The MicroWave approach for improving the farm modelling process

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Abstract

The development of farm models used for policy evaluation is often characterized by poor transferability and reusability, lack of quality assessment and poor usage comfort. The goal of the MicroWave project is to tackle these problems with a set of software tools and procedures which are described in this paper. A conceptual framework was designed and translated into a GAMS-implemented version of a generic framework for model building. Several software applications were developed to support model building, model-using and documentation. In addition, a financial-economic simulation model is described as a case to demonstrate the MicroWave approach and its success in resolving the distinguished problems.

Key words: micro simulation framework, reusable models, knowledge registration, model quality, financial-economic simulation model

1 Introduction

In agricultural economics research, a wide range of research methods are used for policy evaluation support. Farm level models can be of much value in this context, as they can be used to assess the implications of market or political changes at the level of the individual farm. As a result, many research projects in policy institutions which deal with impact studies in agricultural sector involve the development of farm level models. The combined experiences of the Agricultural Economics Institute (LEI) in the Netherlands and the Policy Research Centre for Sustainable Agriculture (Stedula) in Belgium and a number of literature references (see e.g. Hertel, 2000; Scholten et al. , 2000) yielded the conclusion that the resulting models are often characterized by a number of problems. First, the quality and the actual working of the model are often only known by the researcher and is rarely reviewed or assessed independently. Second, as models are often only used and maintained by their developers, considerable investments in terms of knowledge and money are lost when the modeller leaves the research institute. Third, when new researchers want to use or share existing models, it is often hard for them to get to known the structure and theories of the model. Fourth, models are often difficult to use by researchers other than the model developer. Finally, models are often difficult to join for combined simulations.

These problems can be attributed to four sources:

- Poor model structure
- Variation of model structure between researchers
- Lack of transparency, documentation and peer-reviewing
- Lack of an easy-to-use graphical user interface (GUI).

To deal with these issues, Stedula and LEI decided to combine their efforts on the development of a micro simulation framework and a number of micro simulation models in a project which was called ‘MicroWave’. Our goals were:

- Developing new models and new model-versions in a more efficient way;
- Coupling different models in a more efficient and correct way;
- Sharing and reusing more easily model-knowledge;
- Assuring the quality of models and their output.

To define a framework, several activities were carried out: desk research, interviews, brainstorm sessions and workshops in which interaction took place between domain experts, technical model experts and scientific methodologists. From these activities, requirements and limitations for the framework were identified of which most important are:

1. Micro simulation. The framework model should include the order and impact of policy measures at individual farm level in order to get a better idea of when and how a farmer will react on certain exogenous factors. We don not consider macro-economic impacts.

2. Farm model structure. The farm model must be simple and transparent. The model should account for the fact that farms can be part of a larger enterprise and can consist of several establishments and divisions.

3. Input. The main input of the model must be a farm accountancy database, but the framework should not be dependent on a very specific database. The starting point is that the minimum level of input is the data provided by the FADN-database, which is the level of detail that is collected by all EU-countries.

4. Output. The model should calculate effects by means of financial-economic and environmental variables.

This paper is structured as follows. First we will describe our model structure as a standard approach to develop models. Second our solution for documentation and reviewing the models will be explained. Third an easy to use graphical user interface will be described. Fourth we will give an overview of the MicroWave approach. Fifth a recent application of the MicroWave approach will be presented: the financial-economic simulation model. Finally, the approach is discussed and several conclusions are drawn.

2 A model structure as a standard approach to develop models

By using a framework as a more standard approach to develop models, other modellers will be able to learn quicker from your model as you will be able to learn quicker from others. At the same time, using a common backbone for modelling will facilitate the coupling of modules and the reuse of models by other modellers, as such greatly increasing time and money efficiency and hopefully also creativity.

2.1 A Conceptual framework development for micro simulation

Instead of each problem having its own farm model, it would be more efficient to have a generic farm model that is valid for every type of farm and be used for every research theme that is applicable to micro simulation. We developed a conceptual framework as a generic model to deal with those problems. In MicroWave, the framework comprises the basic structure for a micro simulation application and can be easily tailor made for specific situations.

