MIND STEP

MODELLING INDIVIDUAL DECISIONS TO SUPPORT THE EUROPEAN POLICIES RELATED TO AGRICULTURE

Deliverable D7.2:
Beta version of a wrapper to allow a standardized communication channel between the models

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ACRONYMS

AML	Algebraic Modelling Language
GAMS	General Algebraic Modelling System
GDX	GAMS Data Exchange Format
GGIG	GAMS Graphical Interface Generator
GUI	Graphical User Interface
OpenMI	Open Modelling Interface
SEAMLESS	System for Environmental and Agricultural Modelling; Linking European Science and Society
SEAMLESS-IF	SEAMLESS Integrated Framework

EXECUTIVE SUMMARY

The MIND STEP toolbox is a suite of models intended to be a modular framework where functionality can be added with additional models and data and where the models can be executed in flexible combinations. The latter requires to embed the models in the toolbox following protocols developed in other work packages (namely WP2.2, WP3.1 and WP4.1) by using software wrappers which permit the execution of each model from an external environment.

This deliverable 7.2. describes a linkage between an empirical model concerning farmers' risk attitudes and a simulation model using wrapper functions. This represents a typical workflow between the models at farm level developed in Work Package 3 of the MIND STEP project, which can be extended to other tasks and simulation models used within the project.

1. INTRODUCTION

The MIND STEP suite of models is intended to be a modular framework where functionality can be added with additional models and data and where the models can be executed in flexible combinations. The latter requires to embed the models in the toolbox following protocols developed in other work packages (namely WP2.2, WP3.1 and WP4.1) by using software wrappers which permit the execution of each model from an external environment. The wrapper concept reduces the work to adjust the models for the toolbox and ensures that arguments and data are standardized and well documented. While it would be preferable to design a generic wrapper, the manifold solutions foreseen in this project with respect to programming languages and the number of interlinkages, specific wrappers will be needed. A prototype wrapper function was implemented in the R programming language, as described in MIND STEP Deliverable 7.1. It permits the execution of a GAMS-based simulation model, exploiting some of the features of the applied user interface for model set-up and parallel execution, and the exchange of complex data structures between models. The R language facilitates handling of complex data structures and is an environment model developers within MIND STEP are familiar with, thus the wrapper function prototype can serve as a tool to facilitate the integration of the MIND STEP toolbox.

This report describes the application of the concept of wrapper functions to a specific case, namely the linkage between empirical estimates of farmers' attitudes towards risk and a farm-level simulation model.

