model:
 - One of the user requirements was to analyze the tourism effect on the regional economy. In order to do this an extra model component was added (see figure 3.11) that provided the necessary data.
 - Because the jobs in the non-basic sectors could not be calculated with the shift-share analysis separate model components were constructed to deal with the job development in these sectors (see figure 3.8 and 3.9). These components also have a higher level of detail compared to the job development in the basic industry sectors.

When dealing with a skewed model it is important not to let the highly detailed model sections take up an unjust large part of the model outcomes (Sterman 2000a).

- 3) *Dimensional consistency* assesses if there are errors in the chosen dimensions in the simulation model. There is 1 dimensional inconsistency that might cause some confusion with the model users. In the user interface the distribution of households is not indicated in households but in dwellings³⁵. This error can occur because household is not included as a model dimension in the simulation model.
- 4) *Boundary adequacy* tests if the policy recommendations resulting from the model changes when the model boundary is extended or if exogenous variables are relaxed. If the boundary of the model were extended by for instance adding a demographic module, new feedback loops would arise in the model. This is a known problem that is carefully weighted against other options and does not compromise the boundary adequacy. If the boundaries of the exogenous variables are relaxed, the policy recommendations do not change except for two variables.
 - The CPB scenario's that are use to calculate growth are very sensitive to changes, especially changes between scenarios can have huge effect on the model outcome.
 - The regional binding factors are also very sensitive to changes of their boundary and will change the model outcomes significantly.

This problem is noted and might be resolved by dimming down the effect of the CPB scenarios. More information on these variables is given in the sensitivity analysis in section 4.2.
- 5) An *Extreme conditions* test is executed to make sure the model presents estimated behaviour even under extreme conditions. This involves setting variables to infinite, zero or π . Some errors occurred during these tests that should be regarded when using the simulation model:
 - The initial values in the simulation model are unrelated. Therefore if for instance the initial value of dwellings in the region is set to 0, this does not mean that there are not inhabitants. This makes it even more important to have all the initial value data set on the price level of 2005.
 - Some constant variables in the model are implemented to assists the user interface, for instance the variable that controls what economic scenario is used. Due to the use of "If" statements the model will give erratic data if other values are used in those constants.
- 6) *Integration error* tests if the model is sensitive to changes in the time step of the numerical integration method. The time step is normally set to 10 days. The model outcome of regional spending differs 0,06% if a 20 days time step is chosen. Using a 1 day time step increases the accurateness, however it also decreases the simulation speed with a factor 6 taking 30 seconds per simulation run of 25 years³⁶.

4.1.2 Model behaviour tests

Now the structure of the simulation model has been tested it is time to test the behaviour of the model. The behaviour tests focus more on the conduct of the model during model during changes in variables and relationships. Two tests will be performed. The behaviour reproduction test analyzes if the model can constantly reproduce trustworthy data. In the behaviour anomaly test some assumptions are relaxed to analyze the effect on the model outcomes.

- *Behaviour reproduction* should be able in every simulation model and is possible through the use of PowerSim. Because no stochastic variables have been used in regular simulation settings,

³⁵ Mentioned in the consultancy test (section 4.3.2)

³⁶ With computer specs: Pentium4 1,80 GHz processor with 256 Mb RAM and Windows 2000 OS.

this is not a problem. If random behaviour is induced on model variables, it remains possible to reproduce the exact behaviour due to the adjustability of the random number generator. For the stochastic values in the sensitivity analysis, the seed value is always set on PowerSim default (100). The behaviour of the model is fully reproducible. The behaviour reproduction also entails the reproduction of observed behaviour in the real world system. This is the case for the used relationships in the model, which translates into the correct behaviour of the simulation model.

- When testing *behaviour anomaly* some model assumptions are deleted in order to see what the reaction of the model is. Some issues arise:
 - Because it is possible that the inhabitants do not move into their house directly the time between moving into the region is delayed with a year (Pipeline delay). This delays the growth of inhabitants and household also with exactly one year.
 - If the assumption is relaxed that the historic performance decreases over time and that the influence of available labour increases the job development shows a reaction. Because the historic performance has a higher growth rate compared to the labour availability it shows a further increase of the jobs in the region.
 - In that line of thought if the effect of the available labour force is stronger the opposite effect mentioned above should take place. When the “Max effect” is increased 4 fold the effect on the jobs is much higher than that of the historic performance.
 - The elasticity has an effect on the regional spending. When the elasticity is set to 0 the new inhabitants will spend the same amount of money in the region. When all elasticity’s are set on 100%, their regional spending on daily, non-daily and tourism will increase with the same amount as their disposable income.
 - When the regional binding is omitted from the simulation model regional spending is € 0 per year.

4.2 Sensitivity analysis

Sensitivity analysis is a method for testing the robustness of the simulation model. It checks if the conclusions drawn from the model outcomes change substantially if the assumptions are relaxed a small amount. This information is also important for policy makers; it can for instance tell them what the most “potent” steering variable is. This is the variable that causes the largest effect with the smallest change. Sensitivity analysis should therefore play a part in the both in model testing as in the communication towards the policy maker. Not all variables have to be tested on uncertainty. The input variables tested here are either based on an assumption from section 3.4 or on a quote in the parameter test in the previous section (Sterman 2000a). To include a measure for sensitivity a standardized factor is used for each sensitivity calculation, this factor is called absolute uncertainty (δ). This measure is the bandwidth of the 90% interval, divided by the average outcome times a 100%. If this figure is small, the variable that is tested is relatively insensitive; if however the figure is high the variable is very sensitivity to changes in the model assumptions³⁷. Most of the variables have an uncertainty smaller than 10%, if a variable exceeds this value it should be labelled as highly uncertain and special attention should be taken in account when working with this variable. If a variable is found to be very sensitive two issues should be pointed out. First it should be analyzed if the parameter is accurately determined, and how the

³⁷ From discussion with Bert Schilder, in Risk Analysis this is the common form of indicating risk involved with a model variable.

accuracy of this variable can be improved even more. Secondly the large sensitivity should be explained in order to grasp the issue that causes the large sensitivity. The sensitivity analysis is divided in similar fashion as section 3.3 and 3.4 and includes the earmarked variables from these sections:

- 4.2.1 Labour markets in the basic and non-basic industry sectors
- 4.2.2 Regional spending and disposable income
- 4.2.3 Inhabitants, available labour force and housing developments

4.2.1 Sensitivity: labour markets in the basic and non-basic industry sectors

CPB scenario sensitivity

The CPB scenarios have a large impact on the outcomes of the simulation model. Especially the shift in job development in 2020 has a large visible impact on the outcomes (see figure 4.1). Several other outcomes of the simulation model are also influenced by the CPB scenario forecasts including unemployment, gross national product and productivity of employees (Huizinga & Smid 2004). This effect of the CPB scenarios is tested for one economic scenario and its specific sensitivity properties. Figure 4.1 indicates the bounds for the least optimistic economic scenario (Regional Communities) plus the implementation of the WRM project. What becomes clear is that the bandwidth relatively small compared to the total jobs in the region. This is logical as the maximal deviation from the average is only 0,05% while the difference between scenarios can be more than 1%. In 2030 the 90% interval consists of a little more than 100 jobs. The absolute uncertainty (δ) is particularly low with 1,4%. The absolute uncertainty of the CPB scenarios has a marginal effect on the outcomes of the simulation model. Hence, if the correct CPB scenario is chosen the sensitivity can be called low. The effect of choosing a different scenario is described in section 4.3.

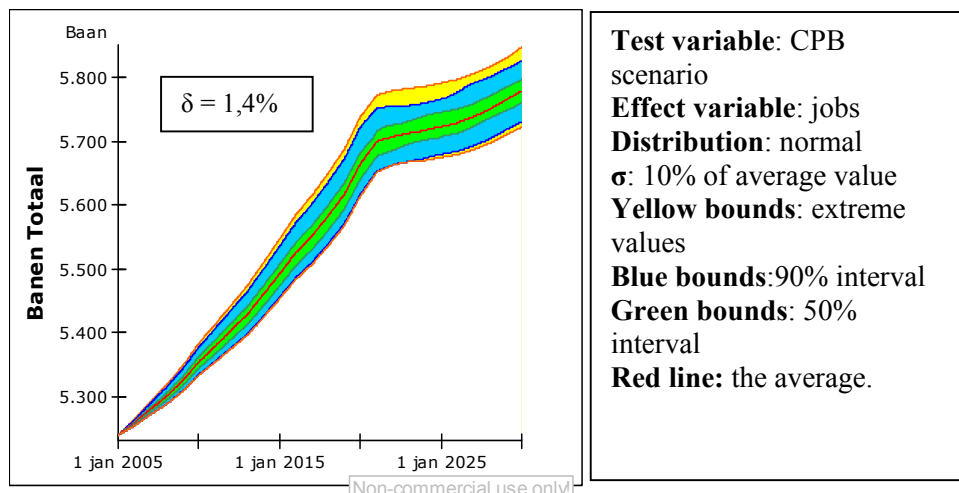


Figure 4.1, total jobs in region with Regional Communities scenario and investment

Shift-share sensitivity

The shift-share analysis is used in the simulation model to come to an estimation of the development of jobs in the project region. The shift-share analysis determines the growth or decline of jobs and therefore is tested on its sensitivity. Within the shift-share analysis different assumptions are made to come to the final jobs growth factor. Each of these factors will now be analyzed for its effect on the final increase in jobs.

- *Shift-factor effect on shift-share analysis:* the effect of the shift factor is important for the overall image of job development in the region. The shift factor is a combination of the historic

performance and the potential labour force in the region (Koops 2005). Figure 4.2 shows the sensitivity bounds for a uniform distribution of the shift factor from 0% to 100%. These extreme bounds are used because it is plausible that the shift factor might not influence the region at all. 0% indicates that the effect of shift factor is 0; hence the CPB scenarios cause the job development (the share factor). The effect reaches a maximum bound of about a thousand jobs, which results in an absolute uncertainty of 18%. This means that the shift factor is a relatively sensitive parameter. However due to the extreme uniform distribution between 0% and 100% the absolute uncertainty might be expected to be significantly higher. A consequence is that high certainty must be aimed for in determining the shift factor input variables.

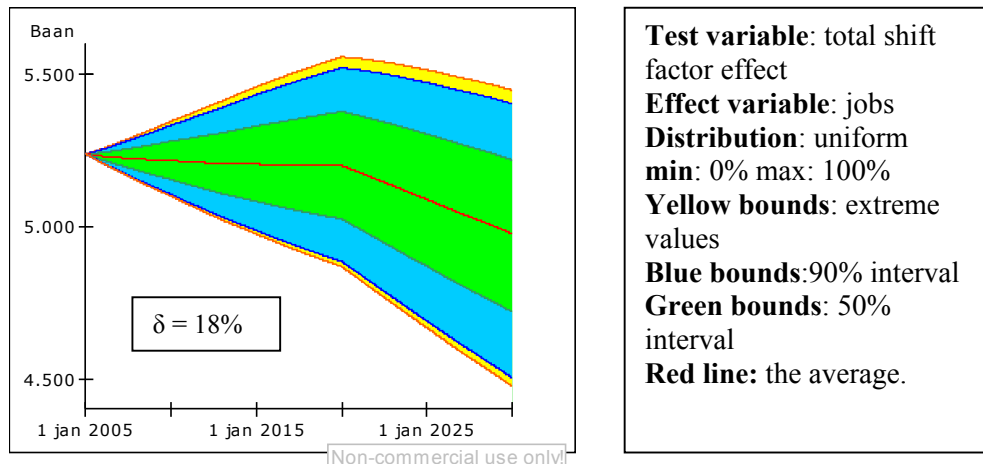


Figure 4.2, sensitivity of the shift-factor on jobs

- *Shift-share combined sensitivity:* the two previous sensitivity tests analyzed the individual components of the shift-share analysis. Now the combined sensitivity is tested, relaxing all the assumptions in the shift-share equations. Because no other factual data is available on the input parameter each variable is relaxed with a normal distribution and a standard deviation that is 10% of their initial value. Figure 4.3 shows a 5,8% absolute uncertainty in 2030 on the jobs in the region caused by the shift-share analysis. This indicates that the total combined uncertainty of the shift-share analysis adds about 6% uncertainty to the outcome of the simulation model.

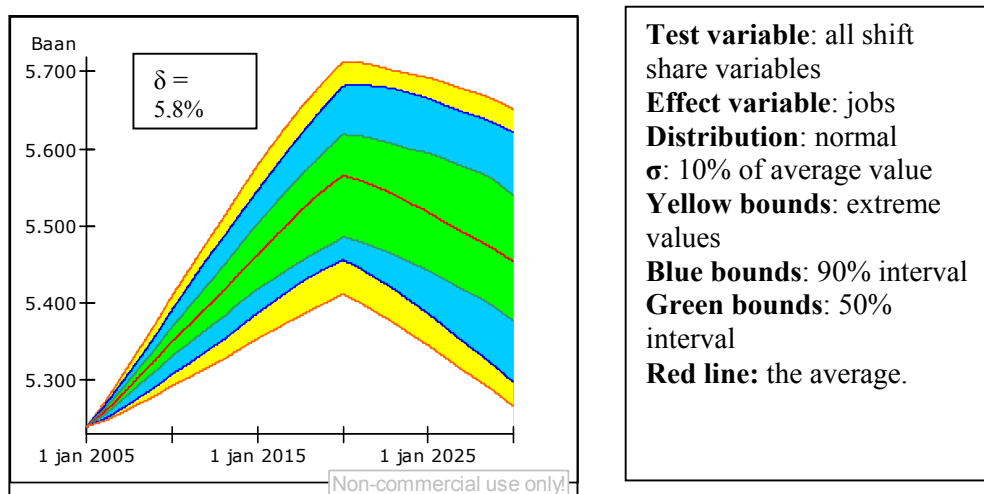


Figure 4.3, combined sensitivity of shift-share

4.2.2 Sensitivity: regional spending and disposable income

Regional binding factor sensitivity

The regional binding corrects for the amount of disposable income that inhabitants of the project region spend inside the project region. For a rural area this amount is lower compared to a high amenity urban area (KSO 2004). Figure 4.4 shows the uncertainty bounds when the regional binding factors for daily, non-daily and recreation are relaxed. The binding factors are quite sensitive; the absolute uncertainty is 21% in 2030, indicating that this variable plays an important role in determining regional spending.

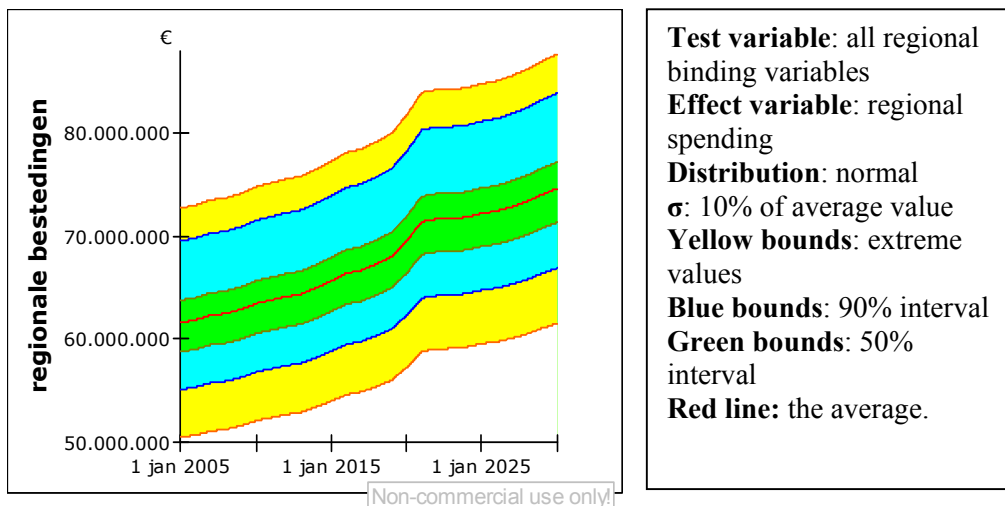


Figure 4.4, effect of regional binding on regional spending

Because of the importance in determining the regional spending the values of the regional binding variables should perhaps be researched deeper. Executing a market research that assesses for the WRM region what the regional binding is compared to daily, non-daily and leisure spending can for instance do this. Another option would be to initiate a regional binding research for the province of North Holland just like the “Koopstroomonderzoek” for central Holland. Furthermore the sensitivity of this variable should be kept in mind while processing the outcomes related to regional spending.

New dwelling price sensitivity

The disposable income of the new inhabitants is based on the value of the houses that will be built in the region (CBS, woonquote). The sensitivity of the housing price, hence the disposable income of new inhabitants is tested by relaxing the housing price and testing the effects on regional spending. From figure 4.5 it becomes clear that the effects increase over time, this is due to the facts that the inhabitants join the region in-line with the completion of new dwellings. The total maximal bound in 2030 is about 7 million euro which results in an absolute uncertainty of 2,7% of the total regional spending. Overall this means that the housing price of the new dwelling is relatively insensitive. In the end of 2006 more certainty will be given on the average housing prices as more details of the project are worked out.

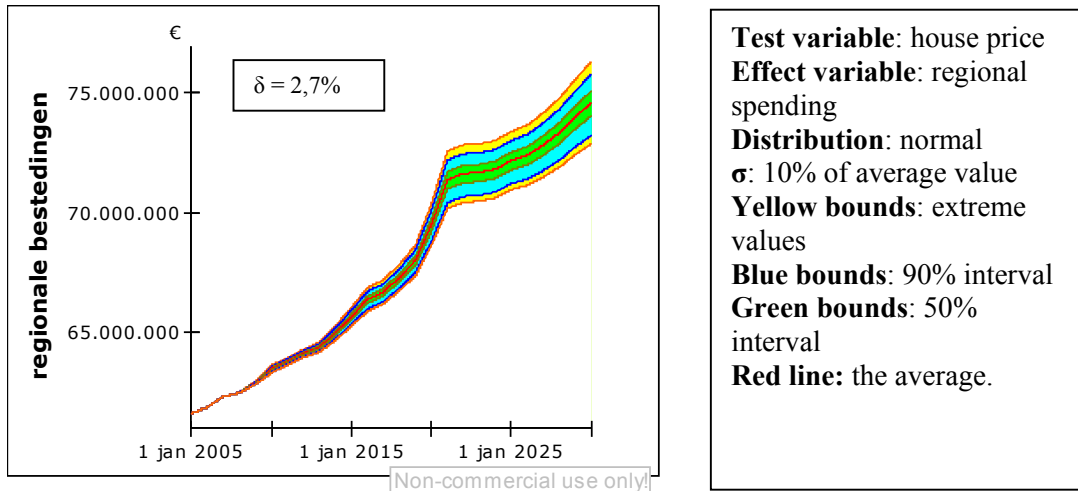


Figure 4.5, effect of housing price on regional spending

Elasticity of disposable income sensitivity

The new inhabitants have different disposable incomes than the current inhabitants. To calculate how much those new inhabitants contribute to regional spending a set of elasticity rules is included in the model. The new inhabitants do not spend all the “extra” disposable income in the region. These elasticity rules are tested on sensitivity in figure 4.6. With a very small absolute uncertainty of 0,7% the elasticity variables are not very sensitive.

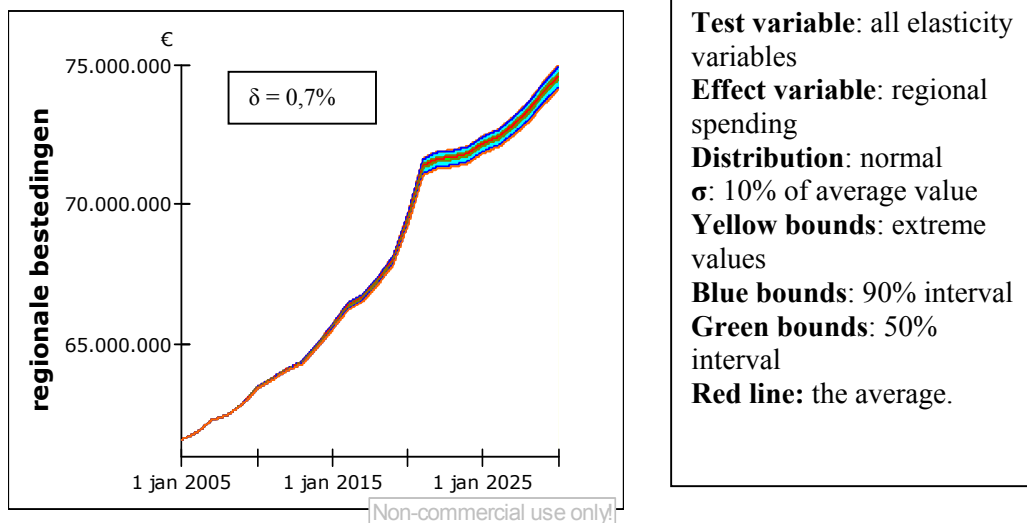


Figure 4.6, effect of price elasticity on regional spending

4.2.3 Sensitivity: inhabitants, available labour force and housing development

The availability of labour bounds sensitivity

To examine the effect of available labour on the jobs in the region more closely the variable available labour is relaxed. Dividing jobs in the region with the potential labour force in the region and comparing that to the national average determines the relative supply of labour in the region. This value is used in the simulation model. Because the effect of the availability of labour increases over time, the uncertainty bounds do so too (see figure 4.7). The variable is not overly sensitive as the bounds in 2030 are within a 100 jobs and the absolute uncertainty is 2,8%.

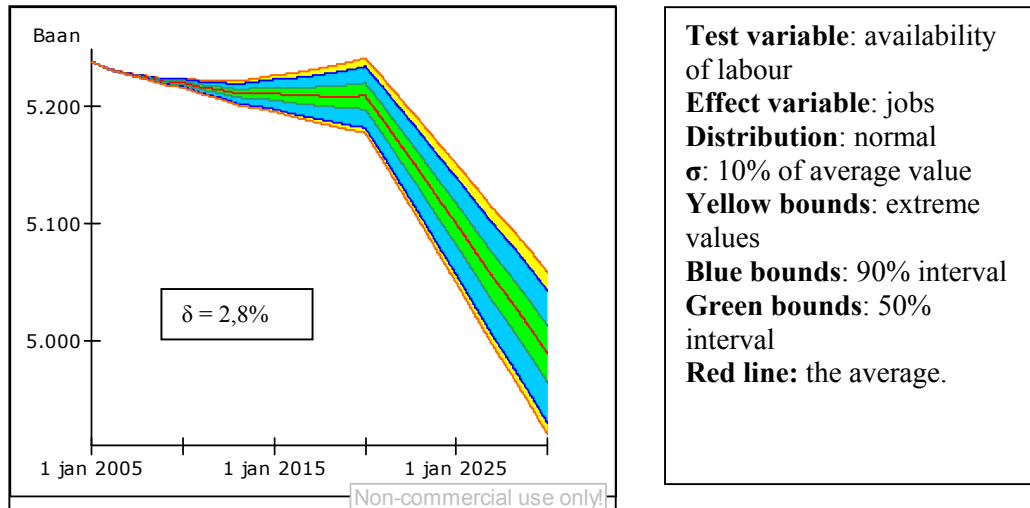


Figure 4.7, *availability of labour bounds*

Next to the sensitivity of the individual input variables the sensitivity of all the variables together is analyzed. The effect on the jobs in the region can be seen in figure 4.8 and the effect on regional spending in figure 4.9. An issue that occurs when all the variables are relaxed without underlying dependency is that a cancelling out effect reduces the absolute uncertainty³⁸. Therefore it is called the lower bound of the absolute uncertainty of the entire model. The higher bound can be tested if all the input variables are made dependent from each other. For instance that an increase of the regional binding factor in daily shopping will strongly be correlated to the increase of square meters of retail (KSO 2004). This effect is visible in figure 4.9 where the absolute uncertainty is 1% lower compared to the individual uncertainty of regional binding factors. The lower bound of the absolute uncertainty for the jobs in the region is almost 8%, which is higher than measured in other tests. What this illustrates is that more accurate statements can be made with this instrument on the development of jobs than on the development of spending in the region. Executing the higher uncertainty bound is not possible in the PowerSim software as it is not possible to connect two input variables in the sensitivity analysis.