From the limitations described in the introduction, a conceptual framework was defined that is depicted as a scheme in Figure 1. A first structural element is the division between data initialization and the iterative loop, separated by the dashed line in Figure 1. The actual simulation takes places in the iterative loop (t,t+1,…, t+T) where T is equal to the simulation horizon. The state of the enterprise describes the characteristics of the enterprise at time t. Endogenous state variables represent the result at point t of the actions that were taken during production period P. Exogenous state variables remain constant during period P. The state of an aggregated set of enterprises (indicated by the shadow boxes) changes over time as a consequence of external factors: public policy and autonomous developments. This is indicated by the transition of the left state block (t) to the right one (t+1), which is in fact an iterative loop that runs a number of times and for each enterprise. How the transition takes place, is determined by the period simulation model, indicated by the curved arrows and entities in between.

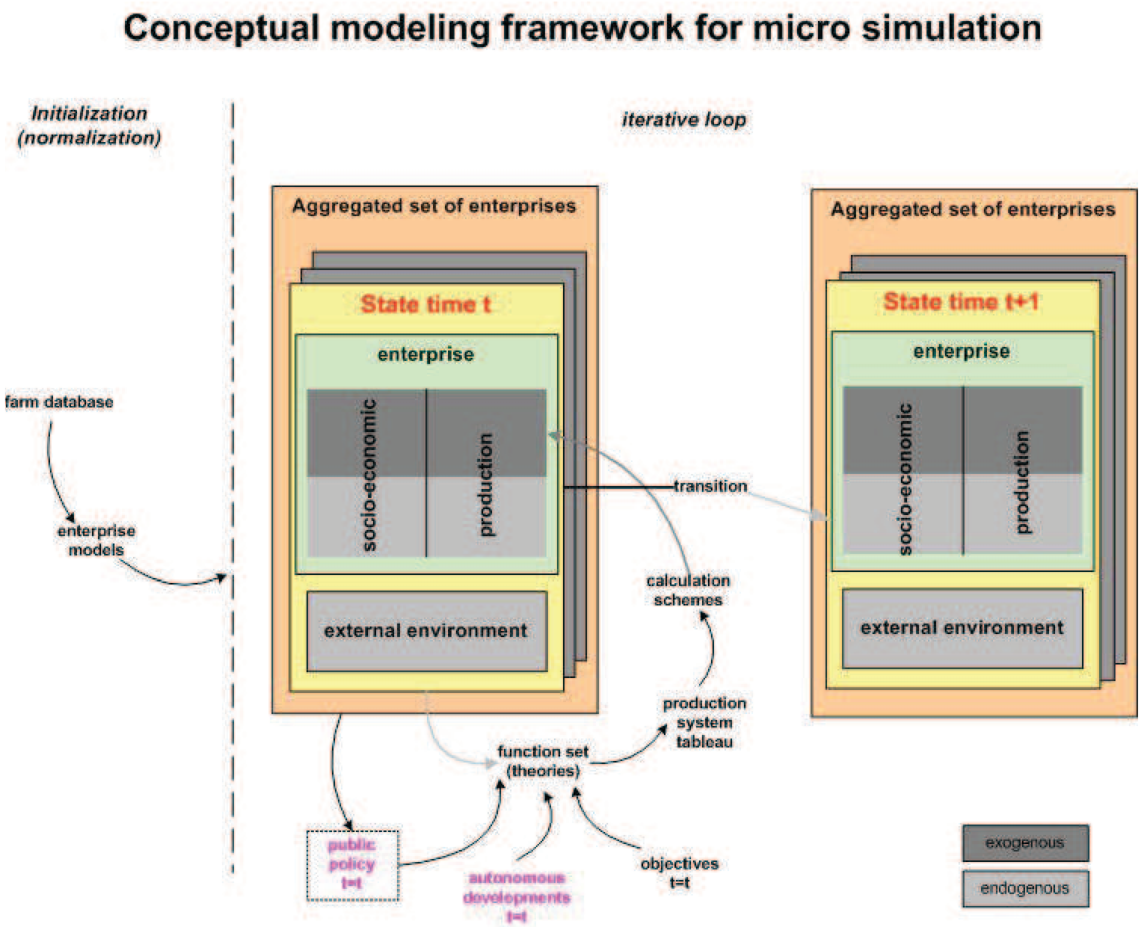

Figure 1: The MicroWave conceptual framework

2.2 The MicroWave GAMS Model Tree

A software implemented version of the described conceptual framework was developed in GAMS and was called the *MicroWave GAMS Model Tree*. GAMS (General Algebraic Modelling System) is a high level modelling system for programming often used in economic modelling. The MicroWave GAMS Model Tree is a translation of the conceptual framework. From the conceptual framework, the following major phases can be identified (also depicted in Figure 2): 1. Reading input data into a data structure, 2. Using data as input for different functions, 3. Simulations using a set of generic functions; 4. Putting outcomes of the functions into the data structure.

Those four steps form the basis for the structure of the Tree. The basic approach and underlying principle is: develop generic modules that can be used and reused independent of time or place. We defined several branches that make up the backbone, the stem of the MicroWave GAMS model Tree, and should be used in all modules that are built using the MicroWave approach.

Besides the MicroWave GAMS model Tree, a software application, GTree, was developed. This software tool makes it easy to build up and visualize a tree structure of a set of GAMS files and at the same time provides an editor to read and modify the GAMS source code. GTree can also be used outside the scope of the MicroWave approach (free version on http: //www.nacquit.com).