2. DESCRIPTION OF EXAMPLE TASKS

The research activities in MIND STEP at farm level comprise empirical studies on farmers' preferences for the adaptation of GHG mitigation options (Task 3.3), the adjustments of crop management systems in case of changing prices (Task 3.4), and the attitudes towards risk (Task 3.5). Integrating the results from these empirical tasks and using them to improve the empirical grounding of an individual decision making (IDM) simulation model at farm-level is the main objective of Task 3.2. At the time of writing this report, the research activities on risk attitudes were the most advanced and could be used as test case for establishing an example work flow of exchanges between models. Figure 1 depicts the honeycomb of models and tools as envisaged in the MIND STEP proposal. The IDM model FarmDyn covers already a wide range of topics relevant for this honeycomb, for instance animal feed rations, crop rotations, and cost accounting, as represented by the grey-framed hexagons. It also covers crop management, risk management, and GHG emissions; the MIND STEP tasks 3.3 to 3.5 aim at improving the empirical grounding of these parts of the model (red and blue hexagons in Figure 1).
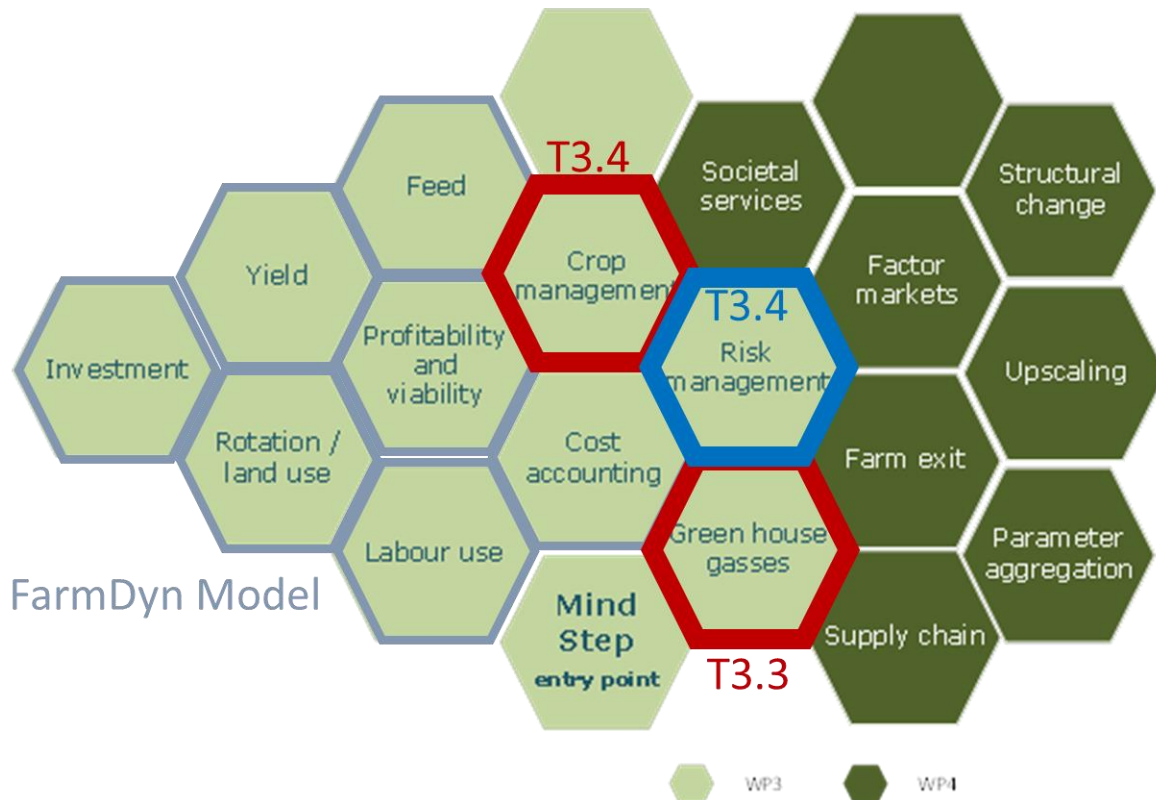
Figure 1 MIND STEP: system of interlinked models centred around individual decision making units

2.1. Risk Modelling in MIND STEP

The empirical studies on risk behaviour carried out in Task 3.5 are based on the concept of Cumulative Prospect Theory (CPT, Tversky and Kahnemann 1992, TK), which is more flexible in describing risk utility compared to expected utility and other approaches. It was found to describe more accurately risk behaviour in many empirical studies because it permits different individual weightings for possible outcomes of farming decisions, for instance by giving higher weights to potential shortfalls, which is plausible in the case of risk-averse farmers. The shape of the used utility function depends on a range of farm characteristics, for instance age and university degree of the farm manager as well as acreage and economic size. Figure 2 depicts an example for the empirical results for a sample of farmers in Germany.

Variables	Description	Coefficients b to calculate pros		
		b_sigma	b_gamma	b_lambda
age	= age in years/10	-0.04	-0.05	0.52
sex	= 1 if male; else 0	-0.01	-0.11	-2.57
UniDegree	= 1 if university degree; else 0	0.08	0.07	-2.15
logArabLa	= LN(hectar cultivated arable land)	-0.01	0.00	0.96
FullTime	= 1 if full time; else 0	-0.05	-0.06	-1.27
PropSales	= Sales revenue from arable farming / total Sales revenue	0.02	0.02	-0.48
cons	Constant	0.69	0.93	1.22

Figure 2 Estimated coefficients for TK utility function parameters

Based on these coefficient estimates, it is possible to derive TK utility function parameters for individual farms once the data for the shown farm characteristics are available.