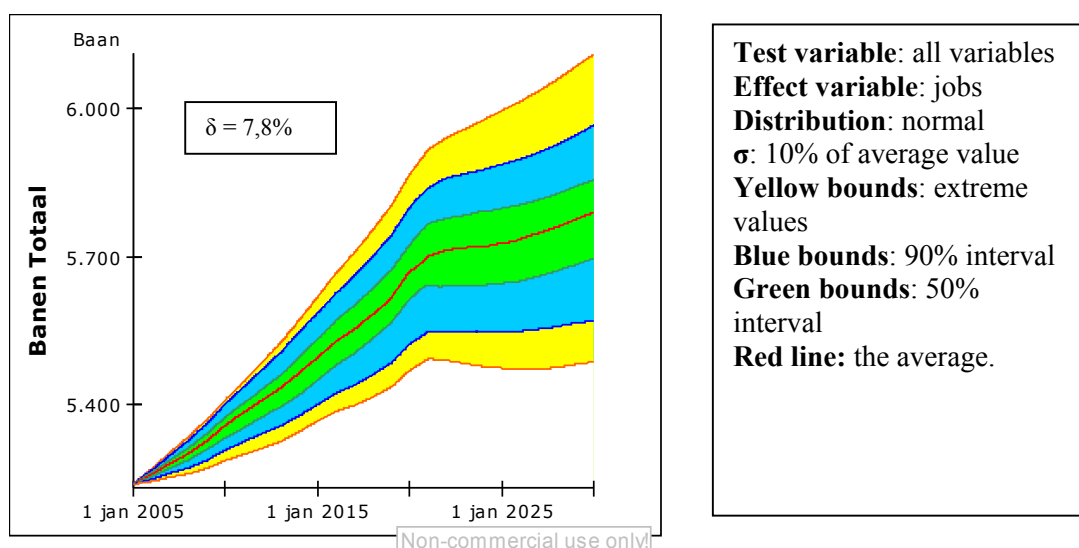


Figure 4.8, *effect of all variables on jobs in the region*

³⁸ From discussion with Bert Schilder

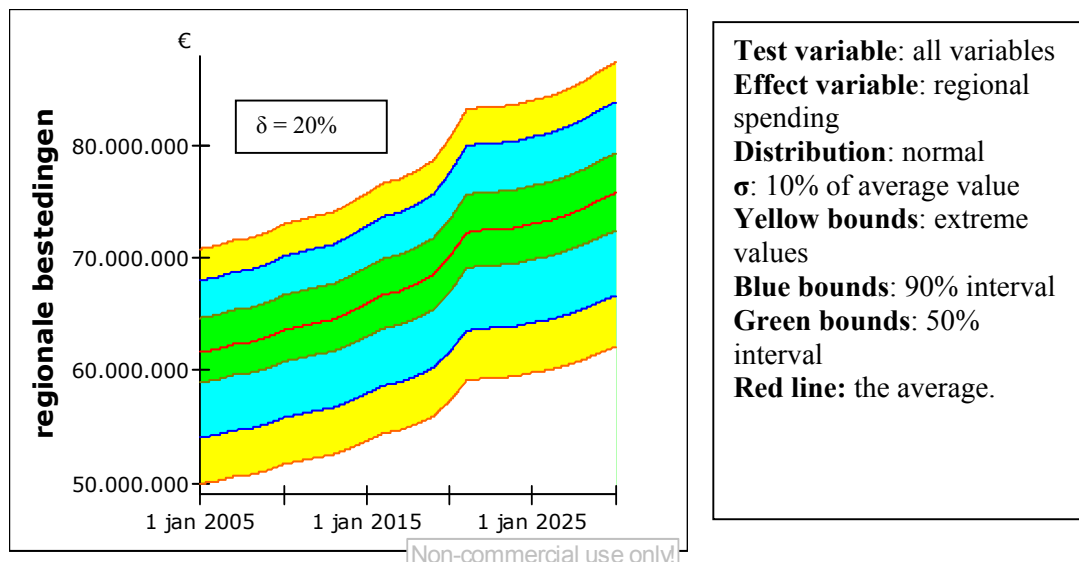


Figure 4.9, effect of all variables on regional spending

The sensitivity analysis focuses the attention on the regional binding variables that prove to be very sensitive to changes. The other model variables do not show the same response to relatively small changes.

4.3 Applicability of the simulation model

Section 4.3 describes the applicability of the simulation model. In the next paragraphs some reality checks are performed. These checks indicate if the simulation model responds accurately to changes that could occur in reality. It also gives a margin or error for which the simulation model to use and describes potential pitfalls (section 4.3.1). To test the applicability of the simulation further a historic validation is executed, comparing the outcomes of the simulation model with historic data (section 4.3.2).

4.3.1 Reality tests: potential pitfalls of the simulation model

CPB scenario sensitivity

The CPB scenarios have a large impact on the outcomes of the simulation model. Especially the jobs in the region in 2020 have a large visible impact on the outcomes (see figure 4.10). In the section 4.2.2 the sensitivity of a single scenario was tested. This reality test will analyse the effect that the different scenarios have on the outcomes of the model. The question is what the bandwidth of the outcomes is with respect to the two extreme scenarios (Regional Communicates and Global Economy scenario). What becomes clear from figure 4.10 (jobs in the region) is that a large difference is visible between the best and worst economic scenario. It appears that in the best scenario (red line) the WRM region will flourish and that the amount of jobs in the region will resume growing after 2020 even without implementing the WRM project. On the other hand the worst-case scenario gives reason for action (the green line). The kink that is visible in the year 2020 is caused by the change of the CPB scenario projection. CPB scenarios are made for 2005-2020 and for 2020-2040. This causes a change in direction of the growth of jobs in the year 2020. What this means is the differences between the CPB scenarios is considerable and that they can influence the final decision on a project in a great deal. Therefore, the scenarios should only be used for the testing of a solution under different futures.

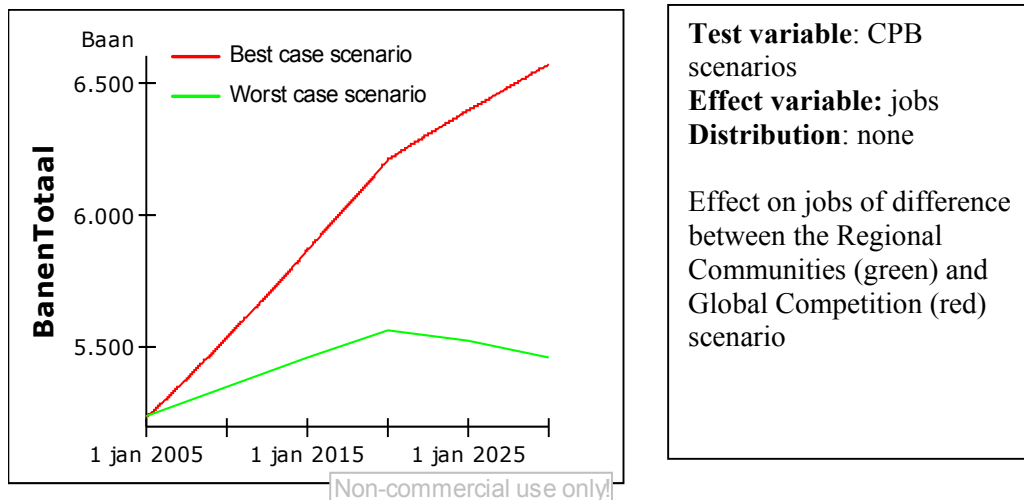


Figure 4.10, total jobs in region under different scenarios

Shift factor components effect

Figure 4.11 illustrates the extreme values of the two components of the shift factor; the historic performance and available labour. The figure shows the effects of jobs in the region when in the autonomous scenario. The red line indicates that the shift factor is fully based on the availability of potential labour force (jobs-follow-people theorem). The CPB scenario for job development causes the decrease in jobs that is set in motion from 2020. The green line shows the effects on the jobs in the region if the shift factor is fully determined by the historic performance. This indicates that under the available labour growth, the initial job growth exceeds the historic performance growth. This can be attributed to the fact that the level of available labour starts dropping from 2005. The extra negative effect of the CPB scenario from 2020 causes the available labour factor to loose jobs. Because the extrapolation of historic performance remains at a constant level throughout the 25-year calculation it does not show a job decrease but only a decreased growth.

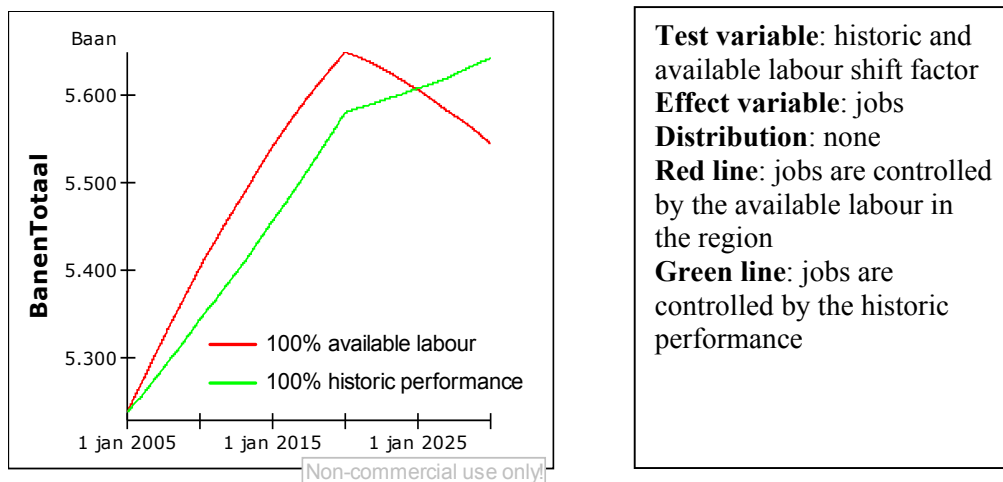


Figure 4.11, components of the shift-factor

What these reality checks illustrate is that the user of the simulation model should always pay attention to the assumptions that lie at the basis of the concept model. Furthermore the user should

be aware of the assumptions made in other models, like the CPB scenario predictions. Laymen might not recognise the “2020 effect” in the outcomes of the model as belonging to the change of CPB projection.

4.3.2 Validation with historic data

The former section illustrates the caution and knowledge with which to approach simulation models. It is never certain to what extent the model is predicting the actual developments and how far it is from the actual future developments. To create some confidence in the outcomes of the simulation model and as final validation step historic data is used to test the model. The historic validation has been executed with the time series data from old PRIMOS files, former CPB scenario forecasts and historic data from the CBS StatLine database. The earliest PRIMOS data that was available dates back to a prediction of demographic developments in 1997. Because the simulation model cannot be run without the PRIMOS data the earliest historic analysis dates to the earliest PRIMOS model. This restricts the historic validation within the time frame from 01-01-1998 until 31-12-2005. Data from the StatLine website from this time period can be used to verify the outcomes of the simulation model. If the data predicted by the simulation model relates closely to the actual events, the simulation model can be regarded as fairly capable of predicting socio-economic developments.

Because a large part of the input data in the model is directly derived from the PRIMOS database, the quality of the PRIMOS forecast determines for a large part the quality of the outcomes of the simulation model. Figure 4.12 illustrates the documented inhabitants by the CBS (blue line) and de the predicted developments by PRIMOS (pink line). On average the predicted value is only 120 inhabitants from the actual value. It can also be seen that between 2002 and 2006 the CBS and PRIMOS values are vary closely related. However claims are hard to make with only one historic analysis of only one region, it appears that the predicted value is very much like the actual value. What can be concluded is that for the purpose of exploring future developments the prediction of inhabitant growth is valid and sufficiently accurate.

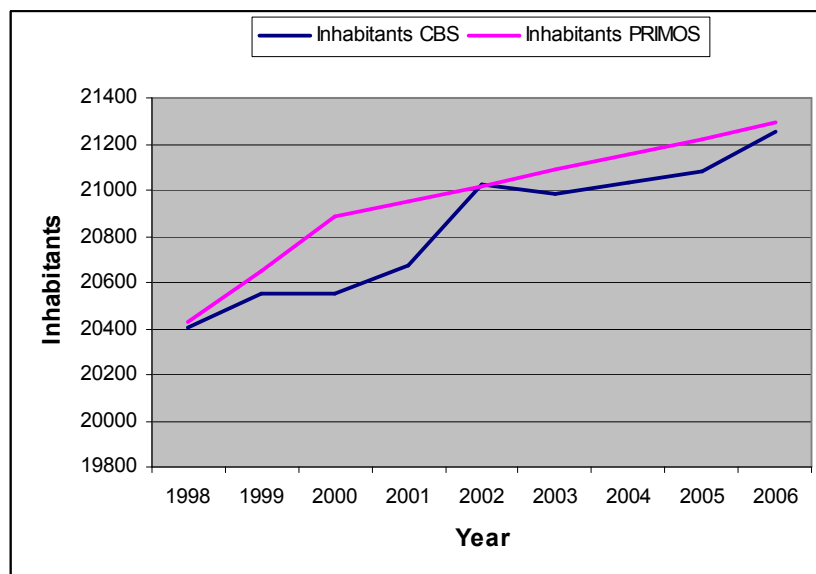


Figure 4.12, *forecasted and actual inhabitants*

In order to continue with the historic validation a small change was made in the model with respect to the CPB scenarios. The old CPB forecast includes only three scenarios whereas the currently used forecasts consist of four scenarios. The model integrity was not changed by this operation, which also illustrates the simplicity of applying changes to the model. The former section already illustrated that the effect that the CPB scenarios have is quite extensive, this should be kept in mind during the assessment of the historic data. From the three “old” scenarios the average scenario is depicted in figure 4.13. The blue line illustrates the actual jobs in the region while the pink line represents the predicted jobs by the simulation model. The moderate scenario predicted a stable economic growth and further automation in secondary and tertiary industry sectors. Because in the WRM region the primary industry sectors are strongly overrepresented the “burst of the internet bubble” is hardly visible in figure 4.13.

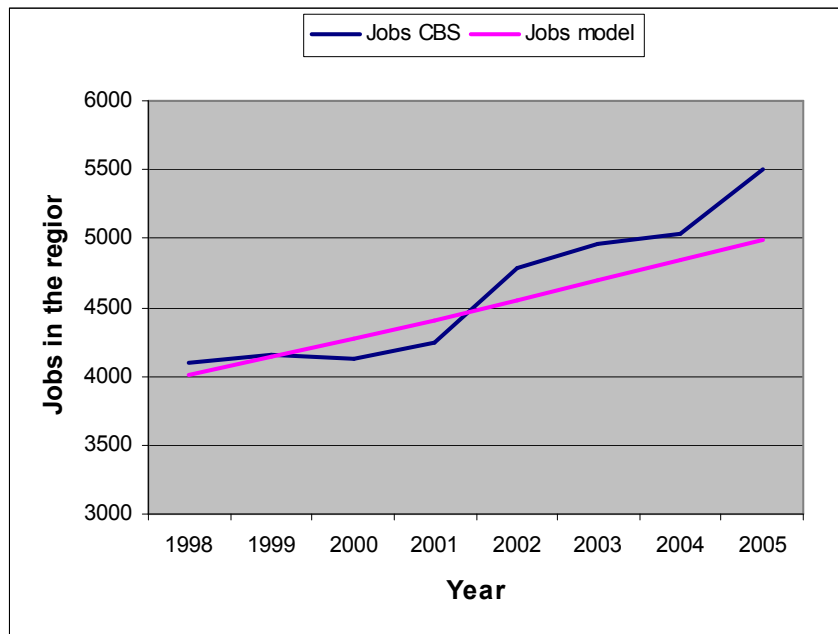


Figure 4.13, forecasted and actual jobs

The development of jobs in the region depends on the economic scenario, historic performance³⁹ and available labour in the region. In 2005 the difference between the predicted and actual jobs in the region is 500 jobs or 10%. Over the period 1998-2005 the average deviation is 200 jobs or 4,4%. This is well within the range of the absolute uncertainty of the sensitivity analysis. Based on this time sequence alone (only one historic dataset is available) it can be said that the model uncertainty bound for jobs is 4,4%. This is sufficient for the exploration of future developments of socio-economic effects.

³⁹ A regression analysis has been executed to calculate average historic performance based on data from 1993-1998.

4.4 Performing group and expert tests

In order to get a better, unbiased and hands-on validation of the simulation model and test the requirements from step 4 (see section 2.5) a number of experts will assess the model. The model will furthermore be tested on applicability in actual group settings where the model will support policy development. In total six expert judgements are given, from the policy and consulting field and also from model experts with experience in spatial economic models (section 4.4.2). The experts will assess the simulation model for its validity. The principles, assumptions and logical deductions that are used must together form a consistent whole in order for the simulation model to be validly usable. In order to test the practical use of the simulation model three group tests will be performed (4.4.1). One will be a peer-group test that will focus on the model purpose, model construction and user interface. The test panel will exist from student members that are knowledgeable on the subject of simulation and system dynamics. The second group test will take place with consultants of DHV, in this test each member of the test team will take on a role from which to take a critical look at the model. The third and final group test involved another group of DHV consultants and focused on the specific use of graphs and table in the presentation of the outcomes of the model. Appendix 10 gives a more detailed description of the expert interviews and group tests.

4.4.1 Group validation tests

Three group validation sessions have been executed in order to test and improve the simulation model. The most important comments, critiques and observations are included in this section, a more detailed description can be found in appendix 10. Based on the results of the group tests the simulation model is improved between each groups test. First the aim of the group session is explained, and then a list of the most important improvements is supplied. Finally a list of improvements is given that not have been implemented in the simulation model yet.

1. The first test case for the simulation model is the peer group test where a group of students acts as the advocate of the devil. The graduate students will test the model hands-on and experience how the model would be used in an actual situation. They were asked to look at the simulation model both from different actor viewpoints especially that of a policy maker and a consultant.
2. The most important results of the first group test, the peer-group, have been incorporated before the second group test. During the second test of the simulation model the actor role principle is explored in more detail. Due to the political sensitivity surrounding the Wieringerrandmeer project the case cannot be tested with the municipalities of Wieringen and Wieringermeer. Therefore a group of 6 members of the DHV E&R staff will participate in the model test acting as important stakeholder in the Wieringerrandmeer case. Before the session, each participant received a short introduction that described the purpose of the test and the role they will “play”.
3. The final group test did not focus on actor roles. It focussed on how the information, the model outcomes, is displayed in the simulation model interface. A group of 4 member of the Management Consultancy department of DHV participated in this test.

Remarks made during the group tests that have been dealt with.

- The information on the outcomes of the simulation model must be displayed in a consistent and structured whole. This way the model user gets quickly adapted to the model interface. Have one central interface layout that shows different graphs and other data.
- The policy makers must be able to see the relation between “their” region and the simulation model. This can be done by:
 - Including a map of the region.
 - Showing the region specific data like inhabitants, jobs, gross regional product before the calculation starts.
- Show the basic assumptions that lie at the foundation of the simulation model. Do however not go too far in detail unless the policy makers request it
- The value axes of the graphs should have fixed values. Now the value axes adjust to the displayed information. This sends a wrong image of the actual situation.
- Clarify the role of the CPB scenarios in the instrument better. It currently is unclear why it has such a large effect on the job development in the region.
- How does the model deal with inflation? It does not need to because all the outcomes that are presented are on a 2005 price level. This should however be mentioned in the assumptions page.
- To prevent the outcomes of the simulation model to be taken without consideration of assumptions and scenario choices the interface should only show graphs. This means that (almost) no numerical information is given on the socio-economic development.
- The subscripts next to the graphs in the simulation model should express more accurately what the viewer is looking at.

Remarks made during the group tests that not have been dealt with

- It would be useful to see the developments after 2030 when for instance the project is delayed.
- It would be useful to see the developments before 2005 to get a better feeling of the past developments in the region.
- The assumption that all the residents of the project dwellings come from outside the project region is not realistic. It should be possible to include a measure for the amount of people that move into the newly built dwellings.

The group tests were particularly important for the validation of the presentation of the simulation model. What especially was mentioned during the first test was the information should be presented in a more consistent manner. After fixing this issue before the second test session no more complaints were heard on the model user interface. The second meeting focused more on what the instrument could do and how useful this information would be to the different stakeholders. The third session revealed that still a lot had to be done in making clear what information was on display. Improvements were made in the semantics of the descriptions of different graphs and tables.

4.4.2 Expert opinions: consultants, policy makers and model experts

In addition to the group sessions a series of expert validations is conducted. The purpose of these expert sessions is two-sided. The aim is to test if the requirements that have been implemented meet the demands of the end user. In other words is the model able to fulfil the intended goal as policy supporting instrument? The second aim is to establish the position and value of the socio-economic simulation model in the field of other available spatial economic models. The list of

interviewed experts is given below, followed by an overview of the most important remarks concerning the simulation model. For a full overview see appendix 10.

1. *Arjan Stegeman* (10 may 2006): Member the project management team of the WRM project. Also interviewed for the requirement analysis.
2. *Wouter Vermeulen* (12 may 2006): Researcher at the CPB and at the University of Amsterdam. Vermeulen is the creator of the regional labour market model of the CPB (Verkade & Vermeulen 2005, Vermeulen & van Ommeren 2005 & 2006).
3. *Bert Schilder* (16 may 2006): Risk analysis expert at DHV. Also interviewed for the requirement analysis.
4. *Wim Voordenhout* (23 may 2006): Financial policy maker for the Province of North Holland. Also interviewed for the requirement analysis.
5. *Mark Thissen* (15 June 2006): Researcher at the RPB and author of the REAM model (Thissen 2005). Also interviewed for the requirement analysis.
6. *Frank van Oort* (15 June 2006): Researcher at the RPB and Professor at University of Utrecht. Author of the book: A survey of spatial economic planning models in the Netherlands (van Oort et al. 2005).