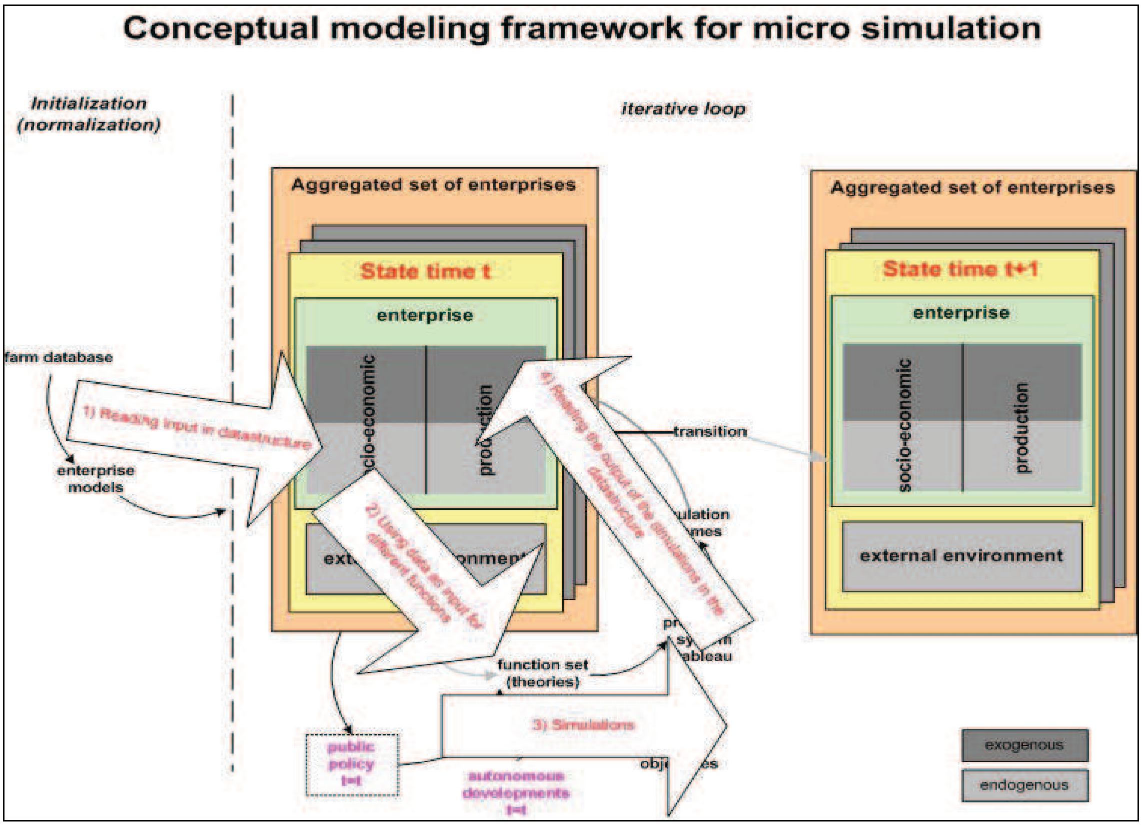

Figure 2: The four major phases for the GAMS tree in the conceptual framework

3 Facilitating documentation and peer reviewing by using MetaWave

Building models in a similar way is only one means to improve exchanges between different modellers. Modellers should also register their knowledge. Registration of knowledge is the first step in sharing knowledge with others. There are two reasons for sharing or registering knowledge. First, by documenting your model, it becomes possible to peer review its scientific contents. Secondly, as a result of these documentation efforts, it becomes easier to reuse parts of a model in other models. A MS-word template to document models was developed. To register knowledge we decided not to work only with a MS-Word template but also to build a software application called MetaWave (a contraction of Meta-information and MicroWave). MetaWave is a database application which makes it possible to browse and search through the information in a convenient way, because it is electronically available. However, occasionally (e.g. peer reviewing) it would be more convenient to have an integral document of a module. Hence, a feature was developed that generates a Word document exactly in the same format as the MS-word template. So MetaWave is useful to register and reuse models, search for models and knowledge within them, and makes it possible to register knowledge in a uniform way (independent of model, model type and model builder). MetaWave facilitates looking at models and extending them by using them for new research questions.

4 Model versions and scenarios using GSE

As a last means to improve model development, we use GSE to run model versions and scenarios. GSE is a software tool that is very useful and quickly getting a user interface for an existing GAMS model and keeping your scenarios separated from your base model. Like GTree, GSE was not developed exclusively for the MicroWave approach; it can also be used for other modelling activities in which GAMS is used for computer programming. However, GSE perfectly fits in the MicroWave philosophy of developing efficient models with higher quality where knowledge registration plays a key role.

5 The MicroWave Manual: integrating the MicroWave products in a workflow

So far, a conceptual framework and several supporting tools were presented that should overcome the problems that were mentioned in the introduction. Obviously, the MicroWave approach supposes a modelling process in which several persons are involved. Communication between persons has a potential risk of loosing information and thus lowers the quality of the final result. To minimize this risk, a MicroWave Manual was developed to describe the different steps in model building. This total picture of the MicroWave approach is shown in Figure 3.