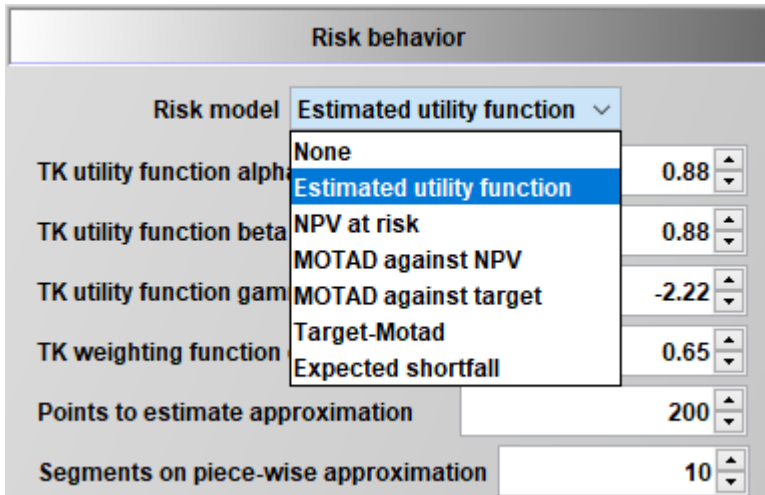## 2.2. TK Utility Function in FarmDyn

The single farm programming model FarmDyn (Britz et al. 2016) allows simulating optimal farm management and investment decision under changes in boundary conditions such as prices, technology or policy instruments. It is based on a model template for a fully dynamic or comparative-static bio-economic simulation building on Mixed-Integer Programming. Figure 3 provides an overview on the blocks of equations (modules) of FarmDyn. This modular set-up permits also the inclusions of different risk behavioural models as shown in the screenshot of the FarmDyn GUI in Figure 4.

Source: https://www.ilr.uni-bonn.de/em/rsrch/farmdyn/FarmDynDoku/template/introduction/
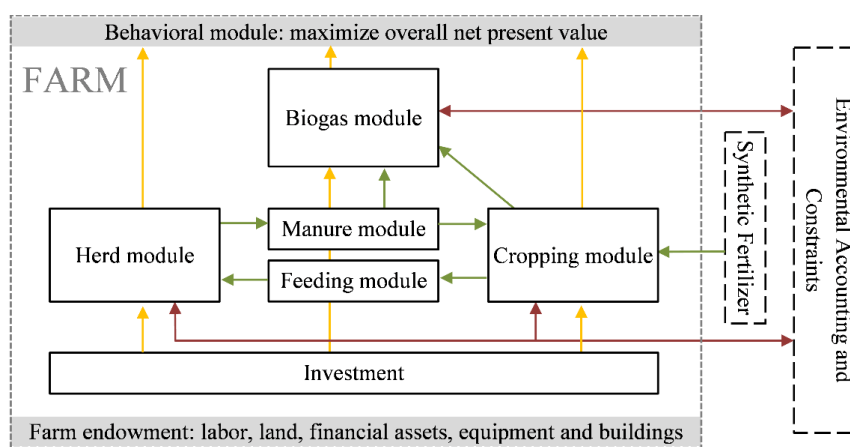
Figure 3 FarmDyn Template model

The risk utility function feature is a recent addition to the FarmDyn model developed in the context of the MIND STEP project and described in Britz (2022). It is based on a linear approximation of the TK utility function and the simulation of a range of likely outcomes of farming decisions and permits the assessment of risks related to crop yield and crop prices. The Shape of the TK utility function is determined by the parameters that can ,

Figure 4 Risk behaviour options in FarmDyn

FarmDyn can be executed for individual farms in national of EU-wide FADN datasets or for specific groups (e.g. for average dairy farms in a region). Routines for the extraction of the datasets required by FarmDyn are available for standard settings and for some national as well as EU-wide FADN datasets. The computation of the utility function parameters requires

3. ESTABLISHING A WORKFLOW

Connecting the empirically estimated utility function parameters and individual farm instances of FarmDyn requires updating the input data for parallel runs of a sample of farms. As described in Deliverable 7.1, for the execution of multiple instanceys of FarmDyn, the user has to provide the wrapper function "runFarmDynfromBatch" with the following information:

- Path to the FarmDyn directory
- Name of an xml file that governs the model-specific appearance of the GUI (e.g. GUIsettings.xml), available by default in the /GUI subdirectory of the FarmDyn directory
- Name of an ini-file that contains user-specific information like the GAMS version to be used (e.g. userSettings.ini), by default in the /GUI subdirectory of the FarmDyn directory
- Name and location of the scenario file used for the batch execution (scenarioBatch.txt) in a location chosen by the user