Most important expert validation remarks

- Use of the simulation model is different policy phases:
 - The instrument is useful in the early phases of the policy process contributes in the conceptualization of a regional economic investment problem. However the pitfall remains that if the instrument produces information that is not profitable for the policy makers they might reject it (Stegeman)
 - The model might prove useful in a policy phase were policy makers have “forgotten” why an investment had to be made in the first place. (Voordenhout) This would put the use of the instrument in the implementation phase of the policy life cycle.
 - The thesis model should be used as an instrument in the early policy phases because of its explorative nature (Schilder). The possible uncertainty rate for projects in the construction phase is often in the range between 5-10% for less complex projects and more then 30% for complex long-term projects. As the thesis model has a deviation that exceeds the 30% higher uncertainty it should therefore only be used in explorative situations. Simply put; the accuracy bounds of the instrument do not allow it to be used in more detailed project planning.
- Why is the model not suited to illustrate the difference between the municipality of Wieringen and Wieringermeer in the WRM region (Stegeman)?
 - Reducing the geographical scale of the model further, to the level of individual municipalities is not desirable. This would require a competitive and more complex relation between the two municipalities. Due to the geographical spread of the municipalities and the location of the project dwelling this competition is especially for the WRM case not realistic.
- The instrument has a “shell” or user interface that has never been applied to any regional economic model (Vermeulen, van Oort, Thissen). This also indicates the difference between models developed at the CPB and RPB and more practical model developed by consultancy firms. The ability to “play” real-time with the variables and recalculate the effects is a useful option.

- What does such a shell add (Thissen)? Why is it useful to show the inner workings of the simulation model? By making the details in relations, assumptions and input values visible to the public the model is very open to scrutiny. If a policy maker is not convinced of the results (or the results are not what he or she expected) it becomes easy for the policy maker to criticise the model. If however the model is very complex and the policy maker is unable to understand the inner workings it is much harder for him to criticise the model (Thissen). What is then the value of making a model relatively easy?
- In the regional labour market model the calculations are made on a COROP level. For all COROP regions the model shows that jobs-follow-people. Vermeulen claims that an opposite relation on a lower geographical scale (like the thesis model scale) is not plausible. On a short term the effects are far harder to predict, however in the long term (more than 10 years) jobs-follow-people in all regions and on each geographical scale.
- Vermeulen answered the question if the model could be used for multiple types of regions with yes. The effects that play in a rural area are not similar to that of one of the 6 large municipalities in the Netherlands. However because the model is supply driven, it can be used for a larger variety of regions, not only rural.
- In the thesis model the household and age distribution can be adjusted independent from each other, this can lead to mistakes. In reality these variables have a strong relation. A steep increase of for instance “parents with kids” will also lead to an increase in the age group “0-15 years old” and to a lesser degree in group “15-30 years old”. An unsuspected model user might forget this dependent relation and fill in incorrect data (Vermeulen).
 - Yes that would be possible but it would also compromise the intention to keep the model as simple as possible.
- The relation that jobs-follow-people has only be proved by Vermeulen (Vermeulen & van Ommeren 2005, 2006) for COROP regions. It is therefore not correct to translate that directly to the WRM region, as the model only entails two municipalities of the COROP region. If the inhabitants in the region increase this will certainly have an effect on the non-basic sectors. However it has not been proven on a municipal level that jobs follow people (van Oort). The latter is also an effect that is generally more associated with Randstad developments. Is it realistic to assume that the financial market will grow as a consequence of the newly built dwellings?
- Because the thesis model uses the PRIMOS model outcomes a conflict occurs in the calculation of the economic development. At the basis of the PRIMOS model a series of assumptions and calculations lie that are also present in the thesis model. However the demographic developments that are calculated in the PRIMOS database are also calculated and based on of the jobs in the region.
 - The calculation of the investment impulse in the simulation model does consider this effect and calculates the new inhabitants based on the new dwellings in the region.

4.5 *Conclusions of model validation and requirement testing*

The third sub question of the thesis focused on the applicability of the simulation model and how the instrument could be used in real life and what value can be attributed to the outcomes?

What is the practical applicability of the developed instrument?

- a. What is the robustness of the model in terms of predictability?*
- b. Can the instrument fulfil the requirements that were initially set at the start of this research?*
- c. Is the instrument applicable for regions with different characteristics?*

In chapter 3 the simulation building process is described making the transition from causal concept model to the final simulation model in PowerSim. To assess if any inadequacies found its way into the model the validation phase in this chapter is the final check before the model can be used. The validation also indicates points of attention and known weaknesses in the simulation model. These known weaknesses have to be considered whenever using the model or the outcomes of the model. Section 4.5.1 goes into more detail on the robustness of the simulation model (sub question a) while 4.5.2 assesses if all the requirements are implemented in the final instrument. Section 4.4.3 illustrates the applicability of the simulation model on multiple regions.

4.5.1 **What is the robustness of the simulation model**

In the validation process the sensitivity analysis receives special attention because it also functions as an uncertainty measurement technique that relates to the core of this thesis problem. The validation illustrates that some variables are very sensitive compared to others. This can prove weak point in the input data of the simulation model. However if sensitivity analysis is applied to the policy instruments or steering variables it can indicate which instrument is the most potent. Therefore, the sensitivity analysis should form an integral part of the simulation model. The total robustness of the model can be expressed with the lower uncertainty bound. For the jobs in the region this gives an 8% absolute uncertainty and for the regional spending 20%. This means that more accurate claims can be made on the development of jobs than on the development of the regional spending. This also illustrates that the predictability of the model only is valuable in the early phase of the policy life cycle. As for later policy phases a predictability of less than 10% is required (Interview: Schilder 16-05-2006).

During the development of the simulation model, the series of assumptions that have been made are tested on their impact in the sensitivity analysis. The most important conclusion from this analysis is that the CPB scenarios throw a large overcasting shadow on the outcomes of the model. The fact that the CPB scenarios press hard on the outcomes has two causes:

- The CPB scenarios for the long-term development of the economy have been estimated in two time series. In the simulation model this translates into economic development between 2005-2020 and between 2020 and 2030. Because the growth or decline percentages differ significantly between these two time series a sudden change is visible in the model outcomes (see figure 4.1). This sudden change leads to a lot of discussion that was also picked up during the test sessions.
- A second cause of the large effects of the CPB scenarios is the difference between the four scenarios. The best and worst case economic scenarios are depicted in figure 4.1 and show a

difference of more than 1000 jobs in 2030, more than 20% of the total jobs. The effects of the economic scenario change are often larger than the effect the investment impulse. This also means that in the economic stagnating scenarios the investment impulse can be the difference between growth and decline of the economy in the project region. However in the economic best scenario the investment project a less important factor than the economy.

Another variable that is highly sensitive is the regional binding factor and the effect it has on the regional spending. Because regional binding is directly linked to the amount of disposable income inhabitants spend in their own region the influence on regional spending is very large. The absolute uncertainty of the binding factors is 21%. Caution should be taken when assigning these values to the simulation model. A market study of “Koopstroomonderzoek” specifically on the WRM region could provide more solid data (KSO 2004).

The sensitivity analysis of the simulation model gives information on the delicate variables in the simulation model. It does not say anything however on the quality of the outcomes of the model. In order to get a better understanding of the predictability power of the simulation model a historic validation is executed. The historic validation illustrates that the predicted values lie very close to the actual data, the development of jobs in the region is only differ only 4,4% from the actual value (see figure 4.13).

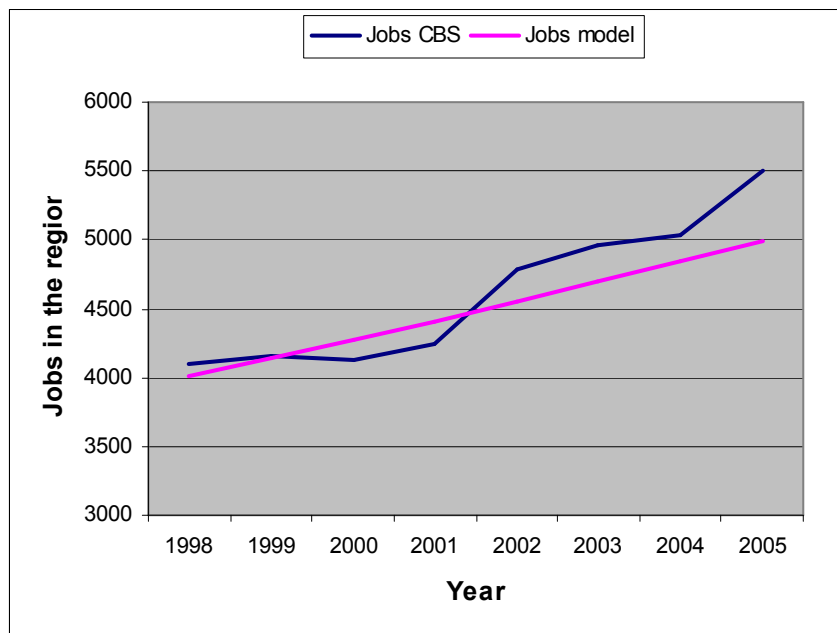


Figure 4.13, forecasted and actual jobs

The outcomes of the historic validation indicate the simulation model can be used in early phases of policy development. Due to the large uncertainty in the sensitivity analysis it is less suited for more detailed planning and policy implementation calculations.

4.5.2 Did all the requirements find their way into the simulation model?

Now the model has been validated and tested in different use-case settings by respondents and model experts, it is time to look back at the starting principles of the model. This section will assess which of the need-to-have requirements from chapter 2 were included into the final simulation model presented in chapter 3. A complete overview of all the requirements is given in appendix 6.

The most important matches and mismatches between the requirement analysis and the final simulation model will be discussed in this section. About 85% of all the requirements could be implemented in the simulation model. For the discussion of the requirement the same tables are used as in chapter 2.5.3 so that each requirement source will be dealt with.

Policy maker requirements

For the policy makers requirements concerning understanding the model and having sufficient insight in the reliability of the simulation model were among the most important. The interface has been made in such a way that a “Jip & Janneke” version is presented at the start of the model (2, 3). If more specified information is required, the model user can enter the advanced modus for more complex functions.

| Policy maker: communication | | In model? |
|--|--|------------------|
| 1 | Avoid using tables and use at the most 2 variables per graph | YES (max 1) |
| 2 | Be able to change presentation “styles”: comprehensive to simple | YES |
| 3 | o Include a "Jip en Janneke" version explainable to laymen | YES |
| | Include the following factors | |
| 4 | o Housing market and inhabitant development | YES |
| 5 | o Employment | YES |
| 6 | o Show 4 year policy cycles and economic growth | YES |
| 7 | Not require more than 5 minutes on theory of system dynamics | Depends |
| 8 | The interactive session with client must not take longer than 2 hours | YES |
| Policy maker: model performance | | In model? |
| 9 | Include new variables (region specific) and remove obsolete variables | YES |
| 10 | Only use averages in the presentation of outcomes | NO |
| 11 | Communicate reliability and the status of the model outcomes | YES |
| 12 | Present uncertainties and assumptions in complete but orderly fashion. | YES/NO |
| 13 | Offer the possibility to calculate different policy scenarios | YES |
| Policy maker: policy issue | | In model? |
| 15 | Support gut feeling of policy makers | YES |
| | Communicate different stakeholders: | |
| 16 | o The residents of a region (they will influence local government) | YES |
| 17 | o Other governments (for the creation of support) | YES |
| 18 | o Other political parties for the (creation of support) | Not always |
| 19 | Be used in early phase of policy life cycle | YES |
| 20 | Give indication of effects on provincial scale | NO |
| 21 | Give indication of effects between small municipalities | NO |
| 22 | Show result on a time scale between < 30 years | YES |

Table 4.1, requirement list of the policy makers

A requirement that found it’s way half into the model is the presentation of uncertainties and assumptions (12). During the group testing sessions users tended to believe the information without a doubt, and not question the underlying assumptions or reliability of the output (section 4.3). However showing *all* the assumptions and uncertainties will not improve the understanding of the model user, it would only confuse him or her. Therefore only the key assumptions and uncertainties are shown in the model and available in the advanced modus. Two requirements that could not be included were the effect of the investment impulse on a province scale (20) and the difference in socio-economic effects between two small municipalities (21). To include the effects of an investment project on the province would require a complete province model, which would increase the complexity of the instrument ten fold. To illustrate the effects between to small

municipalities would require a lower geographical scale level. This would mean that even smaller effects would occur. For instance, small changes like the departure of a local grocer would present large deflections in the model that are not justified. The geographical scale of the model will therefore remain a multi-municipal and COROP scale. Table 4.1 gives an overview of the important Need-to-Have requirements that were identified in the requirement analysis in chapter 2. The left column indicates if the requirement has been incorporated into the model.

Consultant requirements

To meet the consultant requirements the model incorporates different levels of detail in the outcomes and the relations between the in- and output variable are made visible (3). The model relations are visualized both in a causal model and in the PowerSim model itself (5). The sensitivity of the input variables is made visible in the model by using of the risk analysis tool (9, 12). This tool also provides reliability intervals and the confidence bounds of the model outcomes, hence the uncertainty of the outcomes. Another important requirement of the consultants was that the outcomes of the simulation model had to be producible (15). This has been accomplished by omitting the stochastic variables. A nice-to-have consultant requirement that was built into the simulation model is the “help” function. This function displays information on how to use the model and gives background information on system dynamics.

| | Consultant: communication | In model? |
|----|---|------------------|
| 1 | Be suited for the use with different actors and different regions | YES |
| 2 | Present results in graphs with a maximum of 3 variables | YES (max 1) |
| 3 | Show relationship between input and output variables | YES |
| 4 | o Highlight the policy steering variables | YES/NO |
| 5 | Show visual representation of model relations | YES |
| 6 | The interactive meeting should take a half to a full day | YES |
| | Policy maker: model performance | In model? |
| 7 | Display additional variable information on demand: | YES |
| 8 | o Standard deviation of outcomes. | NO |
| 9 | o Input variable sensitivity. | YES |
| 10 | o Reliability interval and model bounds. | YES |
| 11 | Show distribution of uncertainty on output values. | YES |
| 12 | Use sensitivity analysis for uncertain input variables. | YES |
| 13 | Make use of known modelling techniques like the PRIMOS model and the shift-share method for estimating employment development. | YES |
| 14 | Clarify the relation between the thesis model and available models and methodologies: Social Cost Benefit Analysis, REGINA etc. | YES |
| 15 | The model outcomes must be reproducible results. | YES |
| 16 | Store time-series outcomes in spreadsheet (Excel) | YES |
| | Consultant: policy issue | In model? |
| 17 | Present model outcomes in simplified “Jip & Janneke” versions. | YES |
| 18 | Give insight in the “mitsen en maren” of a project → show the model assumptions. | YES/NO |
| 19 | Scale of the project the model should be suited for: | |
| 20 | o Financial: > 10 million euro. | YES |
| 21 | o Time span: 10 - 30 years. | YES |
| 22 | One input screen for all the regional variables. | YES |
| 23 | Use the model to gain insight on a provincial scale. | NO |

Table 4.2, requirement list of the consultants

Requirements that are *not* present in the model are for instance the presentation of the standard deviation from model outcomes (8). Due to the lack of statistical functions in PowerSim this requirement fails the instrument. However because the data from each model run is written to MS Excel the standard deviation and other statistical data on repeated model runs can be analyzed with excel. Table 4.2 gives an overview of the important Need-to-Have requirements that were identified in the requirement analysis in chapter 2. The left column indicates with yeas or no if the requirement has been incorporated into the model.

Policy issue requirements

The requirements related to the policy issue, the Wieringerrandmeer project, focused on the effects of tourism on the region. To meet these requirements the instrument is able to indicate a tourism ambition level for the project region that indicates the amount of tourism the WRM region would like to attract (4). Indicators are also implemented to give insight in the supply of retail and social services.

| | <i>Policy issue: communication</i> | In model? |
|----|---|------------------|
| 1 | Very simple model interface | YES |
| 2 | Understandable for laymen | YES (Depends) |
| 3 | Model must be able to deal with local communities and government | YES |
| 4 | Give insight in the effect of tourism | YES |
| 5 | o Day tourists and long holiday | YES |
| | <i>Policy maker: model performance</i> | |
| 6 | Indicate the risk and uncertainty involved in the project | YES/NO |
| 7 | o Make a difference between Wieringen and Wieringermeer | NO |
| 8 | o Uncertainty with respect to economic scenario | YES |
| | <i>Policy issue: prolem setting</i> | |
| 9 | Illustrate the effect of stopping the project half way | YES |
| 10 | The model should facilitate a setting that will lead to a closer relation between Wieringen and Wieringermeer | YES/NO |
| 11 | The model must show growth in retail, social services and recreation | YES |

Table 4.3, requirement list of the policy issue

A requirement that has not been implemented is the possibility to assess the risks and uncertainty for each municipality individually (7). This compromises the requirement of individually analysing the municipalities in order to gain insight in possible skewed benefits between the municipalities. Table 4.3 gives an overview of the important Need-to-Have requirements that were identified in the requirement analysis in chapter 2. The left column indicates with yeas or no if the requirement has been incorporated into the model.

Literature based requirements

Requirements found in literature study aim at a more conceptual level of the requirement analysis. The model includes a differentiation of the regional economic industry sectors, household types and age groups. From the work of Koops (2005) and Armstrong and Taylor (1993) the most important socio-economic factors were used: labour market, age, households, available labour, the gross regional product, regional consumption and housing market (2-5,7,8). A requirement that has not been included is the attractiveness of the region (6). Identifying an attractiveness factor for a region is more a market study where different amenities in a region have to be valued for their positive or

negative attractiveness. This does not fall in the scope of the thesis model. According to Vermeulen (2006) a conceptual choice has to be made between jobs-follow-people and people-follow-jobs (1). Jobs-follow-people has been implemented into the simulation model, for discussions of this issue see section 2.3.3. The simulation model also includes a new interesting and unconventional concept (Glaeser et al. 2001 and Florida 2002) through the introduction of the decreasing historic importance in the shift-share analysis (15). The historic importance is substituted by the availability of labour force in the region. The concept of limiting growth capacity of Nijkamp & Reggiani (1998) is used to prevent historic events to be extrapolated unrestrained (10).

| | <i>Literature requirements</i> | In model? |
|----|---|------------------|
| 1 | Make a choice in the theoretical predicament of job-follow-people or people-follow-jobs (Vermeulen & Verkade 2005). | YES |
| 2 | Differentiate a set of production sectors to indicate economic and employment growth in these sectors (Heida 2002) | YES |
| 3 | Include the following factors (Armstrong & Taylor 1993) and (Koops (2005): | |
| 4 | o Labour market: working labour force, unemployment, jobs in region, vacancies. | YES/NO |
| 5 | o Demography: household size and composition, age, migration, birth/death rate. | YES |
| 6 | o Gross added value. | YES |
| 7 | o Attractiveness of region (through labour, residential or income advantages). | NO |
| 8 | o Income: Regional wage level, consumption, average income. | YES/NO |
| 8 | o Real estate and land: supply of dwellings, demand of dwellings, price levels. | YES/NO |
| 10 | Include limited capacity of growth factors to prevent interpretation errors with extrapolation (Nijkamp & Reggiani 1998). Major, one time events in the past may have had a large effect on the historic growth. Extrapolating this growth without indication of such an event happening again would be unjust and therefore growth (and decline) bounds should prevent excessive growth. | YES |
| 11 | The model must be able to indicate potential risks early in the policy phase (TCI 2004). | YES |
| 12 | Show underlying assumptions of the modelling technique (Meadows 1976). | YES |
| 13 | The model must not predict the future but give direction to the effects that a decision has in the far future under different economic scenarios (Handbook of Knowledge Society Foresight 2003). The model should be interpreted more as giving direction opposed to providing a prediction (Koops & Muskens 2005). | YES |
| 14 | Always include expert opinions of non model-makers for specific regions (Forrester 1980). | YES |
| 15 | Develop the model in such a manner that it is possible to include other interesting (unconventional) economic relations (Glaeser et al. 2001) and (Florida 2002) | YES |

Table 4.4, *requirement list based on literature research*

4.5.3 Is the simulation model applicable for regions with different characteristics?

The simulation model in the thesis model is developed with the aim to implement the model for different projects, hence for different regions. This is made physically possible through the loosely coupled relation between the input variables in an Excel database and the simulation model in PowerSim. Because the PowerSim software imports data from an excel spreadsheet file it is relatively easy to replace this data with data from another region. Therefore the reference information used for instance for the shift-share analysis is based on national data for which no adjustments need to be made. It also is possible to add extra model components to the instrument. Some extra components were already added for the WRM case. Fact is that not every region exhibits the same characteristic and not every policy issue is concerned with in the same variables of the economic system. As mentioned this requires great flexibility of the simulation model. On the other hand the question remains if one simulation model can be used for multiple regions. For the WRM case study more detailed information was required concerning tourist spending in the project region. For other regional investment projects tourism might not be an issue. For instance

the attractiveness of a business development location might be an important focus. In terms of model construction this would therefore be possible.

From an economic geographical focus, a highly urban region with extensive industries and high concentrations of jobs has more complex economic relations. Relations like for instance agglomeration effects and knowledge spillovers. To incorporate these effects more modules should be added to the current instrument that corrects these effects. However a problem that can arise due to the implementation of those extra modules is an increase in the simulation model complexity. Due to the interdependent relations between the different variables the complexity of the simulation model spirals out of control. This would compromise a basic principle of the instrument: keep it manageable.

In the expert interview Vermeulen mentioned that if a model is controlled by the supply of labour (Vermeulen & van Ommeren 2005, 2006) it can be applied to multiple regions. Supply controlled means that the availability of labour (the potential labour force) determines the growth of jobs in a region. Most of the existing models (for instance REGINA) are controlled by the demand of labour. This means that if more jobs are created by for instance building a new industrial area, the people will come subsequently. New empirical evidence that has been researched by Vermeulen suggests that demand controlled job development is not correct. This research shows a clear, long-term relation between the supply of labour in a region and the development of jobs in a region. Because the job development in the thesis model is also controlled by the supply of labour through the shift-share analysis (see section 3.2) it can be classified as a supply model. Vermeulen and van Ommeren state that the model can then be used for multiple regions.

A consequence of a supply driven job development is that the construction of new dwellings causes people to move to that region and hence, supplying labour and therefore increasing job growth. The development of housing projects is for Vermeulen the most important factor for the socio-economic developments in a region. Vermeulen therefore thinks that the simulation model in the thesis can be applied to a large scope of rural and urban areas. The application of the model limits and should not be used for the socio-economic analysis of one of the 6 larger, more industrial cities in the Netherlands. Because only one case study has been performed the historic validation of an urban region has not been tested. As a recommendation it would be very interesting to see if the historic validation performs equality well for a rural as for an urban region.

5 Conclusions

The problem identified in the introduction of this thesis was the lack of an instrument that could quantify and explore socio-economic effects early in the policy life cycle. The instrument could especially be used in regional, spatial investment decisions. The consultants at DHV Economy and Space (E&S) have witnessed an increasing demand for socio-economic studies and search for an instrument to supply this demand. Literature research showed that the currently available instruments for the assessment of regional investments lack some important properties. These economic instruments either have a wrong geographical focus, they do not correctly convey the uncertainty of the outcomes or they are too difficult to function as a communication instrument in a group session. The latter is important because according to Don (2004) better decisions are made if policy makers and consultants work more closely together. A *simulation* model could provide visual aid in this relationship between consultant and policy maker. To be more specific a system dynamics model could fulfil these requirements. System dynamics has the property that it can portray the non-linear, dynamic and time dependent behaviour that is nested in regional socio-economic relations.