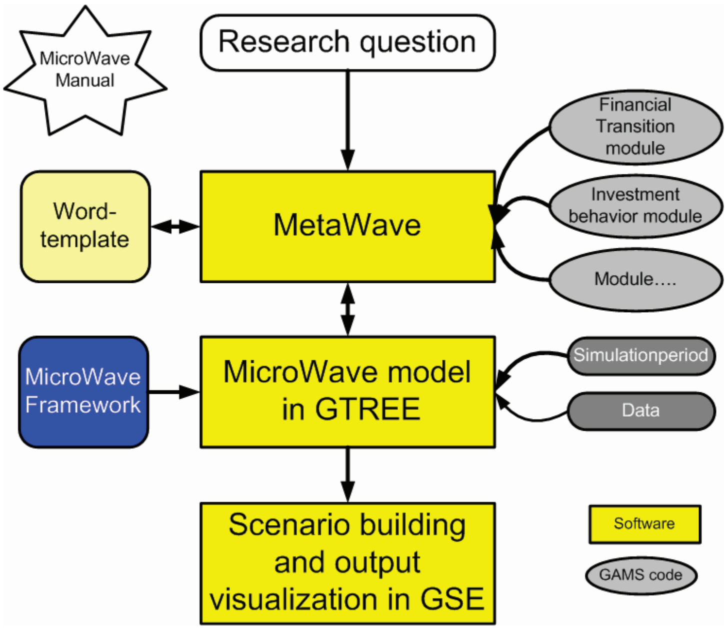

Figure 3: The MicroWave approach: the total picture

As shown in Figure 3, the starting point is the research question. Research questions which can be answered or partly answered by using farm models will be considered. A first step is to make research objectives clear. The next step is to study the documentation of already existing models or modules using MetaWave. Often existing models or components of existing models can be reused to answer research question. Besides the MetaWave software, a word-template is also created to help the model builders to register his/her knowledge. The next step in our approach is the model building and model adaptation itself. This step is handled using the MicroWave GAMS model Tree. This is the translation of the conceptual framework in actual program code. After making new models or adjusting existing models, this knowledge should be documented in MetaWave (or in the Word-templates). This facilitates reusing and understanding the new models or modules. As a result a reciprocal relation is depicted in figure 3 between MetaWave and the MicroWave GAMS model Tree. Finally, different scenarios can be calculated using the finished model version. To visualize the outputs of different scenarios we use GSE. This software tool is very useful for quickly getting a user interface for an existing GAMS model and keeping the scenarios separated from your base model.

6 Illustration of the MicroWave approach: the financial economic simulation model

The MicroWave approach has been briefly described in the previous sections. In this section we will provide a concrete example that illustrates how the approach can be used. This application is called the financial economic simulation model. Other applications and illustrations can be found in Wolfert et al. (2005).

The objective of the financial economic simulation model is to (partly) answer research questions about the continuity of agricultural and horticultural farms. Researchers at the Dutch Agricultural Economics Research Institute and the Flemish Policy Research Centre for Sustainable Agriculture develop this model. Using this simulation model, continuity perspectives for a medium long period (5-10 years) of agricultural and horticultural farms can be determined.

Consistent with the limitations as described in the introduction we use farm accountancy data as input. The financial economic simulation model consists of two major parts: the *financial transition* part and the *investing and financing* part as shown in Figure 4.

Simulation of the future financial economic situation of a farm cannot be carried out without considering choices concerning investing in technically new assets, replacing old assets and other strategic measures such as changing the production plan. In the investing and financing module, the aim is to appraise different alternative measures and evaluate them against the background of the financial space available at the firm. For reasons that were explained before the methodology should be general, so that it can be used for every (type of) farm. New investments as well as replacement investments are considered. The Net Present Value and annuity are calculated for each measure. When considering the evaluation of measures and their future implications, two issues made us choose to design a 'package generator'. First, when assessing different investment options, entrepreneurs take more than just individual investment alternatives into account. Measures, or in this case investments, can also be combined into packages. Second, some investments exclude others, and a number of investments can only be done in combination with other investments. The package generator is therefore the place to delete and combine the relevant combinations of measures. Furthermore using financial indicators the financial space of each farm is calculated as the minimum of the lending capacity based on the cash flow, the securities and the solvency rate. The calculation of the financial space is based on Mulder (1994). Finally the investment decision of the farmer is simulated. From all packages that can be financed, the package with the highest annuity will be chosen and implemented.

In the financial transition modules we use the economic balance sheet, the profit and loss account, farm income, farm spending and investment decisions to calculate and describe the financial economic situation of each farm for each year. Good financial results will improve the liquidity position of the farm and bad results will worsen the farm liquidity.

It is important to notice that the overview of the financial simulation model (figure 4) are the generic functions described in figure 3 as the third step in the implementation of the conceptual framework. So these steps will be repeated for each enterprise and for each period. All modules were documented in MetaWave, reviewed by experts and implemented in GAMS in accordance with the conceptual framework and the MicroWave GAMS model Tree. In this way other model builders can easily judge and reuse the modules. They can also upgrade certain modules or replace modules by others. For example, in the currently implemented modules, the most optimal package is selected by using the *Net Present Value method*, but other methods can be applied by replacing this module.