The objective of this research was to define the (user) requirements for an instrument that could be used for the support of policy makers in spatial policy development. More specifically: an instrument in the form of a simulation model for the assessment of socio-economic effects that result from investments in spatial projects. Based on these requirements and the system dynamics methodology, the policy-supporting instrument is constructed and tested. This objective has been accomplished and DHV Economy and Space can use the instrument for aiding consultants in giving better advice. The higher quality of advice is hopefully translated into better decisions made by policy makers.

5.1 *The thesis questions partly satisfied*

This thesis project started with research in regional economy, econometric models, policy supporting models and the potential of system dynamics as economic modelling technique. From this literature research the main question spawned:

How can the system dynamics approach contribute to the ex-ante exploration and assessment of policy options in spatial investments in a region?

To answer this question the properties of system dynamics have to be matched to the goals of an instrument that is capable of exploring policy options in spatial investments. A great strength of SD models is that they relate closely to mental models and that discussion of the relations in an SD model is relatively simple. If "A" increases then "B" decreases is the basic line of thought when analysing an SD model. This simplicity is desired for the communication between policy makers and consultants. Therefore the most important principle when using a SD methodology is to make sure that the policy maker understands the consequences of a proposed policy option. This will assist policy makers in understanding the non-linear developments in a project region.

In order to test the qualities of SD in this matter a simulation model is built based on the properties of system dynamics. An SD simulation model has two important components. First, it calculates results like any other mathematical (economic) model. In addition the SD model provides the possibility to turn levers and adjust model setting relatively easy. The second component of an SD model is that it gives elaborate visual representations of the outcomes of the model and how these outcomes come about. This will lead to a better understanding of the economic system by the policy maker. It also provides a platform on which the consultant (assisting the policy maker) and the policy maker can discuss potential situations in the project region. This in turn will involve the consultant more in the local problems, giving him or her a better basis on which to form his advice.

Next to the visualisation of the socio-economic relationships the instrument must provide a high quality projection of the future developments in the region. Therefore regional information from different sources is used to provide the input variables with correct data. The use of data from existing models can greatly reduce the complexity of the model, leaving only the relevant socio-economic relationships. This also has advantages when applying the model on different project, the external data is easy to exchange.

By managing the complexity of the model (as representation of reality), the presentation of the model outcomes and different theoretical economic discussions, a basic SD property been lost. By using external databases (to reduce complexity), a lot of the model variables have become exogenous variables. This means that these variables are no longer controlled by the internal behaviour of the model. This in turn causes the causal feedback loops to fall apart. Causal feedback loop form a major element of the SD methodology (see figure 5.1). The concept model that is used as basis for the simulation model does not show any causal feedback loop. The question then comes to mind if this model is a true system dynamics model? All the other conditions surrounding the problem and the development of the model are evidence of, and approve of, the use of system dynamics. The models properties (time dependent, dynamic and non-linear) all justify the use of system dynamics.

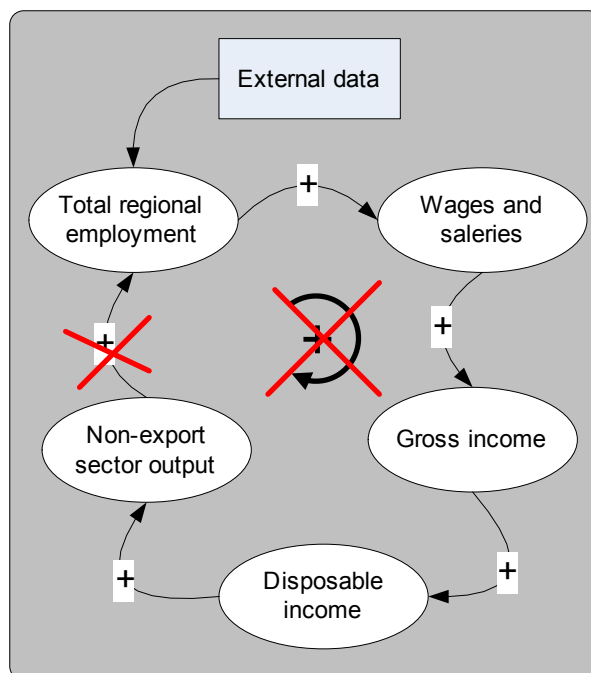


Figure 5.1, broken causal feedback loop

Why the feedback loops are not present in the concept model can be explained by the exogenous data itself. The exogenous data “breaks up” the feedback loops in the system. In figure 5.1 this is illustrated using part of a regional export model. There exists a causal feedback loop that increases the total regional employment through spending in the region, which in turn causes more regional employment. This loop is interrupted if the total regional employment becomes exogenous and is controlled by external data. The same happens in the thesis model because the inhabitants, dwellings and households are exogenous. Because the model cannot control these variables causal loops that control endogenous behaviour do not occur. So it seems that the solution for the problem of controlling the complexity of the model has caused a failure in the justification of the methodology. The question then becomes if the thesis model is a system dynamics model? The answer to this question is yes. The instrument is still based on causal relationships and it calculates the inflow of inhabitants, dwellings and jobs in a region. Furthermore the visual representation in the model assists in explaining why certain effects occur in a region. The simulation model illustrates the time lagged, dynamic behaviour of the socio-economic effects in a region. This could not have been done with for instance an Excel model or with another methodology. This leads to the conclusion that without feedback loops all the properties of system dynamics contribute to the thesis model, and that therefore system dynamics is a valuable instrument.

5.1.1 Leading indicators and underlying relations

The first sub question follows logically from the main question and concern the properties of a system dynamics instrument. What demands should it meet, what are the intended users and what variables must be included in the model? This leads to the following question concerning the instrument requirements:

- 1) *What are the leading indicators and underlying relations of an instrument for the ex-ante exploration and assessment of policy options in spatial investments in a region?*

From the requirement analysis and the research of existing economic models it can be concluded that the three most important indicators for the socio-economic instrument are:

- 1) Demographic data
 - a. The development of the age and household distribution
 - b. The development of dwellings in the project region
- 2) Employment data
 - a. The development of jobs in different industry sectors
- 3) Economic data
 - a. Spending in the region
 - b. Gross regional product

These indicators need to have a prominent place in the presentation of the outcomes of the instrument that is used for advising policy makers. Sub-questions *a*, *b* and *c* go into more detail concerning the model requirements, existing models and available data

- a. *What are the user requirements of such an instrument?*

To answer this question a number of requirement sources are addressed. First a series of interviews is conducted with policy makers, consultants and model experts. Second, a literature study is performed on existing economic instruments for the assessment of socio-economic issues.

The results of the interviews and the literature study are grouped into requirement lists. These lists are then used as a guideline during the construction of the instrument.

The most important requirements demanded that the instrument must:

- Include variables that project developments of the regional demography, employment, housing market and gross regional product.
- Show a distribution of the uncertainty of the outcomes and the sensitivity of the input parameters early in the policy process.
- Provide a clear indication of the assumptions involved in the model.
- Show effects of different policy options under different economic scenarios.
- Illustrate the development of jobs and in different industry sectors.
- Export the instrument data to excel for further processing and storage of output data.

During the requirement analysis respondents posed some contradicting requirements. Because these simple dilemmas can have huge design implications or indicate weaknesses in the instrument concept, contradictory requirements are handled with care. Passing the dilemma through four steps solved each contradiction issue. The underlying meaning of the contradiction is analysed first, to check for hidden “icebergs”. Secondly a simple solution is sought like implementing both requirements parallel to each other. If this does not solve the issue the requirement with the predicate “need-to-have” is given priority over a “nice-to-have” requirement. When a contradiction persists, the forth and final step is choosing the requirement that is the least time consuming to implement in the instrument.

During two of the interviews the term “Jip & Janneke” presentation was mentioned. Apparently to indicate that the instrument should be understandable in an instance and that using the instrument should not require special skills. However, other requirements demanded detailed information with high complexity. To solve this problem, the instrument is equipped with multiple levels of complexity in order to give novice and advanced user options. A second example is the contradiction between making the instrument suited for the provincial and municipal level. The desire to apply the simulation model on varying geographical scales is understandable. The requirements put forth by the respondents to apply the model on a provincial or small municipality scale is not possible though. On a provincial scale the model should incorporate more complex variables like province competitiveness, the model is too simple for this scale. On a small municipal level the necessary information is not available. Furthermore, on a small scale, small changes (for instance the departure of a local grocer) present large deflections in the model that are not justified. The geographical scale of the model will remain a multi-municipal and COROP scale.

- b. What can be learned and used from the existing models or instruments for regional economic analysis?*

The publication of van Oort et al. (2005) on the currently available spatial models in the Netherlands provided a good starting point for researching economic models. In this paper a selection of models discussed that all have a specific goal in serving policy development. For a more detailed description see section 2.4. Table 5.1 shows the properties of the economic models that have been discussed in this thesis. The properties of the models are listed in the left column and are (except for welfare effects) all requirements for the thesis instrument. For the SCBA the simple (“kentallen kba”) version is included in table 5.1 because it is the most used.

| <i>spatial economic models</i> | | | | | | Labour market | Thesis model |
|--------------------------------|---------------|-------------|---------------|-------------|---|----------------------|---------------------|
| | PRIMOS | RAEM | REGINA | SCBA | | | |
| Demographic developments | • | | | | | • | • |
| Housing market developments | • | | | | | • | • |
| Labour market developments | | • | • | | | • | • |
| Regional spending | | • | | • | | | • |
| Gross regional product | | • | | | | • | • |
| Visual data presentation | | | | | | | • |
| Scenario analysis | | • | • | • | | | • |
| Welfare effects | | | | • | | | |
| Geographical scale level | M - C | C | M - C | C | C | | M - C |

M = Municipal level
C = COROP level

Table 5.1, *spatial economic models comparison*

What table 5,1 illustrates is that none of the existing spatial models possesses all the properties that are required for the thesis model. There is one property that is only present in the thesis model: the ability for direct visual presentation of the outcomes⁴⁰. Although the other models did not fulfil the requirements, they did provide interesting notions and model concepts that could be used in the development of the thesis model. The thesis model is drenched with concepts and data from existing models. Without these concepts the thesis model could not have been built. Some examples how the other models are used in the thesis model.

- The PRIMOS model is used for its forecasts of demographic and housing developments until 2040 (Heida 2002). The time series output data of PRIMOS is used as input for the thesis model. Furthermore PRIMOS supplies some excellent insights in how demographic development comes about and what motivates inhabitants of a region to migrate to another region.
- The REGINA model from TNO (Koops 2005) shows that a relatively simple technique like shift-share analysis can be extended to make it more realistic in presenting economic and labour market developments. The shift-share analysis is adopted in the thesis model with the availability of labour as extra steering variable.
- The regional labour market model from the CPB is useful because it has examined, based on empirical data, the relationships between housing, employment and migration (Vermeulen & van Ommeren 2005, 2006). These issues are particularly important for the thesis model. The labour market model makes the statement that in fact “jobs-follow-people”; this concept has also been used in the thesis model.

c. *What are the generally accepted data sources that can be used as input parameters for such an instrument?*

Finding all the required information for the simulation model proved to be a long and painstaking process. Data from over 10 sources were used in the model. The two largest suppliers of data were the PRIMOS model and the CBS StatLine database:

- The PRIMOS model provides time series predictions between 2005 and 2040 for a set of demographic data (Heida 2002). These forecasted data are available on the level of municipality and therefore can be used in the thesis model. The data used from the PRIMOS

⁴⁰ The results of the other models can only be presented in graphs and tables after being processed in a spreadsheet program.

model included the composition of the population distributed over household types and age groups. The autonomous development of the dwellings in the project region is also extracted from the database.

- The CBS StatLine is the largest database on historic economic data in the Netherlands. It contains thousands of table's worth of information from unemployment levels until level about how safe people feel. The data from StatLine have been used in the historic validation and served as starting values for a lot of model variables. Among these start values were: dwellings in the region, jobs per industry sector in the region, unemployment, working labour force and disposable income of households
- The economic forecasts based on the work of Huizinga & Smid (2004) also play an important role in the simulation model. The validation showed that the economic scenarios are very determining in the outcomes of the model. The economic forecasts that are used include: forecasts for the unemployment, estimations of the development of the gross national product and productivity.

Data from the sources mentioned above are generally accepted in the regional sciences community. The data from the PRIMOS model has received a lot of critique over the past ten years. Claims that the PRIMOS prediction would not be accurately enough and the structure of the model was not sufficient. However, since there has never been another fruitful attempt to model demographic developments in the Netherlands, PRIMOS remains the purveyor of demographic data for a lot of economic studies.

5.1.2 Construction of the simulation model

In order to build a simulation model two translations have to take place. A translation from general idea to concept model and secondly a translation from that concept model into the actual simulation model. The second thesis sub-question concerns the coming about of the simulation model.

- 2) *How to construct an instrument for the ex-ante exploration and assessment of policy options in spatial investments in a region?*

The requirements found in literature and in the requirement interviews (see chapter 2) formed the basis of the concept model. By identifying the important model variables from the requirement interviews the literature handed the relationships between these variables. Then the existing models showed some interesting characteristics or insights that provided useful in the second translation (concept to quantified model). When the conceptual model was finished it had to be translated into the actual simulation model using PowerSim and Excel. An important aspect of simulation model building is making iterative steps. The simulation model is built from different model components. Each of these components is a functioning whole that is attached to the model once it is finished. Figure 5.2 illustrates the eleven model components that currently comprise the simulation model. Due to the component structure removing and adding other components is relatively easy and does not interfere with other components.

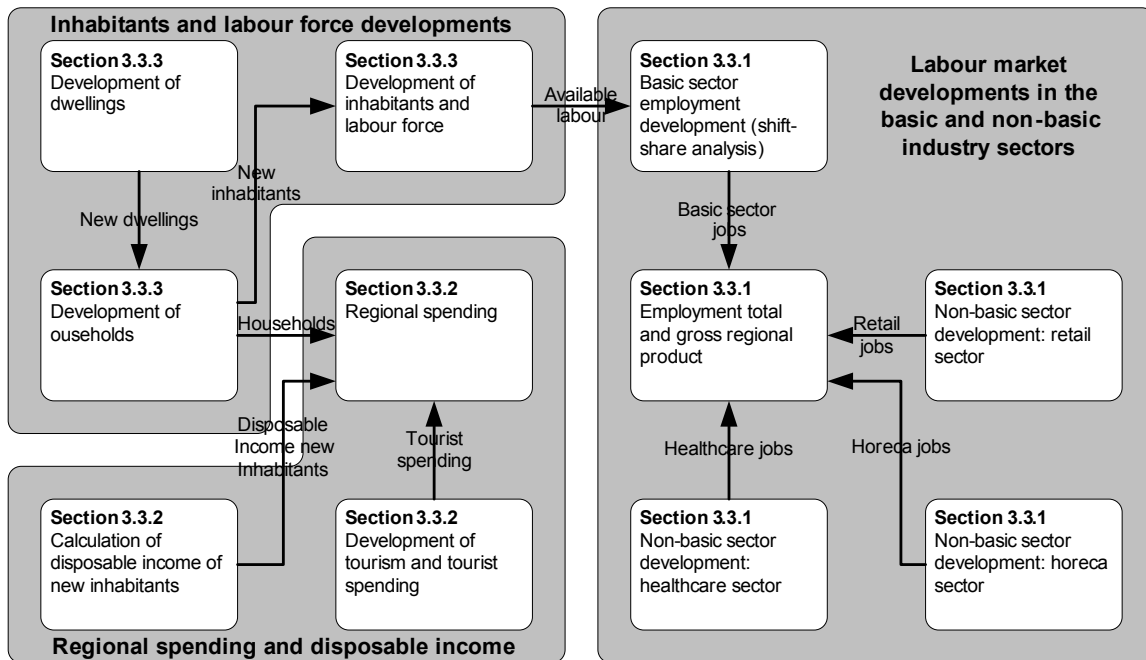


Figure 5.2, the simulation model components

- a. How are the notions from the requirement analysis, literature study and existing models translated into a conceptual model?

The first step of constructing the concept model started with a white board and marker. Using the knowledge from the literature the important variables are written down. The next step is to connect the different variables and to name the relations. These relations will, later in the process, be quantified. Then a long process of discussion and redrawing starts that finally results in a concept model. During the development of the concept however assumptions are made to keep the concept model manageable. It is for instance not realistic to extrapolate the historic performance in the shift-share analysis indefinite a control mechanism is built in. The availability of labour gradually replaces the overrepresentation of the industry sectors (the jobs-follow-people theorem). Initially the model was intended to incorporate a lot of aspects and causal relationships from the Urban Dynamics model from Forrester. However when the first translation started it appeared that the user requirements were hard to match with some of the properties of the UD model. The geographical scale of the model of Forrester was hard to extract because it is based on a small town that grows into a metropolis. This growth period was also a problem because the UD model was made to calculate the developments of a city over a period of 250 years while the thesis project is only interested in a ten times smaller runtime. The concept model is therefore built from scratch, using UD and other material where needed.

- b. How is this conceptual model translated into a mathematical simulation model?

The concept model is the blueprint for the simulation model in PowerSim. The first step of this translation is copying a small piece of the concept model in PowerSim. This small piece has to function before further development can continue. During this period of model development a lot more assumptions are made. In the model it is for instance not possible for dwellings to be uninhabited. Uninhabited dwellings make up an insignificant part of the total supply of dwellings. By leaving the empty dwellings out the model becomes much less complex because households

and dwellings could be coupled to each other. These assumptions are far easier to make and implement early in the second translation than when the model is almost finished. Another assumption that is made for the sake of simplicity is the reduction of the 15 basic industry sectors to only 9. Once the small model components work correctly other components are added, just as long as all the variables from the concept model are included in the simulation model

5.1.3 Practical applicability of the simulation model

The third sub question of this thesis project concerns the evaluation of the simulation model that has been constructed. It is mainly concerned with the practical applicability of the model. Can DHV use it for the exploration of socio-economic analysis? The third sub question is:

3) *What is the practical applicability of the developed instrument?*

The simulation model can fulfil most of the requirements it is currently able to satisfy more than 85% of the requirement list. Some of the requirements have been left out due to time constraints while others simply appeared impossible to implement due to restrictions in the software or available data. The dilemma that required the model to have novice and advanced user options (including the “Jip & Janneke” version) has been resolved adequately by making simple and advanced user interfaces. The instrument starts in novice mode; more complex analyses can be requested by clicking on advanced mode. All the required model variables (demography, employment, housing) have also been included in the simulation model. With respect to assessing the risks and uncertainties of the proposed policy option there are multiple options. First, what-if analysis can be performed by individually changing input variables of the model. Second, by using the risk assessment tool in the simulation model a specific variable can be analysed on sensitivity by executing multiple simulation runs. The economic scenarios are also present in the instrument.

a. *What is the robustness of the model in terms of predictability?*

The sensitivity analysis of the instrument proved that only the regional binding factors are overly sensitive to small changes. The regional binding factors determine the amount of disposable income that is spent in the project region. This means that the model is less robust on this point. To make sure that the correct regional binding factors are used a Koopstroomonderzoek (KSO 2004) should be executed in the WRM region. This will make the binding factors more certain; hence the predictability of the model rises. Another factor that reduces the predictability of the simulation model is the influence of the CPB scenarios. Although the ability to select different economic scenarios is very useful it can also be misused. If the investment project is justified in one economic scenario, this does not mean that it also holds true for another economic scenario. Because the simulation model is intended as exploration instrument the economic scenarios are very valuable. The model outcomes should however always be accompanied with a remark on the used scenario. The historic validation proved that over a period of 8 years (1998-2005) the average deviation for the jobs in the region is only 4,4%⁴¹. This is regarded as acceptable for the use of the instrument as socio-economic effect exploration instrument. Based on the sensitivity analysis and historic validation and excluding the effect of different CPB scenarios the uncertainty bound of the model

⁴¹ Based on time series: 1998-2005. Historic PRIMOS and CBS data is used and the historic industry sector performance is calculated with regression analysis based on data from 1993-1998.

outcomes is 10%. This should be kept in mind when working with the outcomes of the simulation model..

- b. *Can the instrument fulfil the requirements that were initially set at the start of this research?*

The simulation model fulfils more than 85% of the requirements that were identified. The requirements that could not be implemented have been left out due to time constraints, the limits of the software or data availability. To comply with the requirements from the policy issue at hand, the Wieringerrandmeer case, the effects of tourism in the project region were given special attention. It is also possible to visualize the effects of stopping the project before it is completely finished. The demand to include a method for analysing the municipalities individually was not included. The latter is caused by the fact that the geographic scale would become too small. Another important requirement was that the instrument must be able to provide a clear indication of the assumptions made to come to the final results of each simulation run. This has been incorporated into the simulation model by the addition of a specific assumption page in the user interface. Because 85% of the requirements are implemented in the model, including the most important requirements, the conclusion can be drawn that the instrument is able to fulfil the requirements.

- c. *Is the instrument applicable for regions with different characteristics?*

The simulation model in the thesis model is developed with the aim to apply the model in different projects, hence for different regions. This is made physically possible through the loosely coupled relation between the input variables in an Excel database and the simulation model in PowerSim. The component structure of the simulation model (see figure 5.2) also makes it possible to add extra model components. Fact is that not every region exhibits the same characteristic and not every policy issue is concerned with in the same variables of the economic system. It can be concluded that it is physically possible with the software and the manner in which the simulation model is constructed.

The geographical scale of the simulation model is very important. With respect to this scale, the model is only suited for (multiple) municipalities with over 20.000 inhabitants. A socio-economic forecast on the provincial scale would require more complex variables like provincial competitiveness. The thesis model is just too simple for this scale. The simulation model is also not applicable on a *small* municipal scale because the necessary information is not available in the StatLine database. Furthermore, on a small scale, small changes (for instance the departure of a local grocer) present large deflections in the model that are not justified.

The simulation model can be applied for other project region with similar scale levels. However, a highly urban region with extensive industries and high concentrations of jobs has more complex economic relations. Relations like for instance agglomeration effects and knowledge spillovers. To incorporate these effects more modules should be added to the current instrument that corrects these effects. However a problem that can arise due to the implementation of those extra modules is an increase in the simulation model complexity. Due to the interdependent relations between the different variables the complexity of the simulation model spirals out of control. This would compromise a basic principle of the instrument: keep it manageable. The use of the simulation

model is restricted to the large, industrial developed cities in the Netherlands. Mainly because the socio-economic effects of these cities transcend their own region. However because the job development in the model is controlled by the supply of labour through the shift-share analysis, Vermeulen and van Ommeren (2006) state that the model can then be used for multiple regions.

5.2 The model in practice: socio-economic analysis of the WRM investment project

The case study that is used in this thesis is introduced in section 1.4. The Wieringerrandmeer is a project that has large ecological, transport, economic and demographic effects on the adjacent municipalities of Wieringen and Wieringermeer. In this thesis a method has been developed that analyses the economic and demographic effects or socio-economic effects for these municipalities. Section 1.4 gives a description of the current status of the project, the stakeholders that are involved and a socio-economic status of the WRM region. This section gives an analysis of the expected socio-economic development if the project is executed. The project is currently in the policy implementation phase of the policy life cycle. However, not a spade of sand has been moved and the project is still in the hands of the policy makers and the construction consortium Lago Wirense. Throughout the thesis the case study has been used to test the simulation model under development and to illustrate different model concepts. The most recent developments in the coming about of the final decision on the WRM project are the presentation of the SCBA in March 2006 (Lago Wirense 2006a) and the adjusted regional development plan (Lago Wirense 2006b). Currently (time of writing is 19-06-2006) Lago Wirense, the municipalities and the province are engaged in ongoing negotiations about the details of the execution of the project (Interview Arjan Stegeman from Lago Wirense 11-05-2006 and Wim Voordenhout from the Province of North-Holland 23-05-2006). The remainder of this section will give a forecast of the socio-economic effects that occur with and without the execution of the WRM project. The thesis model has been used to calculate and illustrate the effects that are visible in graphs 5.3 to 5.6.

Demographic projections

As mentioned in section 1.4.4 the demographic cross-section of the WRM region (in 2005) does not deviate far from the Dutch national average. However the prognoses of the future demographic developments show that the region is aging (8%) above the national average. On top of that, the young generation (under 30 years old) is declining. Figures 5.3a and b illustrates the autonomous (blue) and investment effects (pink) in the region for the inhabitants older than 65. In the left graph the new inhabitants share the same demographic properties (age and household type) with the existing population in the WRM region. The right graph shows the effects of the 65 plus group when the dwellings in the region are designed for pensioners. Even without the pensioners housing the rate of single household will rise between 2005 and 2030 with 46%. This has an effect on the average household size and will increase demand for dwellings even further. An extra stimulated increase of the 65 plus population might reduce the support of different services and facilities in the region.

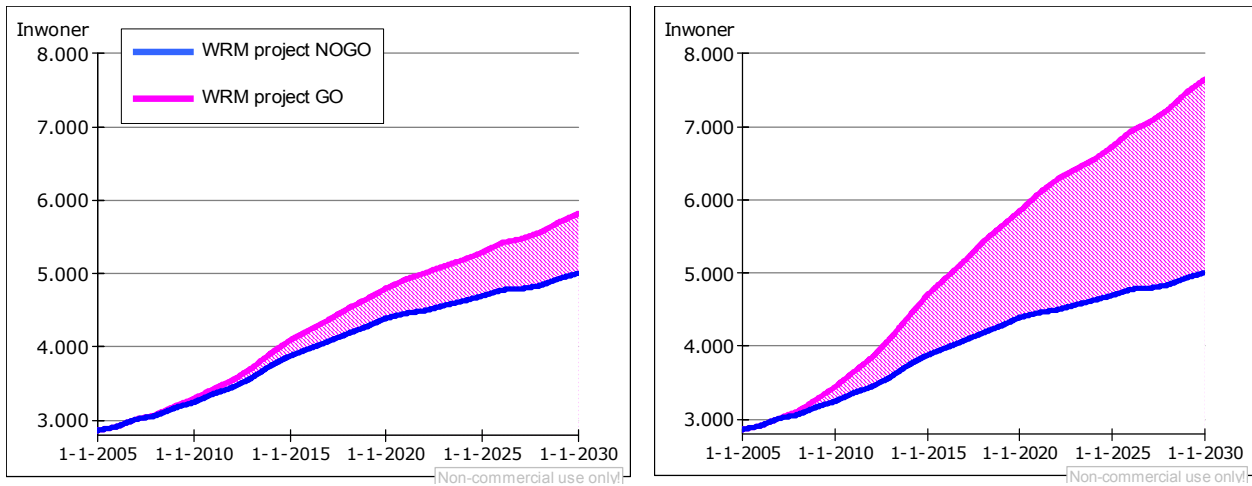


Figure 5.3a and 5.3b, inhabitants older than 65 in the WRM region with and without pensioner dwellings

Between 2005 and 2010 in the autonomous scenario 104 new dwellings are built on a yearly basis in the WRM region. In 2025 this figure has been reduced to only 43 dwellings per year. A part of the investment impulse in the WRM region includes the construction of 1845 dwellings. Figure 5.4 illustrates the consequence of the increase for the amount of dwellings in the region. The autonomous growth (blue) is the predicted growth of dwellings in the region when the project is not executed (PRIMOS 2005). In 2030 this means that 20% of the regional dwellings is part of the WRM project.

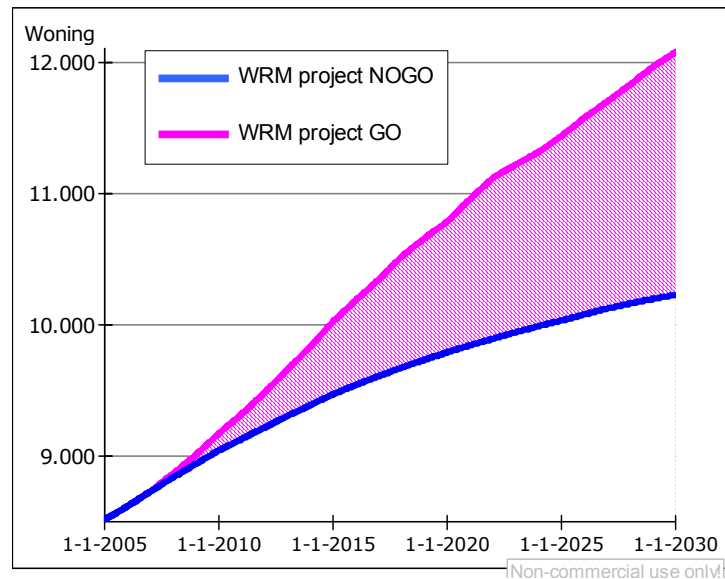


Figure 5.4, development of dwellings in the WRM region

Labour market developments

The developments of labour market are depicted in figure 5.5. The autonomous growth predicts a strong decrease of jobs after 2020⁴². Between 2020 and 2030 the jobs in the WRM region decrease with 3%, when the WRM project is executed the jobs in the region will rise with 3%. The decreasing jobs in can partly be attributed to the aging population in the region. As less inhabitants in the region belong to the potential labour force (between age 15-65), jobs will slowly disappear from the project region. Due to the development of tourism in the WRM project, more than 8% of

⁴² Calculations made with the Regional Communities scenario.

the jobs in the WRM region in 2030 will be supported by tourism. Due to the relative high age in the WRM region the (non-basic) jobs in the healthcare sector will increase more than average.

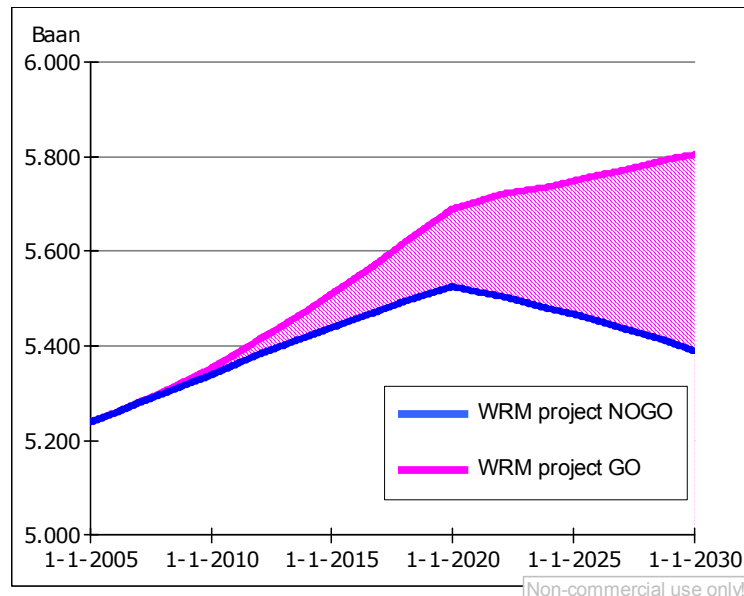


Figure 5.5, development of jobs in the WRM region

Regional spending

The regional spending in the WRM region is composed from four different sources. The inhabitants of the region spend a part of their disposable income on daily and non-daily purchases and on leisure expenses like seeing a movie or going out to dinner. The fourth spending source comes from people outside the project region, mostly tourists. In the autonomous scenario in figure 5.6 the spending in the region increases hardly over a period of 25 years⁴³. This also means that there is not a broad basis for the development of new retail or leisure in the region. The pink line in figure 5.6 indicates the effect of the WRM project on the regional spending. With 25% in 2030 the spending in the region increases proportionately more compared to the increase of inhabitants. This can be attributed to two factors. First the extra spending of tourists in the region increases regional spending. Secondly the inhabitants of the new dwellings in the project area have a higher disposable income compared to the current inhabitants. Therefore they spend (elasticity corrected) more 10% more in the WRM region.

⁴³ Regional spending in price level of 2005, inflation is not included.

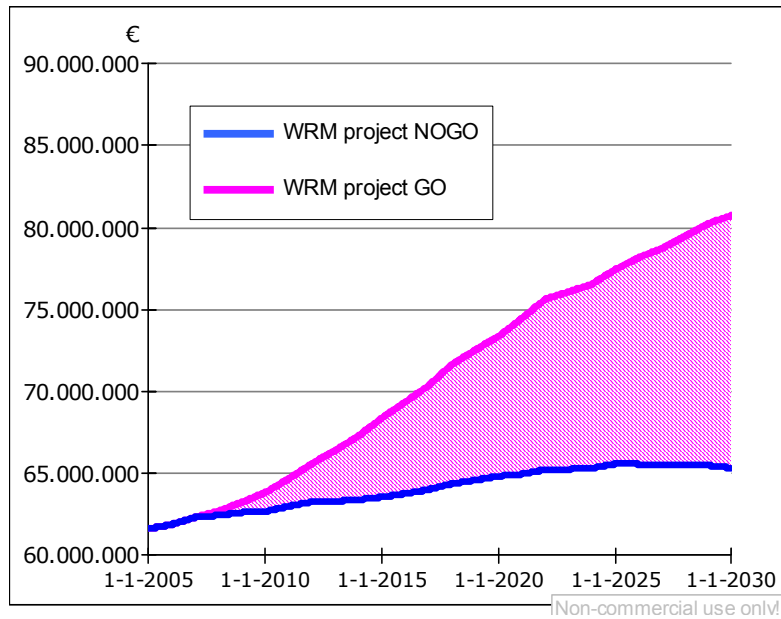


Figure 5.5, development of annual spending in the WRM region

The implementation of the WRM project would mean a healthy boost for all industry sectors in the region. The choice to develop more dwellings for senior citizens however might decrease the support of facilities and services in the region. A younger target group for the WRM region will also increase possibilities for the development of jobs in the region.

6 Recommendations and reflection

This chapter gives an overview of recommendations for further research and a reflection on the development of the thesis simulation model. Section 6.1 gives an indication of potential improvements for the current model. Section 6.2 provides reflection on matters that have been learning experiences during the development of the simulation model. These findings might assist future simulation model builders or people who want to use system dynamics in forecasting economic effects. Section 6.3 reflects on the limits of the simulation model and on the actual meaning of the model outcomes in relation to newly predicted demographic developments.

6.1 *Recommendations for further research*

During the construction of the simulation model and the literature study some subjects had to be delineated while other subjects simply fell out of the scope of the thesis project. However these subjects are interesting and provide clues for further research in regional socio-economic models. Below a division has been made between quite practical improvements to the current instrument. Most of these improvements did not make it into the final instrument due to time or scope constraints. The second list entails more theoretical notions that require more research in either existing models or socio-economic relationships

Practical model improvements

- Initially two case studies were planned for this thesis project, a project in a rural area and one in an urban area. However the second (urban) case study has not been executed due to time constraints. The historic analysis unveiled that the simulation model can relatively accurate predicts future developments in a rural region. Furthermore Vermeulen states that the long-term socio-economic effects should not differ between a rural and an urban region⁴⁴ (interview: 12 may 2006). It would be interesting to perform a second case study, taking an urban area as study region and see if the simulation model still produces correct results.
- Currently the model is able to deal with 9 production sectors. That is half of the total of 15 major industry sectors used by the CPB and CBS. Splitting up some of those sectors, or even implementing all the 15 major industry sectors would improve the outcomes of the model. For the case study of the WRM region for instance, it would have been convenient if the hotel and catering industry would be disjoint from the trade sector. This improvement would require some programming work in the shift-share analysis and in the input data.
- In the thesis model the household and age distribution can be adjusted independent from each other, this can lead to mistakes. In reality these variables have a strong correlation. A steep increase of for instance “parents with kids” will also lead to an increase in the age group “0-15 years old” and to a lesser degree in the group “15-30 years old”. An unsuspecting model user might forget this correlation and fill in incorrect data. To prevent this situation from occurring two solution are possible;
 1. Only allow consultants with knowledge of this issue to work with the model
 2. Develop a dependent relation between these two variables.
- The current instrument has a time span between 2005 and 2030. For this era the simulation model makes a socio-economic forecast. However it would be desirable to be able to see

⁴⁴ With the exception of the six largest Dutch cities.

historic development as well as development after 2030. Historic data will help interpret the autonomous development of the region. On the other hand if the project is postponed or delayed the time span should run to 2040 to see the delayed effects of the investments.

- It is unlikely that all the new residents of the housing project in the WRM will come from outside the project region. However in the current model that is an assumption. The model would improve when a selector is implemented for the percentage of people that are going to live in the new dwellings that are from outside the project region.
- The average household income is used to illustrate the disposable income of all the household types in the region. This should be corrected for single person households as on average these households have a lower disposable income. This is also relevant in the WRM case as the single person household level increases heavily in the future projections. This adjustment would cause the regional spending to become lower.

Theoretical notions

- Because the WRM project only issues owner occupied houses, rented homes are not included in the simulation model. A valuable addition to the instrument might be the inclusion of rented homes. This would mean that for the current situation (and the autonomous growth) the rented home development should be known. Including rented homes will complicate the relation between disposable income and household and age group as these variables are all interrelated. The PRIMOS model (Heida 2002) includes some information on rented / owner occupied homes and so does the CBS StatLine database.
- A more elaborate literature study on the effects of the hypotheses “jobs-follow-people” and “people-follow-jobs” might enable a simulation model were it is possible to select either one of these hypotheses. The effects of these assumptions might be studied further using the model from Vermeulen (2006) as starting point.
- Currently the jobs in the region are expressed in an array of 9 industry sectors; the labour force however is expressed only as a total. This makes it impossible to model a market between demand and supply of jobs in a region (demand and supply of labour). A labour market model could be constructed if data was available on the qualifications of people living in the project region. Unemployment in an industry sector might trigger companies from the same industry sector to locate themselves in the region that has an over supply of skilled labour. This means that all the members of the potential labour force have to belong to a specific production sector. The latter might prove hard to do, as no specific data is available on the jobs that people have live in a specific region.
- A market model can also be developed for the housing market in the region. The addition of a housing market module could provide insight in the question if the new dwellings built in a region will sell and for what price. This market model would have to incorporate the relative attractiveness of a dwelling in the project area based on regional amenities and closeness to large cities and main ports. The PRIMOS and REGINA model both have similar attractiveness indicators. System dynamic modelling could be used to indicate relative attractiveness as used in the Urban Dynamics model of Forrester (1969).
- Currently the model does not have an unemployment level that varies over time. In reality regions with relatively large unemployment will have a significantly higher job growth rate compared to other regions (Interview Vermeulen: 12 May 2006). This is only logical as the supply of labour in those regions is larger. This improvement of the simulation model might go in hand with the development of a regional labour market mentioned above.

- It is possible to extend the list of factors that influences the job development in the region. The REGINA model for instance uses a set of 7 indicators for their regional job growth. These other factors might be: closeness to a main port, accessibility or available space for economic activities.
- There most likely is a difference in the relation to which higher and lower educated people attract jobs to a region (Interview Vermeulen: 12 May 2006). Higher educated people will, most likely, have a stronger attractive force than lower educated people. This however has not been empirically tested. To include this factor would first require a statistical analysis on the attractive factor of high skilled labour on job development in a region

When thinking of improving the model by adding extra functionality or extra model components one should keep in mind that the basic principle of system dynamics is to keep it as simple as possible. Adding extra components increases the number of relations that have to be modelled more than linear.

6.2 Learning experiences from developing the simulation model

This section lists some learning experiences that were experienced through the development of the thesis and the simulation model. They might assist future simulation model builder or people who want to use system dynamics in forecasting economic effects.

- Looking back at the development process of the simulation model the most important information has come from model expert with experience in the field of regional economic models. Their contribution has opened doors to possibilities and pitfalls that were obscured before their interviews. Make sure to include some of these interviews early in the development process. This will enhance the understanding of the applicability early in the research project and prevent “expensive” mistakes later on.
- During the requirement analysis it hard to find requirements of simulation models in the literature. However by talking to model experts and reading about different models it is one of the most important requirement sources. By finding these requirement before starting interviewing respondents for the analysis a lot of uncertainty about the functionality of the instrument can be taken away. This will make the interviews more to the point, collection very specific (and often undreamed) requirements.
- The development of the thesis model is a very interdisciplinary task. It involves information from (at least) four different disciplines. The basic required information from these knowledge fields consists of the following:
 1. Regional economy: relations between economic variables, scenario analysis.
 2. Policy analysis: policy processes, the policy life cycle of Winsemius (1988), influencing policy decisions, supporting policy decisions.
 3. System dynamics: basic principles, applying SD on practical cases with input data, causal thinking.
 4. Geography: demographic constellations and development, driving factor in resettlement.

When developing a similar simulation model or when continuing the thesis model, it would be beneficial to include at least two people with experience in at least two of these disciplines.

Working in a team prevents staring aimlessly in the large databases and possible economic relations. Different disciplines have diverse ways of working that are all required in the development of the model. For one person it is hard to attend to all these ways of working.

- For the requirement analysis a framework was used in order to extract the entire set of requirements for the instrument from the stakeholders (see section 2.5.3). The issues that are specific for the case are dealt with in the “policy issue” window. These requirements are specific to the case study and should not be regarded as general requirements. The specific WRM case study makes stresses requirements that are focused on the effects of housing and recreation development. When the simulation model is used for other cases a short requirement analysis should be performed based on the policy issues framework. Based on these requirements that simulation model can then be tailored to suit the demands of the new case.

During the development of the simulation model it became clear that the Urban Dynamics (UD) model of Forrester (1969) could not be used as basis for the thesis model. This resulted in the development of a model from scratch, from which the results can be seen in chapter 3. The reason for abandoning the Urban Dynamics model was threefold:

1. The Urban Dynamics model was still too complex for the purpose of the thesis model. It uses over 400 relations and 100 input parameters. The aim of the thesis model was using as less relations as possible to keep the model manageable.
2. Because most of the input parameter of the UD model could not be found in databases or in the CBS databases it was impossible to validate the model. An example is the labour force. Forrester makes a division in unemployed, working class and management labour. Forrester does not however specify what the attributes of these groups are or how they can be measured. The data for managerial labour are not available in a database even if the concept would be made explicit.
3. The UD model starts out as a small city that turns into a large metropolis over a period of 250 years. This is almost a factor of 10 longer compared to the time span of the thesis model. Furthermore it would not be reasonable to predict that the WRM region will grow out to be a large metropolis.

6.3 Limits of simulation model use

The simulation model can be used for a wide array of regions and can be adjusted to suit different regional requirement. However there are some aspects of working with a system dynamic simulation model that should be kept in mind while interpreting the outcomes. The drawbacks and possible pitfalls of the use of the simulation model are mentioned in this section.

In the simulation model the four scenarios for the Netherlands from Huizinga en Smid (2004) are used. These scenarios have effect on the shift-share analysis and on other factors in the simulation model. However the PRIMOS model outcomes are only available for one scenario, which is an average growth of the economy. Because the outcomes of the simulation model are influenced by both the economic scenarios as by the PRIMOS data a discrepancy can occur when changing the standard economic scenario. It might be possible that the outcomes of the PRIMOS model are different when applying a different economic scenario. The model user should be aware of this fact when interpreting the outcomes of multiple scenarios.

Another pitfall might be the input of data for the model variables. From the large arrays of time series data that are required for the input of the simulation model not all data are “marked” the same. The clearest example is the difference between jobs and inhabitants in a region. When extracting these data from the CBS StatLine database one should be aware that the data on inhabitants is measured on the first of January of each year and that the jobs are measured each 31st of December. So, when looking for the same year StatLine presents data from two years.

For this thesis the aim was to develop a working socio-economic model for regional investments. Providing understanding of regional economic processes to policy maker also was an aim. However this proved to be more difficult than expected because the simulation model turned out more complex than initially intended. Therefore if the simulation model is used purely for educational purposes a game setting might prove more effective. See for example the game of Mayer (2004) where the participants together have to redevelop their own region in groups in sessions of only two days. During this time the participants will experience some of the processes (both economic as political) that occur during the (re)development of a region.

6.3.1 A whole different perspective: noticing population decline

The data that currently is used for the performance of regression analysis in order to obtain regression variables that act as model variables in prognoses model might not be valid. According to Derks et al. (2006) the population will not grow indefinitely. This affects the current econometric models like PRIMOS and REGINA, the CPB labour market model and this thesis model. These models use historic data in their analyses to make estimations on the developments in the future. The problem posed by Derks is that the declining demographic developments predicted in the coming fifty years cannot be compared to the vast expansion of the population visible in the 20th century. This means that all the predictions made by economic model are exaggerated and positively biased.

On the other hand Don⁴⁵ stipulates the fact that the population decline is not equal to an economic recession. On the contrary if political parties act on this development in the next cabinet policy proposal profit might be gained and a seeming recession averted.