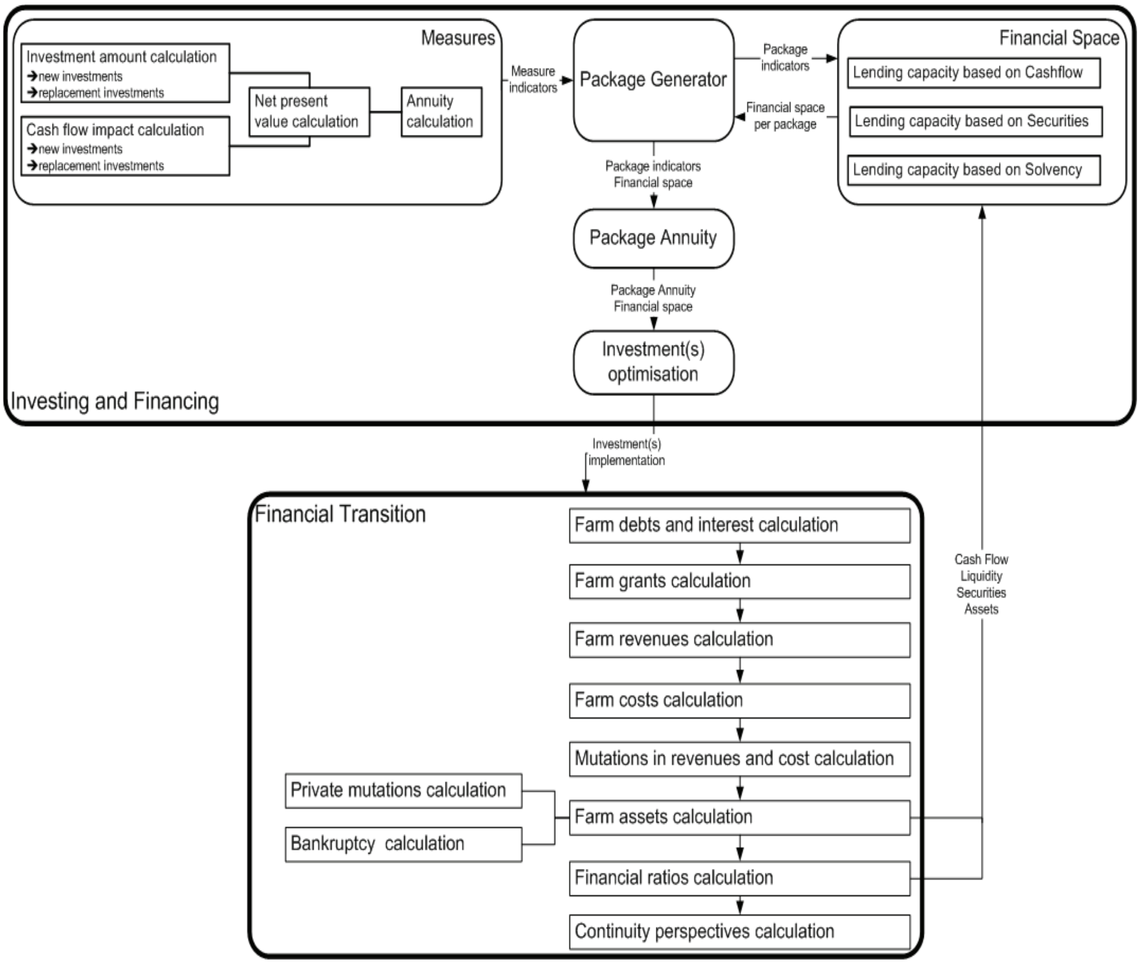

Figure 1: overview of the financial simulation model

An example of results of the financial economic simulation model can be found in Figure 5. This figure shows continuity perspectives of dairy and pig farms using the financial economic simulation model following the MicroWave approach.