⁴⁵ Don, NRC 9 February 2006, *Nederland gebaad bij minder drama*

7 Literature

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8 Appendices

8.1 Appendix 1: List of definitions and abbreviations

Used definitions and abbreviations in this thesis.

| | |
|----------------------------|---|
| CBS | Statistics Netherlands |
| COROP region | Coordination Commission Regional Research Programme: Geographical region larger than a municipality smaller than a province |
| CPB | the Netherlands Bureau for Economic Policy Analysis |
| Demographic pressure | Ratio of inhabitants between 0 and 19 plus 65 and older and the working labour force |
| DHV E&S | DHV Economy and Space. A consultancy division of a large engineering firm concerned with spatial economic problems. |
| Emigration | Departure from the Netherlands |
| Endogen variable | A variable that is completely controlled by the model |
| Exogen variable | A variable that is not controlled by the model but by an external data source |
| Fulltime equivalent | All jobs (full and parttime) calculated in full time equivalent units |
| Gross National Product | Added value for market prices for the national economy. |
| Gross participation | Percentage of labour force of total inhabitants |
| IER | Integral Effect Study |
| Immigration | Foreign settlement in the Netherlands |
| Industry sectors | Division of all the of industries into a set of craft related sectors |
| Inhabitants | Registered inhabitants on 31st of December |
| "Jip & Janneke" | Making something overly simple |
| Job migration | Migration to foreign country with the purpose of working there |
| Job | An occupation in a specific industry sector |
| Labour productivity | Total income derived from the production process divided by the total labour volume |
| Labour volume | Number of fulltime equivalent units |
| Labour force | Persons who work or want to work at least 12 hours per week |
| Level of participation | Percentage of inhabitants 15-65 that participates in the job process |
| LER | Aggriculture impact analysis |
| MER | Environmental impact analysis |
| Migration surplus | Balance between settlement from and to municipalities in the Netherlands |
| Model | see simulation model |
| National migration surplus | Balance between settlement from and to foreign countries and the Netherlands |
| NEG | New Economic Geography |
| Net participation | Percentage of working labour force of total inhabitants |
| OEI (or OEEI) | the Research program Economic Effect of Infrastructure |
| PLC | Policy life cycle |
| Policy maker | Person responsible for and concerned with the development of projects from a government organisation |
| Population desity | Inhabitants per square kilometre land |
| Population growth | Birth and inland and foreign migration surplus |
| Production sectors | see industry sectors |
| Resident-work balance | Balance between jobs and potential labour force in the region |
| SCBA | Social Cost Benefit Analysis |
| SCP | The Social and Cultural Planning Office of the Netherlands |
| SD | System Dyamics |
| SEES | Social Econmic Effect Analysis |
| Simulation model | Mathematical and visual representation of a real life system. |
| SMB | Stratigic environment assessment |
| TCI | Temporary Committee for Infrastructure projects |
| TNO | the Netherlands Organisation for Applied Scientific Research |
| UD | Urban Dynamics |

8.2 Appendix 2: preparation for the requirement analysis

Appendix 2 contains a more detailed description of how the interviews in the requirement analysis came about.

8.2.1 Dealing with different worldviews

Determining requirements is an important but sometimes underexposed phase in the design of simulation models. The model is a translation of the real world, made through a series of assumptions and simplifications by a model developer (Battjes et al. 2000). The model developer or consultant sees the relation between the real world and simulation as a set of equations that approximate the behaviour of the real system. The end-user of the simulation model, a policy maker in this case, has a different worldview compared to the model developer (Checkland 1981). Figure 9.1 illustrates the relation of these worldviews and the relation with the simulation model.

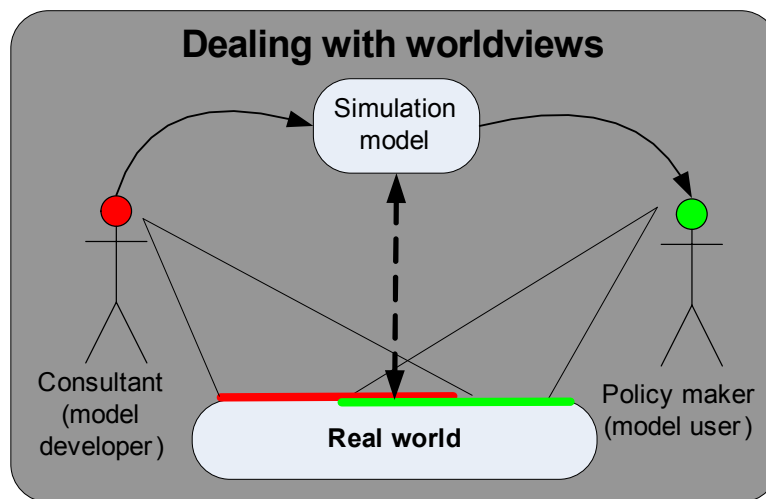


Figure 9.1, *worldviews in model design*

The consultant has to build a model that offers answers to the questions of policy maker. The policy maker's worldview is sunk in politics, previous engagements and deals and tension between governments and political parties. A consultant cannot always be conscious of these issues. A policy maker on the other hand is not conscious of issues that stem (for instance) from the technical background of the software. Because of this lack of insight in each other's worldviews both consultants and policy makers will have to take part in the process of discovering requirements. Another argument for including consultants and policy makers in the requirement analysis is the fact that both are in fact users of the simulation model. The consultant uses the model as means of providing a service for which a fee is charged, therefore the use the model as way of generating income. The policy makers, who are at the receiving end of the consultants' advice, use these services in order to come to better decisions.

Because requirements are often difficult to extract from policy makers and consultants, Robertson (2001) identifies three types of requirements that have to be addressed in order to get an (nearly) exhaustive list of requirements. She considers:

- *Conscious requirements*: this is the set of requirements the stakeholder or client is most aware of. This awareness is directly linked to the worldview of the client and often stems from the

reason for building a new product. An example: the simulation model must be able to run different (economic) scenarios.

- *Unconscious requirements*: the stakeholder does not mention unconscious requirements because he or she implicitly assumes the product will fulfil a particular function or have a particular attribute. This problem is intensified when a stakeholder is informed about the product and makes assumptions concerning the new product based on his existing knowledge. Robertson mentions that it is often politeness that causes people to not name certain requirements, because they do not want to patronize their interviewer. An unconscious requirement for the simulation model may be that people expect that it incorporates validated data from the Statistics Netherlands.
- *Undreamed requirements*: requirements that are not pointed out because either the stakeholder thinks that it is impossible to incorporate an idea or function. Or the stakeholder is totally not aware of a certain function that the product could possess. Finding these requirements is more complex; an end-user is often not able to identify undreamed requirements. It is therefore important to trawl for requirements in combination with technical analysts and model experts too. An example for the simulation model that could only have come from another model expert is the introduction of regression analysis on the relation between the input and output variables.

In order to overcome these problems multiple sources of requirements have to be used: consultants, policy makers and model experts. In the next section several techniques for requirement trawling are introduced.

8.2.2 Why use interviewing as a requirement trawling technique?

There is a broad spectrum of instruments and methodologies for finding requirements for a new product or service. Some instruments are better suited for finding conscious requirements, while others have a larger potential for finding undreamed requirements. The list below shows a short list of techniques that can be considered for the extraction of requirements for the simulation model.

- *Brainstorming*: probably the best-known technique for generating a lot of ideas in a short time is brainstorming. Many variations exist, some very informal with sticky notes, others very systematic using computer aided techniques. Brainstorming is especially good for finding undreamed requirements because creativity is stimulated and no time is given for evaluation. A successful brainstorm should however comply with a few rules: the group members should have diverse backgrounds, no criticism is allowed during the session and seemingly extreme or crazy ideas are very welcome. The ideas should furthermore be snappy and short and be combined or improved by others (Cross, 2000).
- *Interviewing*: interviewing is probably the most applied technique for discovering requirements. It is an instrument for identifying conscious requirements from experts and stakeholders. By interviewing different actors and different experts a holistic view of the requirements is obtained. Due to the explorative nature of requirement trawling most questions should be open to stimulate creative answers and the discovery of new requirements (Horn, 2001). However closed questions are useful when looking for “maximum” or “minimum” requirements.
- *Mind mapping*: a technique for graphically recording thoughts and ideas. By using words, drawings, colours and symbols requirements can be easier identified, as more information is

stored. Mind mapping is generally good for discovery of conscious, unconscious and undreamed requirements. The disadvantage of mind mapping is that drawings are harder to interpret at a later time (Cross, 2000).

- *Reusing requirements*: reusing requirements is not so much a technique as it is an often-overlooked source of requirements. For the development of software and specialized instances of this software (applications) that have been developed in a consistent manner, some requirements can be reused. However, in the development of simulation models the practice of creating a list of requirements is less common and it is therefore hard to reuse requirements for this specific thesis model (Cross, 2000).
- *Use case workshops*: a use case workshop approach stems from soft systems thinking and is a way of observing the world in order to understand it. In a use case workshop a functional part of a system is tested with a group of end users or experts. Translated to the simulation model this would mean that a partly finished model is tested on some of its functional requirements. As nearly all of the end users are not familiar with working with simulation models this could prove to have two results. First, in a use case workshop functions can be tested like adding a new variable to the model or changing the value of a variable. This way the use case workshop also tests the model. The second result a use case workshop has is that it familiarises end users with the simulation model and it offers a good opportunity to show the structure and inner workings of the simulation model. During a use case workshop especially unconscious and conscious requirements are found (Cross 2000).

For the thesis model interviewing has been chosen as requirement trawling technique. Interviews can be executed from remote locations via telephone; furthermore they do not (as work shops do) require complex meeting arrangements or long introductions. The interviews follow an open line of questioning to promote the respondent to think of unconscious and undreamed requirements. Interviewing is also the best way to reach respondents that are situated at different locations, as group brainstorms require all people to be in the same room. Some interviews with policy makers and consultants who were familiar with model building resulted in discussions and brainstorms about the requirements the model should have.

For the reuse of requirements, old lists of requirements had to be found first. As it appeared that requirements of simulation models are not structurally recorded, no reusable lists were found. A final reason for not using case workshops in the requirement analysis is that this technique requires part of a finished simulation model for demonstration. However a use case workshop where end-users will be able to work with the model is scheduled during phase 4 of the thesis project, when the model is partly finished (as described in section 4.2.2).

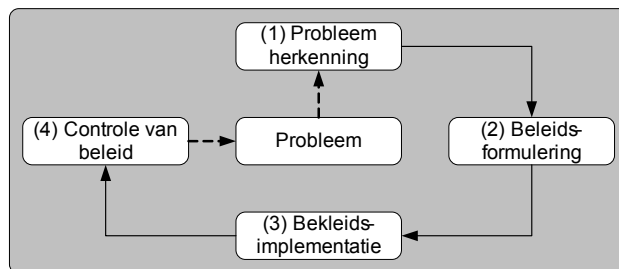
8.3 Appendix 3: Questionnaires

Appendix 3 provides the policy maker and consultant questionnaires that have been used in the requirement analysis. These questionnaires are in Dutch because the respondents were all Dutch native speakers.

8.3.1 Policy maker Questionnaire

1. Bent u wel eens in aanraking gekomen met beleidsondersteunende modellen?
 - a. Ja (vraag 2-5)

- b. Nee (vraag 6)
2. In welke omgeving heeft u deze modellen gebruikt
 - a. Als "modelbouwer"
 - b. Gebruiker van resultaten: op welke manieren zijn de resultaten gebruikt
3. Kunt u een doel aangeven van door u gebruikte beleidsondersteunende modellen
 - a. Financiële haalbaarheid
 - b. Genereren van alternatieven
 - c. Maken van planning
 - d. Anders.....
4. Kunt u aangeven in welke fase van het beleidsproces de beleidsondersteunende modellen gebruikt werden? (figuur 1)



Figuur 1, de policy life cycle

Korte uitleg over de interpretatie van beleidsondersteunende modellen in het afstudeeronderzoek

Dimensie 1) Communicatie

5. Hoe ziet u het liefst de resultaten gepresenteerd tijdens een (groeps)presentatie?
 - a. Grafieken met tijdsverloop (1 of meerdere variabelen)
 - b. Histogrammen (1 of meerdere variabelen)
 - c. Plaatjes (foto's, diagrammen)
 - d. Tabellen (meerdere variabelen)
 - e. Anders.....

Aan welke eisen zou het besluitvormingsmodel moeten voldoen mbt tot presentatie van uitkomsten?

6. Is in uw opzicht een basaal begrip van een beleidsondersteunend model nodig voor het op juiste wijze gebruiken van de uitkomsten?
 - a. Zo ja, in hoeverre?
 - b. Zo nee, waarom niet?
 - c. Zou u dat wel willen hebben?
7. Welke indicatoren zijn het meest belangrijk bij het nemen van een beleidsbeslissing? (financiële haalbaarheid, werkgelegenheid, bestedingen, inkomen, voorzieningen, forensisme)
8. Hoe worden deze indicatoren op het moment berekend?
9. Stelt u eisen aan de duur van een sessie waarbij het simulatiemodel optreedt als instrument in de discussie?

Dimensie 2) Model performance

10. Hoe gebruik u doorgaans de informatie uit onderzoeken?
 - a. Gebruik gemiddelde waarden

- b. Gebruik gemiddelde waarden en standaard afwijking
- c. Gebruik gemiddelde waarde en gevoeligheidsanalyse
- d. Gebruik van uiterste waarden (economische scenario's)

Welke eisen stelt u aan de informatie uit onderzoeken met betrekking tot het bovenstaande?

11. Aan welke aspecten wordt aandacht besteed bij het gebruiken van onderzoeksresultaten in besluitvorming?
 - a. Bij steekproeven: de representativiteit van de genomen steekproef
 - b. Bij model gebruik:
 1. Compleetheit van het model
 2. Juistheid van de modelstructuur
 3. Onzekerheid gebruikte aannames
12. Hoe zou met bovenstaande aspecten moeten worden omgegaan en hoe kan een model daarbij aan bijdragen? (indicatie van bounds)
13. Hoe worden "zachte" gegevens vertaald in "harde" data?

Dimensie 3) Probleem setting

14. Als in het beleidsproces model(uitkomsten) worden gebruikt, waartoe dienen deze dan?
 - a. Het verkrijgen van goedkeuring van een hoger gelegen overheid
 - b. Verantwoording afdragen richting de burger
 - c. Het creëren van draagvlak bij burgers
 - d. Het creëren van draagvlak bij andere overheden in het algemeen
 - e. Het creëren van draagvlak bij andere politieke partijen in uw overheidssetting

Welke eisen aan het model komen hieruit voort?

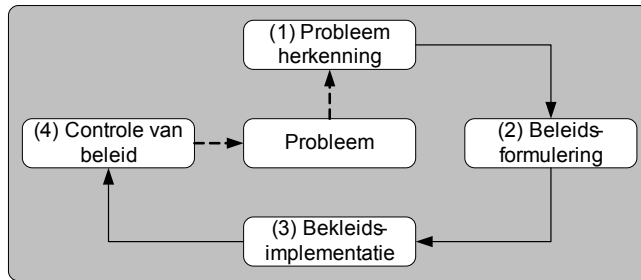
15. In hoeverre geven modeluitkomsten doorslaggevende bewijs in besluitvorming? Probeer een percentage aan te geven 0 – 100%? Waar hangt dit vanaf?
16. Stel u geeft de opdracht tot het uitvoeren van een economische studie naar de effecten van een ruimtelijke investering. Wat zijn de belangrijkste eisen die u stelt? (Inzicht in modelstructuur, betrouwbaarheid, uitkomst richting...)
17. Als we het hebben over schaalniveaus van problemen waarvoor een economische effect studie wordt uitgevoerd waar ligt dan de:
 - a. Geografische schaal?
 - b. Financiële schaal?
 - c. Tijdschaal?
18. Hoe worden verschillende scenario's gebruikt in de besluitvorming?
 - a. Economische scenario's
 - b. Verschillende beleidsalternatieven

8.3.2 Consultant Questionnaire

1. Bent u wel eens in aanraking gekomen met beleidsondersteunende modellen?
 - a. Ja (vraag 2-5)
 - b. Nee (vraag 7)
2. In welke omgeving heeft u deze modellen gebruikt
 - a. Als "modelbouwer"
 - b. Gebruiker van resultaten: op welke manieren zijn de resultaten gebruikt
3. Kunt u een doel aangeven van door u gebruikte beleidsondersteunende modellen
 - a. Financiële haalbaarheid
 - b. Genereren van alternatieven

c. Maken van planning

4. Kunt u aangeven in welke fase van het beleidsproces de beleidsondersteunende modellen gebruikt werden? (figuur 1)



Figuur 1, de policy life cycle

5. Gebruikte u ook een lijst met ontwerpisen bij het ontwikkelen van deze modellen? Zo ja, welke eisen waren dit? (Reusing requirements)

Korte uitleg over de interpretatie van beleidsondersteunende modellen in het afstudeeronderzoek

Dimensie 1) Communicatie

6. Waar geeft u de voorkeur aan bij het presenteren van resultaten uit onderzoek bij klanten in een presentatie?
- a. Grafieken met tijdsverloop (1 of meerdere variabelen)
 - b. Histogrammen (1 of meerdere variabelen)
 - c. Plaatjes (foto's, diagrammen)
 - d. Tabellen (meerdere variabelen)

Aan welke eisen zou het besluitvormingsmodel moeten voldoen mbt tot presentatie van uitkomsten?

7. Met welke interface zou u kunnen aankomen bij een klant? En waarom
- a. Spreadsheet / MS Excel
 - b. SD → Vensim
 - c. SD → Powersim

Aan welke eisen zou het besluitvormingsmodel moeten voldoen mbt tot de user interface richting de consultant?

8. Is in uw opzicht een basaal begrip van een beleidsondersteunend model nodig voor het op juiste wijze gebruiken van de uitkomsten?
- a. Zo ja, in hoeverre?
 - b. Zo nee, waarom niet?

Welke eisen komen hieruit voort?

9. Hoe kan inzicht in het model in uw ogen bijdragen aan betere beslissingen?

Kunt u hier ook functionele eisen aan verbinden?

10. Stelt u eisen aan de duur van een sessie waarbij het simulatiemodel optreedt als instrument in de discussie?
11. Zijn er nog overige eisen met betrekking tot communicatie?

Dimensie 2) Model performance

12. Welke informatie uit onderzoeken levert u doorgaans aan de klant?

- a. Gemiddelde waarden
- b. Gemiddelde waarden en standaard afwijking
- c. Gemiddelde waarde en gevoeligheidsanalyse
- d. Uiterste waarden (economische scenario's)

Welke informatie zou het model moeten kunnen produceren?

13. Is het belangrijk dat model variabelen kunnen worden aangepast en real time kunnen worden uitgerekend (lees: bij de klant)?
 - o Wat is de maximaal toelaatbare tijd voor deze berekening?
14. Binnen welke tijd zou een model door een consultant gemaakt moeten kunnen worden? (wat is gebruikelijk?)
15. Welke eisen zou u kunnen formuleren met betrekking tot het performance aspect van beleidsondersteunend model zoals besproken?

Dimensie 3) Probleem setting

16. Als in het beleidsproces model(uitkomsten) worden gebruikt, waartoe dienen deze dan?
 - a. Het verkrijgen van goedkeuring van een hoger gelegen overheid
 - b. Verantwoording afdragen richting de burger
 - c. Het creëren van draagvlak bij burgers
 - d. Het creëren van draagvlak bij andere overheden in het algemeen
 - e. Het creëren van draagvlak bij andere politieke partijen in uw overheidssetting
17. In welke fase wordt DHV in de meeste gevallen betrokken bij een besluitvormingsproces waar modellen gebruikt worden.
Welke eisen komen hieruit voort?
18. Bij het uitvoeren van een project voor een klant wat is dan de toegevoegde waarde van een model voor een klant
 - Inzicht in modelstructuur en daarmee inzicht in de gevolgen van besluitvorming
 - Bevestiging van een vooraf ingenomen standpunt (steun dmv model)
19. Als we het hebben over schaalniveaus van problemen waarvoor een economische effect studie wordt uitgevoerd waar ligt dan de:
 - e. Geografische schaal?
 - f. Financiële schaal?
 - g. Tijdschaal?

Welke eisen komen hieruit voort?

8.4 Appendix 4: Lists of interviewees

This appendix shows the respondents that have been interviewed for different parts of the thesis project: the requirement analysis, the groups testing sessions and the expert validations.

Interviews for the requirement analysis

| Name | Function | Date |
|---------------|---|------------|
| P. Canisius | Senior consultant at DHV Management Consultants | 17-11-2005 |
| E. van Daalen | System Dynamics expert at the faculty of Technology, Policy and Management of the Technical University of Delft | 04-01-2006 |
| M. Pellenburg | Consultant at DHV Economy and Space | 16-12-2005 |
| B. Schilder | Risk expert at DHV Management Consultants | 19-12-2005 |

| | | |
|----------------|--|------------|
| P. Smolders | Strategic consultant at DHV Economy and Space | 25-11-2005 |
| A. Stegeman | Project coordinator at Lago Wirense PMT | 23-12-2005 |
| M. Thissen | Regional economic models expert at the National Institute for Spatial Research | 20-12-2005 |
| H. Timmermans | Strategic consultant at DHV Economy and Space | 14-11-2005 |
| J.P. Vis | Former municipal council member of the city of Delft | 21-12-2005 |
| W. Voordenhout | Senior financial economic policy maker at the province of North-Holland | 13-12-2005 |

Interviews for the group testing sessions

| Name | Function | Date |
|----------------|---|------------|
| M. van Andel | SEPAM graduate student | 03-04-2006 |
| E.J. van Stijn | SEPAM graduate student | 03-04-2006 |
| M. Pellenbarg | Consultant at DHV Economy and Space | 26-04-2006 |
| H. Timmermans | Strategic consultant at DHV Economy and Space | 26-04-2006 |
| E. Bos Eyssen | Junior consultant at DHV Economy and Space | 26-04-2006 |
| M. Embregts | Junior consultant at DHV Economy and Space | 26-04-2006 |
| C. Raijmakers | Project manager at DHV Economy and Space | 26-04-2006 |
| S. Wilmink | Consultant at DHV Management Consultants | 05-05-2006 |
| R. Derks | Consultant at DHV Investment Services | 05-05-2006 |
| P. Canisius | Senior consultant at DHV Management Consultants | 05-05-2006 |

Interviews for the expert analysis

| Name | Function | Date |
|----------------|--|------------|
| B. Schilder | Risk expert at DHV Management Consultants | 16-05-2006 |
| F. van Oort | Professor at the University of Utrecht | 16-06-2005 |
| A. Stegeman | Project coordinator at Lago Wirense PMT | 10-05-2006 |
| M. Thissen | Regional economic models expert at the National Institute for Spatial Research | 15-06-2006 |
| H. Timmermans | Strategic consultant at DHV Economy and Space | 16-05-2006 |
| W. Vermeulen | Researcher at the CPB | 12-05-2006 |
| W. Voordenhout | Senior financial economic policy maker at the province of North-Holland | 23-05-2006 |

8.5 Appendix 5: Policy maker questionnaire long list

This appendix gives an overview of the answers given during the interviews with the consultants and policy makers. Because a lot of information was given during the interviews that did not fit into the format of the line of questioning each subject that is discussed starts with some general insight on the subject.

8.5.1 Results from the policy maker questionnaire

General insights

- A (financial) model is always used in policy making as long as it contributes to the final goal (project realisation)
- A model should (if possible) accommodate the dynamics of the policy process. Policy goals change over time
- For smaller communities experience and common sense more important than a model
- The model should make clear what the socio-economic effects would be if the project is stopped before the final phase. (WRM stopped after phase 3 of 5)
- The politisation of a policy proposal is extended as long as possible

- Previous model user
 - Yes (2)
 - No (2)

- Important goals of policy supporting models
 - Financial feasibility (2)
 - Risk analysis on investments (0) * (providing some form of assessment)
 - Providing “hard” information in uncertain environments (1)
 - Applying standardized methods on different cases for comparison (1)
 - Generating alternatives (1)

- Policy phase for model use
 - Problem recognition
 - Phase one is in the RO business mostly lobbying
 - Policy formulation (1) *
 - Translation of policy goals into policy alternatives
 - Providing insight towards “management”
 - Zuiderzeelijn → a war that is fought with reports and research
 - Policy implementation (2)
 - Delft urban master plan
 - Policy evaluation is gaining ground, subject deserves more attention (1)

Dimension 1) Communication:

General insights

- Policy makers prefer graphs and visual images in presentations, more information (tables etc.) should be available in the project report.
- Make difference in presentation style for different groups: always interactive but the amount of interaction should depend on how deep you wish to go a specific subject
 - Policy makers: lots of possibilities to change variables and assumptions
 - B&W: present a few alternative (complete solutions) only a few possible variable changes
 - Counsel (de raad): present only one option, they will either appose or approve
- “Local heroes” are more important in small communities and have to be accounted for.
- Level of specialism in small communities not high, make sure the model can depict very basis, simple things and practical examples.

- The timing of the use of the model is crucial; if the PM's are not familiar with the method they will reject it.
- Putting multiple actors in one room with the simulation model might pose a threat; the model will only be used as a political argument.
- Don't forget that policy decision always revolve around 1 alternative and that policy making always on multiple alternatives.
- Presentation style
 - Tables (1)*
 - In report
 - Graphs (3)*
 - Provides quick overview
 - Is not too complex
 - Histograms useful
 - Visual images can support the project (presentation Piet v. Hemmen) policy makers can identify easier with visual images. (Politicians are dreamers who think in images) (2)
 - Always keep your audience in mind
 - Cartoon like (stripverhalen versie)
 - Mix it up
- Interface:
 - Excel ok because familiar
 - Causal relations only to explain principles of model
 - Model must suit the user group
 - Model must be able to support the gut feeling that people have
- Understanding of model by policy makers
 - Yes, but only some basic principles, no math. Give short 5-minute introduction on the principles of SD → emphasis on causal relation and stock and flows.
 - You do not want this; only use very rudimentary practical examples to illustrate the method that you use.
 - No theory!
 - Depends on the policy phase: in a final decision-making phase there is no need for understanding the model, decision makers want (hard) numbers. If a decision needs to be made on what alternative to chose, some understanding is needed
- Important indicators for policy decisions
 - Housing market
 - Inhabitant
 - Employment (especially for WRM) (2)
 - (Show relation between these three)
 - Consumer purchasing power
 - Make explicit: low income + low employment = bad (disadvantaged area); high income + low employment = good (retired empty nesters with good pension)
 - Make difference in municipalities (Wieringen, Wieringermeer)
 - Effects of tourism
 - (Relay the outcomes of the Alterra report)

- Economic trends and growth
- Show 4 year political cycles
- How are the important indicators measured
 - See above
 - Hard numbers always win from soft words
 - If gut feeling not supported with any of the indicators, the model is rejected
- Time span of interactive session with simulation model
 - Not longer than two hours
 - Depends on the policy phase (2)
 - Brief the different political parties first and work with them first before combining multi actor groups

○

Dimension 2) Performance:

- General notions
 - Always check if the all the model variables are included in the specific case
 - Politicians use common sense and base their decisions on their own common sense. (Example: 5% growth for 10 years is implausible) (3)
 - Information from external firm has twice the impact than internal information!! (3)
 - Think on “dakkapellen” niveau
 - Depending on the phase of the policy process different requirements are needed. When the policy is just forming you will want to see the effects of different policy alternatives for a specific problem. In a later phase when decisions will need to be made, a model is necessary that will only show 1 alterative with different economic scenario’s
- Information format: what types of information are communicated towards the client
 - Average (2) always *
 - Average and st. dif (2) if necessary
 - Hardly ever
 - Average and sensitivity analysis (1) *
 - Forms the basis of decision making, is always communicated “up”
 - Never (1)
 - Scenario analysis (1)
 - Most of the time only scenario’s
 - The use of cold numbers is the most common, stick with it
- Dealing with uncertainty
 - Always communicate assumptions (3) *
 - Should be present and clear
 - When model is a big mess (“brij”) policy makers cannot find the steering points! When the model is a brij it is perceived as uncertain

Dimension 3) Problem setting:

General insights:

- Research costs are not intended to be proportional to the investment. It largely depends on the political position of the project.

- If citizens are against and investment the municipal council will follow this trend.
- First approach people individually and find out what their “real” problem is.
- Use of model outcomes for:
 - Getting approval from higher government (1)
 - Not often but does happen
 - Used to create commitment
 - Yes does happen province and national government
 - Responsibility towards residents (1)
 - Almost never happens
 - Yes can happen
 - Creation of support towards residents (2) *
 - Very important in municipal setting
 - Most important!
 - Make clear to the local heroes that this project is important, they will pull other people in agreeing as well
 - Creation of support towards other governments (2) *
 - Promotes cooperation between local governments
 - Delft → most important
 - Creation of support towards other political parties (1) *
 - Very important! Persuading countering parties
 - This does not have to happen with a model; usually it is caused by the lack of political support.
- How much do model outcomes influence policy decisions
 - 60% but never decisive
 - Lobby is sometime more important
 - In WRM different per municipality: Wieringen is very sceptic and will not bow for a model. In Wieringermeer they will use the model in their advantage (70-80%)
 - When a plan has already been made the political will is dominant.
 - In early phase of policy making the effect can be large
- Most important demands (requirements) for client
 - Not model structure insight! (1)
 - Reliability (2)
 - Providing knowledge on reliability
 - Is a given, right?!
 - Direction of outcome very important
 - Reports do not get published if outcomes does not support the project
 - Has to be able to work with different groups on different levels
 - Economic prospects
 - Show difference between different studies, why do they have different outcomes.
- Choice of scale
 - Geographical scale
 - Province (2)
 - Between smaller municipalities (1)

- Financial scale
 - Larger than 10 million (1) *
 - Depending on political climate (1)
- Time scale of outcomes
 - < 30 years (2) *
- How are scenario's used in policy making
 - As reference (2)
 - Provides perspective (2)
 - Also plays role in the dual system and distributed responsibility
 - Always a combination of economic scenario and policy alternatives

8.5.2 Results from the policy maker questionnaire

- General insights
 - Simple models are better
 - Cash flow models are relatively simple compared to mechanical fluid models (technical background is pro in consultant)
 - MKBA is more a method not so much a model
 - A model should give:
 - Insight in problem and solution(s) --> knoppen draaien
 - Overview of the problem --> what is the real problem and what is its root
 - Policy makers are not used to working with models: reduce complexity that is presented to them to a minimum.
 - Agreements on representation of outcomes and mathematical methods (risk analysis)
- Previous model user
 - Yes (3)
 - No (2)
- Most important goal of policy supporting models
 - Creating insight (2) *
 - Financial feasibility (2) *
 - Giving more information than just a yea/no answer (2)
 - Giving support in reaching the end goal. What should change to meet the desired results (1)
 - Providing insight in project risks (1)
- Policy phase for model use
 - Policy formulation (4) *
 - Should we make the investment
 - Formulation of alternatives
 - Is the investment justified
 - Why are alternatives more expensive
 - Weighing risks of alternatives
 - Policy implementation (1)
 - Risk cost calculation
 - Policy evaluation is gaining ground, subject deserves more attention (1)

- Reuse of requirements
 - Requirements? (3)
 - Does not happen in practice very often (2)

Dimension 1) Communication:

General insights

- Policy makers should make an effort in reading tables, they always want graphs.
- Presentation style
 - Tables (3)*
 - Most information in least amount of space
 - Often harder to interpret
 - Graphs (3)*
 - Easy to misinterpret
 - Histograms
 - Distributions of uncertainty of variables
 - Indication what are the causes of large model changes (1)
 - Indication of relation between input and output has to be clear (1)
 - Less information on more sheets is better than lots of information on one sheet (1) * --> not more than 6 items on sheet?
 - Not more than 2 or 3 variables in table or graph
 - Not more than 4 variables in table
 - By providing insight in the risks of a project and the magnitude of these risks, decisions are made on a broader base than only seeing estimations.
- Interface:
 - Preferably only input-output (1)
 - Not too much graphs and pictures (too messy) (2)
 - Stella notation is useful (1)*
 - Very clear overview of assumptions should be available (2) *
 - Separate (but prominent) sheet with assumptions
 - Excel: is the most familiar for users
- Understanding of model by consultant
 - It is important that the consultant knows how the model works and has very basic understanding of system dynamics (2) *
 - It should not be necessary to be a SD expert to use the model or to fully understand the mathematical background (3)
 - A very good (practical) guideline PowerPoint presentation should be enough for the consultant to be able to work with the model (2) *
 - Make a difference in what a model builder should know and what someone would have to know who only presents the results at the customer (1) *
- Other

- Communication of assumptions towards customer very important. Especially highly sensitive assumptions and assumptions with high impact. (3) *
- Don't make the interface too complex --> provide information in the programme --> a help function

Dimension 2) Performance:

- Information format: what types of information are communicated towards the client
 - Average (4) always *
 - Average and st. dif (1) almost never *
 - Average and sensitivity analysis (3) does not always happen, but should be done *
 - Scenario analysis (2) is almost always part of assignment
 - Boundaries of outcomes are very important (2)
 - Boundaries $\frac{\sigma}{\mu} * 100$ and reliability interval (1)
 - In **costing**: 30% boundary space in early phases is allowed in later phases this is about 5% depending on the project.
- Other model information
 - Correlation between assumption values and outcomes
 - Dependence between assumptions and policy variables (2)
 - Relations between policy variables and important factors *
 - Feedback loops *
 - Performance indicator of results for specific region compared to other geographical units
- Model realisation time
 - Unknown (2)
 - One day is allowed (2)
 - One minute *
- Other demands
 - Indication of bounds (3)
 - Indication of model accuracy (= bounds?) (2)
 - Calculation of uncertainty with independent variables → giving the lower uncertainty bound
 - Calculation of uncertainty with dependent variables → giving the upper uncertainty bound (you need to group your variables in depended groups)

Dimension 3) Problem setting:

General insights:

- Are research costs proportional to the project? Is there some sort of “staffel”?
- Research should foremost be executed to create clarity in fuzzy situations.
- The specific use of the model can be attributed to a specific phase in policy making. Not every model is suited for every policy phase.
- Use of model outcomes for:

- Getting approval from higher government (1)
 - Compare policy options (2) *
 - Responsibility towards residents (2)
 - Model outcomes will have to be translated into “Jip & Janneke” language (3) *
 - Creation of support towards residents (1)
 - Turning no into yes in society
 - Creation of support towards other governments
 - Creation of support towards other political parties (2) *
- In which phase is DHV involved in the policy making process
 - All phases (3)
 - The model should accommodate searching for alternatives and testing predefined alternatives (1) *
- Added value of model for client
 - Providing figures on the consequences of the policy decision (1) *
 - Confirmation of predetermined standpoint (the model gives backup) (2)
 - Would like “intended” outcomes, but under specific conditions.
 - Providing insight in how to make a project profitable/acceptable (1) *
 - Providing “mitsen en maren”: project plan is only feasible if ... and ...
- Choice of scale
 - Depending on phase of project, early phases the scale can be very large. Later phases more specific and precise information is needed and therefore the focus will become smaller or your model will grow larger.
 - Geographical scale
 - Difficult due to distributive effects (1)
 - Depends on client and the intentions of the client (gain support etc)
 - Make clear choice why you do / don't take effects in adjacent regions into account (2) *
 - Financial scale
 - Unknown
 - Larger than 10 million (2)
 - Research costs as percentage of investment costs
 - Time scale of outcomes
 - Different per project (2)
 - 10 – 20 years (2) *
- 30 years (1) *

8.6 Appendix 6: The final requirement lists

This appendix shows the final lists with requirements and is the end result of the requirement analysis. The requirements that are vital for the simulation model are indicated as a “Need to have” requirement. All the other requirements can be regarded as “nice to have”. The column “In model” indicates if a requirement is implemented in the final simulation model. The requirement lists are presented per respondent group:

- 8.6.1: the policy makers
- 8.6.2: the consultants
- 8.6.3: the policy issue
- 8.6.4: the literature study

8.6.1 The final requirement list of the policy makers

| <i>Communication: policy maker</i> | Need to have | In model |
|---|--------------|---------------|
| • Present results in graphs and histograms | Yes | Yes |
| - Maximum of 2 variables per graph | Yes | Yes |
| - Use tables only in final report, not in presentation | Yes | Yes |
| • Present results in MS excel format | No | Not realtime |
| • Present results in cartoon like fashion | No | No |
| • Be able to change presentation “styles” from comprehensive to simple | Yes | Yes |
| - Two or three interfaces with different levels of detail | Yes | Yes |
| - A “Jip en Janneke” version explainable to laymen | Yes | Yes |
| • Not require more than 5 minutes on theory of system dynamics | Yes | Variable |
| • Must be able to adapt to the capricious political arenas | No | No |
| • The interactive session must not take longer than an one day part (4 hours) | No | Variable |
| • The interactive session must not take longer than 2 hours | No | Variable |
| • Be as simple as possible | strive to | still complex |
| - Have as least variables as possible | strive to | 75 |
| • Include the following factors | | |
| - Housing market | Yes | Yes |
| - Inhabitants | Yes | Yes |
| - Employment | Yes | Yes |
| - Show relation between housing market, inhabitants, employment | Yes | Yes |
| - Consumer purchasing power | No | No |
| - Effects of tourism | Yes | Yes |
| - Show 4 year policy cycles | No | No |
| - Economic trend and growth | Yes | Yes |
| • Interpret the combination of two factors (for instance high income, low employment) | No | No |

| <i>Performance: policy maker</i> | Need to have | In model |
|---|--------------|-------------|
| • Include variables that are specific to a region | Yes | Yes |
| - Allow to add or remove variables depending on situation | Yes | Yes |
| • Support common sense reasoning | Yes | Yes |
| - What if questions | Yes | Yes |
| • Only use averages | No | Yes + extra |
| • Not give information on variable bounds | No | No |
| • Give information on variable bounds | Yes | Yes |
| • Offer the possibility to calculate different scenarios | Yes | Yes |
| • Present uncertainties and assumptions in complete but orderly fashion. | Yes | Yes |
| • Communicate reliability (outcomes are of model often instantly accepted and used) | Yes | Yes |
| • Provide clear description of status of model outcomes | Yes | Yes |

| Policy issue: policy maker | Need to have | In model |
|--|---------------------|-----------------|
| • Be preceded by session that will give people some information about what they can expect of the simulation model | Yes | Yes |
| • Support gut feeling of policy makers | No | Yes |
| • Communicate to the following groups: | | |
| - The residents of a region (they will influence local government) | Yes | Yes |
| - Other governments (for the creation of support) | Yes | Yes |
| - Other political parties for the (creation of support) | No | Yes |
| • Connect to the lobby efforts (Lobby can be very important) | No | No |
| • Be used in early phase of policy life cycle | Yes | Yes |
| • Show differences between different studies on same subject | No | No |
| • Give indication of effects on provincial scale | No | No |
| • Give indication of effects between small municipalities | No | No |
| • Be suited for projects that have a financial scale large then € 10 mln. | Yes | Yes |
| • Show result on a time scale between < 30 years | Yes | Yes |
| • Use scenarios for reference and perspective (should always be a combination of economic scenarios and policy alternatives) | Yes | Yes |
| • Show what happens if the project is stopped during one of the phases (A project is often divided into phases) | Yes | Yes |

8.6.2 The final requirement list of the consultants

| Communication: consultant | Need to have | In model |
|--|---------------------|-----------------|
| • Be suited for the use with different actors | Yes | Yes |
| - Two or three interfaces with different levels of detail | Yes | Yes |
| • Facilitate policy evaluation | No | No |
| • Present results in tables | Yes | Yes |
| - Maximum 4 variables in one table | (max 3) | (max 3) |
| • Present results in graph | Yes | Yes |
| - Maximum 3 variables in one table | (max 3) | (max 2) |
| • Not have a complex interface | Yes | Yes |
| - Max 6 adjustable variables on one screen | (max 6) | (max 2) |
| • Show relationship between input and output variables | | |
| - Display input and output variables in same window | strive to | Yes |
| - Display effects of steering variables on important factors | Yes | Yes |
| • Provide a clear overview of the (relevant) model assumptions | Yes | Yes |
| - More attention for sensitive assumptions | No | Yes |
| • Have a help function included | No | Yes |
| • Be accompanied by user guide for consultants (PowerPoint presentation) | Yes | Yes |
| • Have an A4 explaining the model principles for layman | Yes | Yes |
| • Show visual representation of model relations | Yes | Yes |

| Problem setting: consultant | Need to have | In model |
|--|---------------------|-----------------|
| • Model purpose should be | Yes | Yes |
| - Responsibility towards residents in region | Yes | Yes |
| ▪ Model outcomes in “Jip and Janneke” language | Yes | Yes |
| - Creation of support towards other political parties | No | Yes |
| - Communication with higher government | Yes | Yes |
| • Give insight in the “mitsen en maren” | Yes | Yes |
| - Show assumptions | Yes | Yes |
| • Support what-if analysis | Yes | Yes |
| - Adjustable input variables | Yes | Yes |
| • Accommodate multi regional scale | No | No |
| • Financial scale of project: larger then 10 mln | Yes | Yes |
| • Time scale: between 10 and 30 years | Yes | Yes |
| • Be usable for consultants without strong mathematical backgrounds | strive to | Yes |
| • Be applicable for multiple regions | Yes | Limited |
| - Basic information of all municipalities available in database connected to the model | Yes | No |
| • One input screen for all regional variables | Yes | Yes |

| Performance: consultant | Need to have | In model |
|---|---------------------|-------------------------|
| • Only display average results | No | No |
| • Display other information only on request | Yes | Yes |
| - Standard deviation of outcomes | Yes | No |
| - Indicate Sensitive variables | Yes | Yes |
| - Reliability interval | Yes | Yes |
| - Indication of bounds of reliability interval | Yes | Yes |
| - Feedback loops (graphical) | Yes | Yes |
| • Show a distribution of uncertainty in output variables | Yes | Yes |
| - Run model with independent stochastic input variables (lower uncertainty bound) | Yes | Yes |
| - Run model with dependent stochastic input variables (upper uncertainty bound) | No | No |
| • Give clear indication of sensitive variables | Yes | Yes |
| - Perform sensitivity analysis | Yes | Yes |
| - Give sensitive variables special colour | No | No |
| • Show dependence between assumptions and policy variables | No | Yes |
| • Performance indicator of results for a specific region compared to other geographical units | Yes | compared to netherlands |
| - Display similar factors from inside and outside the region | Yes | (not all) |
| • Adjust steering variables and calculate new results within 24 hours. | Yes | √ (5 seconds) |
| • Make use of the known models and modelling techniques | Yes | Yes |
| - Shift-Share analysis | Yes | Yes |
| - Housing market models | Yes | Yes |
| • Make use of existing methodology ad theories | Yes | Yes |
| - OEEI | Yes | Yes |
| - New Economic Geography | Yes | No |
| • Be reproducible | Yes | Yes |
| - Provide list with model equations | Yes | Yes |
| - Provide all input factors | Yes | Yes |
| • Store outcomes of important factors in spreadsheet | Yes | Yes |

8.6.3 The final requirement list of the policy case

| <i>Policy issue: communication</i> | Need to have | In model |
|---|---------------------|-----------------|
| · Very simple model interface | Yes | Yes |
| · Understandable for laymen | Yes | Yes |
| · Model must be able to deal with local communities | | |
| - inhabitants | No | Yes |
| - local government | Yes | Yes |
| - Show policy from political party standpoint | No | No |
| · Give insight in the effect of tourism | Yes | Yes |
| - day tourists and longer holidays | Yes | Yes |
| <i>Policy issue: performance</i> | | |
| · Indicate the risk and uncertainty involved in the project | Yes | Yes |
| - Make a difference between Wieringen and Wieringermeer | No | No |
| - Uncertainty with respect to economic scenario | Yes | Yes |
| - The financial risk of the project | No | No |
| <i>Policy issue: prolem setting</i> | | |
| · Illustrate the effect of stopping the project half way | Yes | Yes |
| · Give overview of what the municipalities stand to gain from this project | Yes | Yes (spending) |
| · The model should facilitate a setting that will lead to a closer relation between Wieringen and Wieringermeer | No | No |
| · The model must show growth in retail, social services and recreation | Yes | Yes |

8.6.4 The final requirement list of the literature study

| <i>Literature requirements</i> | Need to have | In model |
|---|---------------------|-----------------------|
| Make a choice in the theoretical predicament of job-follow-people or people-follow-jobs (Vermeulen & Verkade 2005). | Yes | Yes |
| Differentiate a set of production sectors to indicate economic and employment growth in these sectors (Heida 2002) | Yes | Yes |
| Include the following factors (Armstrong & Taylor 1993) and (Koops (2005): | | |
| o Labour market: working labour force, unemployment, jobs in region, vacancies. | Yes | Yes |
| o Demography: household size and composition, age, migration, birth/death rate. | Yes | Yes |
| o Gross added value. | Yes | Yes |
| o Attractiveness of region (through labour, residential or income advantages). | No | No |
| o Income: Regional wage level, consumption, average income. | Yes | Yes |
| o Real estate and land: supply of dwellings, demand of dwellings, price levels. | Yes | Yes (no price levels) |
| Include limited capacity of growth factors to prevent interpretation errors with extrapolation (Nijkamp & Reggiani 1998). Major, one time events in the past may have had a large effect on the historic growth. Extrapolating this growth without indication of such an event happening again would be unjust and therefore growth (and decline) bounds should prevent excessive growth. | Yes | Yes |
| The model must be able to indicate potential risks early in the policy phase (TCI 2004). | Yes | Yes |
| Show underlying assumptions of the modelling technique (Meadows 1976). | Yes | Yes |
| The model must not predict the future but give direction to the effects that a decision has in the far future under different economic scenarios (Handbook of Knowledge Society Foresight 2003). The model should be interpreted more as giving direction opposed to providing a prediction (Koops & Muskens 2005). | Yes | Yes |
| Always include expert opinions of non model-makers for specific regions (Forrester 1980). | Yes | Yes |
| Develop the model in such a manner that it is possible to include other interesting (unconventional) economic relations (Glaeser et al. 2001) and (Florida 2002) | Yes | Yes |

8.7 Appendix 7: What is Shift and Share analysis

Shift-share analysis is used to explain differences in employment growth between regions by analysing the national growth, regional industry mix and other regional factors. If, at national level, a sector performs admirably, an over-performance of that sector in a region will also lead to higher growth rates in that region (Armstrong 1993; Koops 2005). The shift-share technique is widely used, according to Armstrong for three simple reasons: 1, it is simple to use, 2, it is simple to understand and 3, it requires only a little amount of input data. The growth g in a region is determined by the performance of the industries that are present in the region (see equation 1).

$$(1) \quad g_r = \frac{\sum_i e_i^t - \sum_i e_i^0}{\sum_i e_i^0} \times 100$$

e_i = regional employment in industry I

$\sum e_i$ = sum of employment in all industries in the region

t = final year of study period

0 = initial year of study period

The structural or *share* part of the analysis is based on g_n , the employment growth at a national level (see equation 2).

$$(2) \quad g_n = \frac{\sum_i E_i^t - \sum_i E_i^0}{\sum_i E_i^0} \times 100$$

E_i = national employment in industry I

$\sum E_i$ = sum of employment in all industries in the nation

In order to explain differences in regional growth the industry mix is part of the differentiated or *shift* part of shift-share analysis. Equation 3 represents the regional growth at national growth levels for the different industries I.

$$(3) \quad g_m = \frac{\sum_i [e_i^0 (-E_i^t / E_i^0) - \sum_i E_i^0]}{\sum_i E_i^0} \times 100$$

The *shift* is not only determined by the regions industry mix but can also be explained by other factors like labour supply, agglomeration effects and accessibility. This finally creates the function for regional growth depending on the industry mix, the national growth levels and other factors (see equation 4).

$$(4) \quad g_r = (\overset{\text{other}}{f} \text{actors} - g_m) + (\overset{\text{industry}}{m} \text{ix} - g_n) + g_n$$

Shift-share analysis can also be used for the *prediction* of employment and added value in different regions. In that case for the share (structural) part, the national growth predictions are used that are issued by the CPB. Extrapolating the growth rate of industries and including known changes in the industry mix determine the shift part. Other explanatory factors can also be included like labour supply and agglomeration effects. A model that uses shift-share analysis is the REGINA model developed by TNO (Koops 2005).