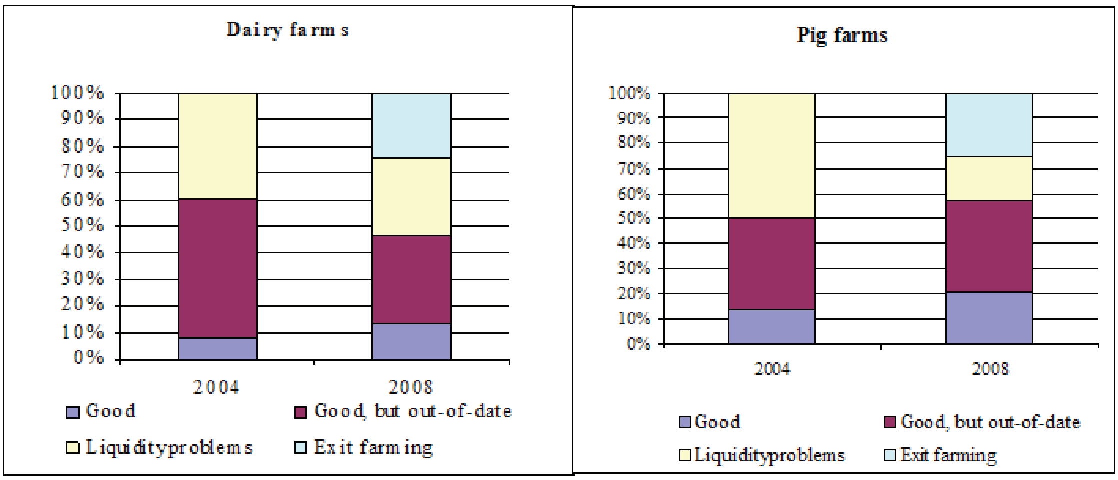

Figure 2: Results of the financial economic simulation model using the financial simulation model

7 Discussion and Conclusions

In this paper MicroWave is presented as an approach that can greatly improve the modelling process. It is developed for the context of micro simulations, but several concepts and tools are also applicable for a wider scope. The MicroWave approach is an infrastructure with associated supporting tools that guide modellers in their modelling process in order to meet the goals in attaining a higher efficiency in model development, a better quality of models and their output and an improvement in knowledge management. The conceptual framework helps to define the model in a structured, uniform way, which enlarges the transparency and comprehensibility of the model. It also makes it possible to concentrate on isolated pieces of the model without being bothered by the whole. By using a standard way of working, researchers that wish to understand the working of a model, or contribute to its extension, can rely on their previous experiences with the MicroWave structure to quickly understand and interpret an existing model. This will increase the efficiency of model building greatly. Because of the modular approach and strong focus on generic pieces of code that are made independent from specific datasets or research themes, coupling of models becomes easier and will lead to results of a higher quality. In fact the focus is not on coupling two separated models, but on combining the right modules to answer a specific research question.

Furthermore, it was explained how documenting in MetaWave highly contributes to a better management of knowledge. This can also improve efficiency by emphasizing peer reviewing and aiming for a central documentation point. This will reduce the change of 're-inventing the wheel' at different places. Peer reviewing also improves the quality of the model in general. The whole MicroWave approach and MetaWave in particular, opens possibilities for efficient co-operation in multi-or interdisciplinary research leading to more effective results.

However, the MicroWave infrastructure and supporting tools are no panacea that automatically guarantees model improvement. This still depends very much on people that use it and work together in model building teams. A successful application of using the MicroWave approach is the development of the financial-economic simulation model. This model can be used to determine continuity perspectives for a medium long period (5-10 years) of agricultural and horticultural farms.

9 Future plans

Despite this application and several test applications described in Wolfert et al (2005), the success of MicroWave still has to be proven by implementing more models/modules in the framework to obtain a critical mass of knowledge that can be reused to increase efficiency. For that reason the Dutch Agricultural Economics Research Institute (LEI) and the Flemish Policy Research Centre for Sustainable Agriculture (Stedula) have decided to continue their corporation in a consortium and invite others to join.

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