8.8 Appendix 8: How PowerSim deals with large data arrays

A problem that started out by a contradiction in the list of requirements occurred when trying to repeat a great number of equations over and over again. This does not only slow the speed of the model down it also clouds an otherwise clear model. A selection of model variables has two dimensions, meaning that they inhibit a range of data specified in an array (see the next section for all variable dimensions). “Households” is one of these variables, consisting of 4 subgroups: 1 parent household, living together no kids, living together with kids and living alone. The problem is that each subgroup has to be regarded as a level variable and which would mean that for each subgroup a separate equation has to be written while in fact they are alike. PowerSim recognises this issue and facilitates the use of arrays in the software. In an array the same equation is used to calculate the different subgroups (see figure 9.2). A major advantage is that the model can be kept relatively simple.

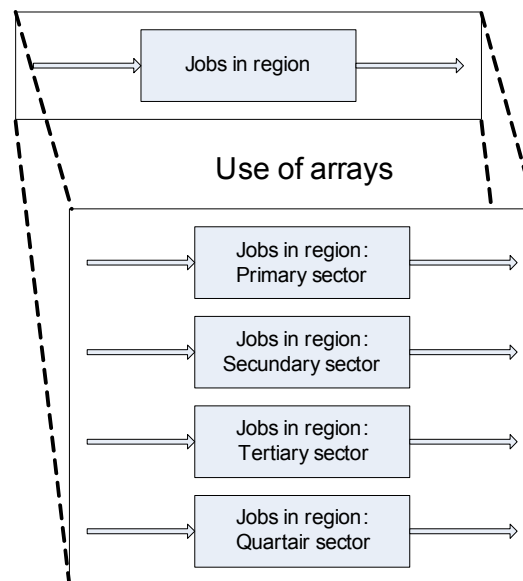


Figure 9.2, arrays for complexity reduction

Next to the example of households a series of these array model variables are used in the simulation model:

- Industry sectors for jobs and gross regional product (split up into 9 sectors)
 - Agriculture
 - Industry (without construction industry)
 - Construction industry
 - Trade
 - Transport and communication

- Financial institutions
- Commercial services (including the catering industry)
- Health and wellness
- Other non-commercial services
- Households: made out of four types of households
 - Single parents
 - Singles
 - Living together no kids
 - Living together with kids
- Age groups: the distribution of age in a region
 - 0-15 years old
 - 15-30 years old
 - 30-65 years old
 - 65 plus
- CPB scenarios: the for economic scenario from the Netherlands Bureau for Economic Policy Analysis
 - Regional Communities (-), decreasing economy
 - Strong Europe (0), stagnating economy
 - Transatlantic Markets (+), growing economy
 - Global Economy (++), vast growing economy

8.9 Appendix 9: Exploring the relation between PowerSim Studio and MS Excel

Combining a simulation tool with a spreadsheet program can combine the best of both worlds. In this case, PowerSim provides the visual representation of the system and calculates the integration equations. Excel on the other hands deals with rewriting data in other formats, suited for the model and storing large quantities of data. Because the cooperation of Excel has not been documented in any of the literature studied during this thesis project some attention is directed to the subject in this section. More specifically the subject deserves attention because the current relation far from optimal, however it does provide lots of potential for future modelling projects.

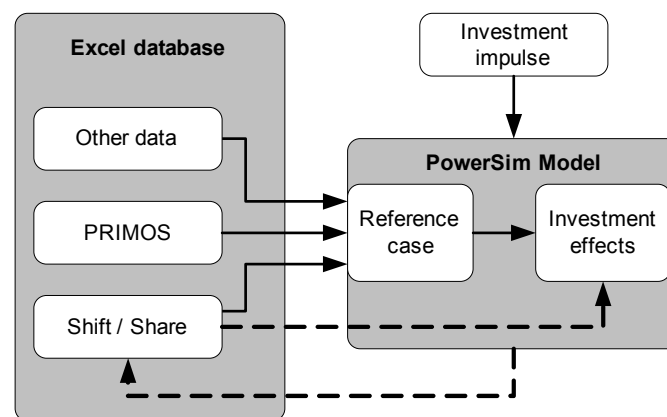


Figure 9.3, initial coupling concept

PowerSim offer the possibility of exporting and importing data from and to MS Excel. This option can be very powerful, especially when the recorded data is analyzed after the simulation run.

From the output data more information can be extracted than is possible in PowerSim, think in this case of statistical methods and variable correlation. On the other side, the input variables that a PowerSim model requires can be controlled from excel. Hereby gaining access to far larger databases that PowerSim is equipped to work with alone. The initial idea of for the coupling between the two software programs is depicted in figure 9.3

In this setup, there are multiple lines going in and coming out of the PowerSim model, in total there were 40 streams exchanging data between the two software packages. The idea was to use “real-time” data from the PowerSim model to calculate the effects on jobs in the model through shift-share analysis. However reading and writing from the same Excel file made the two programs unstable which caused several crashes during model development. To solve this problem two Excel files were used which eliminated the crashing software. The problem that still was present however was the effect that data transfer had on the simulation speed. Without reading and writing to Excel the PowerSim model would calculate a scenario of 25 years in less than 4 seconds. With the reading and writing process in place, the performance fell to more than 25 seconds per simulation run of 25 year⁴⁶. After studying this problem the malefactor appeared to be the writing of continuous data to the Excel database. However, for the Shift-share analysis as used in the model this continuous transfer is necessary. To solve this problem, the shift-share analysis was internalized, meaning that the Dutch reference data is stored in PowerSim database and that the actual calculation of the shift-share factor and the growth in jobs is directly done in PowerSim. Currently the performance of the simulation model concerning speed is approximately 25 years per 5,5 seconds.

It can be concluded that PowerSim and Excel are not meant for large transferring large quantities of data. Using datasets in PowerSim via “Studio datasets” is a better option when large quantities of data are required for the input variables or when large or dense time series are required. Furthermore the use of continuous data transfer is discouraged for future applications.

8.10 Appendix 10: description of the group tests and expert validations

Appendix 10 contains the description of the group tests and expert validations.

8.10.1 Peer group testing: testing the simulation model on practical use

The first test case for the simulation model is the peer group test where a group of students acts as the advocate of the devil. The students will test the model hands-on and experience how the model would be used in an actual situation. The peer group test enclosed two elements. First a use case test and second a model structure test.

The use case test started with an introduction of the Wieringerrandmeer case. Then the students were asked to assume the role of a policy maker or a consultant. Acting from these roles the first started to look at the current situation in the region. This meant showing the age distribution, jobs and regional income. What the “policy makers” mentioned was the fact that they could not relate

⁴⁶ With computer specs: Pentium4 1,80 GHz processor with 256 Mb RAM and Windows 2000 OS

very well to the problem without seeing more specific information grouped together in one display. They also said that a map of the area would create a sense of common goals. The policy makers were from their standpoint a little concerned with the way the data was presented, they themselves did not know exactly where the data came from and therefore found it more difficult to communicate with the policy makers. In reality a similar situation can occur when a consultant is not familiar with the “backside” of the simulation model. What the consultant group also noticed was the lack of structure in the presentation of the data. They themselves had to look too long in order to find information on a subject they requested. To solve this problem the interface has been made more consistent (see section 3.6) and less information is displayed in on one page of the user interface.

The second activity was the model structure test. The students opened-up the (for them familiar) PowerSim constructor interface and started changing variables and inserting new options. An issue was discovered in the interaction between the increase in number of dwellings and the increase in number of inhabitants. This issue could immediately be resolved by adding a variable that prevented the inhabitants to increase without an increase of dwellings. What the students also noted was the strange effect visible in the year 2020. It appeared that this bend in the growth lines appeared in almost all the graphs. They did not find the explanation of a change in the CPB scenario very satisfactory. One would think that more fundamental and system behaviour caused this sudden change. No other issues were identified during the session.

8.10.2 Consultancy testing: testing the model in an interactive setting

The most important results of the first group test, the peer-group, have been incorporated before the second group test. This included a standardized user interface with a consistent layout (see section 3.6) and reduced complexity. During the second test of the simulation model the actor role principle is explored in more detail. Due to the political sensitivity surrounding the Wieringerrandmeer project the case cannot be tested with the municipalities of Wieringen and Wieringermeer. Therefore a group of 6 members of the DHV E&R staff will participate in the model test acting as important stakeholder in the Wieringerrandmeer case. Before the session, each participant received a short introduction that described the purpose of the test and the role they will “play”. The following roles have been given to the participants⁴⁷:

- Policy maker for the province of North-Holland: Herman Timmermans
- DHV consultant as owner of the simulation model: Teun Veldhuizen
- Member of the municipal council of Wieringen and Wieringermeer: Conny Raijmakers
- Spokesman for the Lago Wirense: Michiel Pellenbarg
- Advocates of the devil, scrutinizing the model:
 - With focus on data processing: Marcel Embregts
 - With focus on the leisure and retail developments: Elise Bos-Eyssen

The list below gives an overview of the remarks that were made during the group session; the origin of the remark is illustrated between the brackets. The indented bullets motivate if and what kind of action is undertaken as a cause of the remark.

- (All) The values axes of the graphs should have fixed values. Now the value axes adjust to the displayed information. This sends a wrong image of the actual situation.
 - This issue has been solved; the axes do not adjust anymore.

⁴⁷Test session took place on 26th of April 2006

- (Province) In practice, projects tend to accelerate and decelerate as a cause of political pressure or contracts. The question arose if it would be possible to incorporate in the model.
 - This cannot be done due to the limitations of the PowerSim Studio 2005 software. Perhaps future version will support this feature.
- (Municipality) Because tourism is an important part of the policy issue more light should be shed on this subject.
 - The regional spending interface now supports tourist spending bounds and an indication of the level of tourism. More detailed information would require more detailed tourist effect relation in the concept model.
- (Municipality) Can the model indicate if there are jobs available for the new inhabitants that move into the region?
 - The model is based on the concept that jobs follow people (Vermeulen & van Ommeren 2005) and therefore it is assumed that the jobs will be created as effect of the housing impulse. The jobs follow people assumption has been integrated in the “assumption list” that will show at the start of the simulation model.
- (Devil) What is the role of the CPB scenarios in the instrument? It is unclear why it has such a large effect.
 - It is a fact that the CPB scenarios have a large effect on the outcomes of the simulation model. However the extreme values of the scenarios indicate the uncertainty about developments in the future. The CPB scenarios should be regarded as possible directions of the economy that can assist in assessing for instance the robustness of a decision (does it have the desired effect under all economic scenarios). The model is able to reduce the effect of the CPB scenarios.
- (Province) The assumption that all the residents of the project dwellings come from outside the project region is not realistic. Can the instrument cope with this?
 - The assumption is made that all the inhabitants of the project dwellings come from outside the region. It is possible to correct for the inhabitants that move from the project region to the new dwellings, however due to time constraints this feature will not be implemented in the simulation model.
- (Devil) It would be desirable to see the historic developments in the graphs of the model.
 - That is possible but not implemented due to time constraints.
- (Province) Has inflation been incorporated into the simulation model?
 - No, but this is not necessary as all the prices in the model are based on 2005 price values. So, the disposable income in 2030 is still expressed in the price level of 2005.
- (Lago Wirense) There should be a delay on the increase of jobs. 1 year for non-basic sector and 5 years for basic sectors.
 - The basic sector delay has been implemented in the simulation model. The delay extends the effect that the extra inhabitants have on the development of jobs in the region with the default value of 5 years. The non-basic increase in jobs is neglected because this delay has an effect that is not significant in this instrument.
- (Devil) It would be useful to see the developments after 2030 when for instance the project is delayed.
 - Yes that would be useful but could not be implemented due to time constraints.

The group tests were particularly important for the validation of the presentation of the simulation model. What especially was mentioned during the first test was the information should be presented in a more consistent manner. After fixing this issue before the second test session no

more complaints were heard on the model user interface. The second meeting focused more on what the instrument could do and how useful this information would be to the different stakeholders.

8.10.3 Expert opinions: consultants, policy makers and model experts

In addition to the group session a series of expert opinions is conducted. The purpose of these sessions is two-sided. The aim is to test if the requirements that have been implemented meet the demands of the end user. The second aim is to establish the position of the socio-economic model in the field of other available spatial economic models. The list of experts below gives an overview of the remarks that were given on the model. The indented bullets motivate if and what kind of action is undertaken as a cause of the remark.

Arjan Stegeman (10 may 2006): Member the project management team of the WRM project.

The previous meeting with Arjan Stegeman had taken place in December of 2005 as part of the requirement analysis. Now she could assess if the final product met her own conception of the model as she had formed during the preliminary meeting. Her remarks focused specifically on the ability of the instrument to communicate with policy makers, as she has to deal with them on a daily basis in the WRM project. She deems the instrument useful in the early phases of the policy process and thinks that it could definitely contribute in the conceptualization of the regional economic problem. However the pitfall remains that if the instrument produces information that is not profitable for the policy makers they might reject it.

Her main remarks were:

- Why is the model not suited to illustrate the difference between the two municipalities in the Wieringermeer region (Wieringen and Wieringermeer)?
 - Reducing the geographical scale of the model further, to the level of individual municipalities is not desirable. On this level a difference would need to be made to which new inhabitant would belong to which municipality. This would also infer a competitive relation between the two municipalities, meaning that a new inhabitant in one municipality does not contribute to the economy of the other municipality. Due to the geographical spread of the municipalities and the location of the project dwelling this competition is not realistic. Furthermore, the SD methodology requires the economic processes to be seen as flows of people and goods. Reducing the scale level further would steer the instrument further away from the SD methodology and the use of differential equations.
- The model must give a better indication of what the input parameters of the region are. This will create a better “relation” with the policy maker and it will involve them from the start in the use of the model.
 - If the model is started two pages of input variables are depicted. The first page concerns regional specific values like average disposable income, number of dwellings in the region and current retail floor area. The second screen shows the variables involved with the investment plan for the region. For the WRM case this means: number of dwellings, tourist and leisure development and the development time of the project.

Wouter Vermeulen (12 may 2006): Researcher at the CPB and at the University of Amsterdam

Wouter Vermeulen is one of the creators of the regional labour market model of the CPB employment (Verkade & Vermeulen 2005, Vermeulen & van Ommeren 2005 & 2006). This labour

market model focuses on the housing supply and the interaction of regional population and employment. The empirical evidence found with this model funded the thesis model assumption that jobs-follow-people. Vermeulen his first impression of the thesis model was that the “shell” or user interface was something he had never seen in was very interested in. In his opinion this also indicated the difference between models developed at the CPB and more practical model developed by consultancy firms. The labour market model for instance is not tailored to a specific case or project. Instead it analyses labour- and housing market interaction at a regional level for all Dutch regions. The CPB model therefore does show the size of housing and employment market effects but it does not calculate the specific effects of an investment in dwellings in a region. The CPB looks at the problem on a higher aggregation level. Some other issues that were discussed:

- In the regional labour market model the calculations are made on a COROP level. For all COROP regions the model shows that jobs-follow-people. Vermeulen claims that an opposite relation on a lower geographical scale (like the thesis model scale) is not plausible. On a short term the effects are far harder to predict but in the long term (more than 10 years) jobs should follow people in all regions and on each geographical scale.
- Most of the existing models (for instance REGINA) are controlled by the demand of labour. This means that if more jobs are created by for instance building a new industrial area, the people will come subsequently. As new empirical evidence suggests that this way of reasoning is incorrect the CPB labour market model uses the opposite causal relation and is a labour supply model. Because the job development in the thesis model is also controlled by the supply of labour in the region it can also be classified as a supply model. A consequence this has is that the construction of new dwellings causes people to move to that region and hence, supplying labour. A pitfall that a lot of local governments fall into is that they think they can influence the “attractiveness” of their municipality by creating more jobs.
- The question if the model could be used for multiple types of regions was answered with yes. The effects that play in a rural area are not similar to that of one of the 6 large municipalities in the Netherlands. However because the model is supply driven, it can be used for a larger variety of regions, not only rural.
- There most likely is a difference in the relation to which higher and lower educated people attract jobs. Higher educated people will, most likely, have a stronger attractive force than lower educated people. This however has not been empirically tested.
- Currently the model does not have an unemployment level that varies over time. In reality regions with relatively large unemployment will have a significantly higher job growth rate compared to other regions. This is only logical as the supply of labour in those regions is larger.
 - This has not been incorporated in the simulation model due to time constraints but is mentioned as possible improvement in chapter 6.
- Increased employment growth in one specific sector (for instance in the healthcare sector) might reduce employment growth in other sectors. Because employees are limited and can only fulfil one job the increase in one sector has as logical consequence the opposite relation in other sectors. The thesis model does not yet control for this relation.
 - This has not been incorporated in the simulation model due to time constraints but is mentioned as possible improvement in chapter 6.
- In the thesis model the household and age distribution can be adjusted independent from each other, this can lead to mistakes. In reality these variables have a strong relation. A steep increase of for instance “parents with kids” will also lead to an increase in the age group “0-15 years old” and to a lesser degree in group “15-30 years old”. An unsuspected model user might

forget this dependent relation and fill in incorrect data. To prevent this, only consultants with knowledge of this issue should work with the model or the two variables should be made dependent.

Bert Schilder (16 may 2006): Risk analysis expert at DHV

Schilder also acted as a respondent for the requirement analysis and is therefore aware of the starting point of the instrument. He sees the instrument adding value in larger spatial projects. Schilder's own specialization is indicating risk in the construction phase of a project. He sees the thesis model as an instrument that is used even earlier in the policy process because of its explorative nature. The possible deviation from projects in the construction phase is often in the range between 5-10% (higher uncertainty bound) for less complex projects and more than 30% for complex long-term projects. As the thesis model has a deviation that exceeds the 30% higher uncertainty it should therefore only be used in explorative situations. Simply put; the accuracy bounds of the instrument do not allow it to be used in more detailed project planning. Some remarks for improvement of the current instrument:

- In conveying information on risk in a project to a less quantitatively educated crowd qualitative indicators will improve the *sense* of uncertainty. A number can be attributed to each input variable that illustrates the uncertainty involved in the outcomes the policy maker is looking at. This number is called the absolute uncertainty and can be derived by dividing the maximal bounds (most extreme values or σ or 90% interval) by the average outcome.

Wim Voordenhout (23 may 2006): Financial policy maker for the Province of North Holland

Voordenhout acted as respondent in the requirement analysis and is involved with the WRM project as financial advisor in the development of the project. He was very pleased to see the interface and the manner in which the outcomes were displayed. In the current form the instrument can be used to open-up rusted discussions between municipal, provincial and private stakeholders. Further more it has potential as steering instrument during the development of a project. It can then assist in clarifying the policy goals and identifying the target.

- Currently all the new inhabitants of the project dwellings come from outside the project region. This is not realistic; it is very likely that residents from Wieringen or Wieringermeer will inhabit some percentage of the new dwellings.
- It would be useful to see the historic developments in the region. This will give the policy makers a better idea of why certain trends occur and why there is a need to invest in the region.
- There is a difference between the (job wise) orientation of lower and higher educated labour. Higher educated inhabitants of a region have a wider geographical "range" in where they look for a job. If the model could differentiate between high and low educated inhabitants a better idea is given of the composition of the regional labour supply.
- The model can be used in politics as a means convincing political parties or higher political echelons in the value of the project. However it can also be used in the communication with the municipal counsel and the inhabitants.

Mark Thissen and Frank van Oort (15 June): Researchers at the RPB

Thissen is developer of the RAEM model and Van Oort is Professor at the University of Utrecht and author of A survey of spatial economic planning models in the Netherlands (2005). In a combined meeting both economists were struck by the level of visual presentation of the

simulation. The ability to “play” with the model variables en see what the effects are in the long run was also a new feature they had never seen in spatial models.

- The question remains if it is desirable to show the inner workings of the simulation model. By making the details in relations, assumptions and input values visible to the public the model is very open to scrutiny. If a policy maker is not convinced of the results (or the results are not what he or she expected) it becomes easy for the policy maker to criticise the model. If however the model is very complex and the policy maker is unable to understand the inner workings it is much harder for him to criticise the model (Thissen). What is then the value of making a model relatively easy? Why not make a more complex model with more relationships that has a larger explanatory power.
 - This is a valid question but also another problem. For the thesis the assumption is made that policy makers intend to make the best possible decision. In order to make the best decision it is vital to understand what socio-economic processes occur in the project region. Therefore some transparency is desired.
 - Communication between policy makers and consultants is harder with one-way communication. The instrument facilitates the communication and therefore must be transparent and cannot be have a black box interface.
- An example of additions that can be made is implementing the same “shift” variables (of the shift-share analysis) that is also used in the TNO REGINA model.
 - Yes that would be possible but it would also compromise the intention to keep the model as simple as possible.
- The relation that jobs-follow-people has only be proved by Vermeulen (Vermeulen & van Ommeren 2005, 2006) for COROP regions. It is therefore not correct to translate that directly to the WRM region, as the model only entails two municipalities of the COROP region. If the inhabitants in the region increase this will certainly have an effect on the non-basic sectors. However it has not been proven on a municipal level that jobs follow people (van Oort). The latter is also an effect that is generally more associated with Randstad developments. Is it realistic to assume that the financial market will grow as a consequence of the newly built dwellings?
- The point above also relates to the use of the shift-share analysis. If the historic performance is negative, then by using the shift-share analysis it becomes impossible for a policy maker to adjust his policy in order to change the effects on the regional labour market.
 - This is true what concerns the short-term job development. It is not possible to facilitate the growth of jobs in the short-term; this is always a long-term development.
- Because the thesis model uses the PRIMOS model outcomes a conflict occurs in the calculation of the economic development. At the basis of the PRIMOS model a series of assumptions and calculations lie that are also present in the thesis model. However the demographic developments that are calculated in the PRIMOS database are also calculated and based on of the jobs in the region.
 - The calculation of the investment impulse in the simulation model does consider this effect and calculates the new inhabitants based on the new dwellings in the region.