Creating the latter three files can easily be done my launching the GUI, providing the required settings, and executing the FarmDyn model once. Following the instructions in the GGIG user manual, a marked block of the automatically generated file "runInc.gms" in the /incgen subdirectory of the FarmDyn directory can be copied to the "scenarioBatch.txt" file. Once these preparatory steps are taken, the model can be executed from an R environment by calling the function runFarmDynfromBatch. With the paths to the FarmDyn directory, the two files for the GUI setup (GUISettings.xml, userSettings.ini) and the file for the scenario specification (scenBatch.txt), the wrapper functions generates a temporary command-file containing all the relevant information to execute the model within the GUI. A system command to the GUIExecute.bat file is then issued and the model is run. Figure 5**Error! Reference source not found.** gives a schematic overview on the steps and files involved in the use of runFarmDynfromBatch.
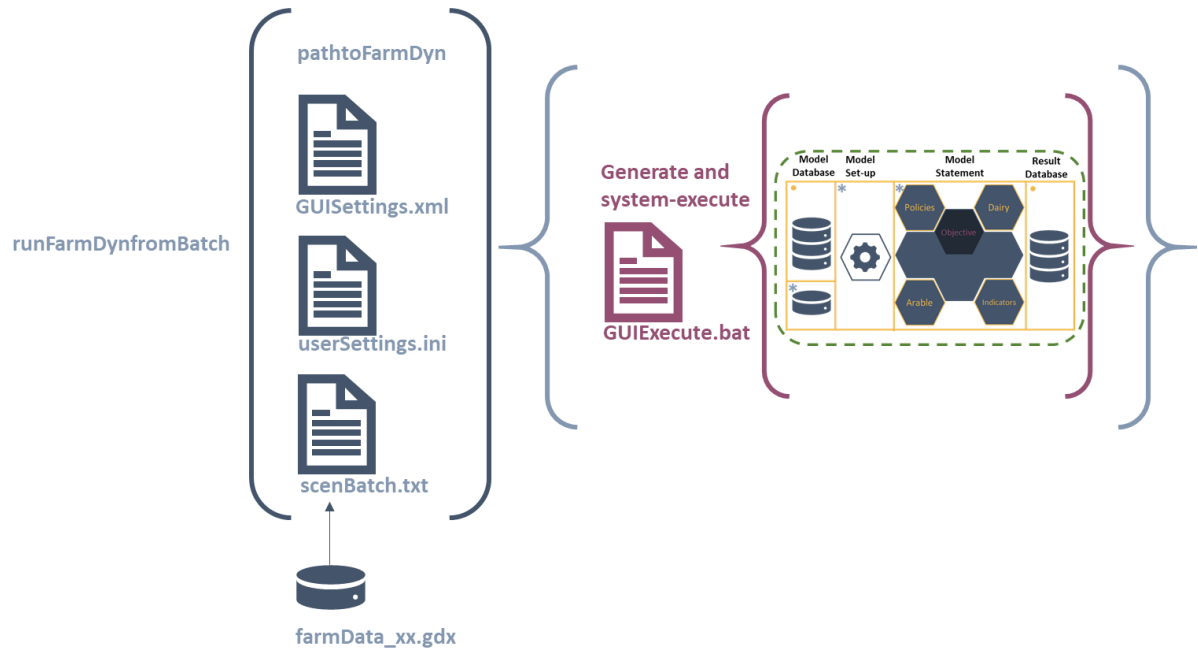
Figure 5 Schematic view of the wrapper "runFarmDynfromBatch"

A crucial input here is the file "farmData_xx.gdx", which is typically generated by an external set of routines to exploit FADN-like datasets. It is read in scenBatch.txt, which includes all the instruction to execute FarmDyn in sample mode. This file includes default settings for the TK utility parameters, which have to be overwritten by the new parameters generated with the farm characteristics and the estimated coefficients shown in Figure 2. The routine "updateFarmData" requires that the user provides the paths to FarmDyn (where also the sample file farmData:xx.gdx is located) and to the locations of farmCharacteristics and estimated coefficients. In the example shown in Figure 6, the coefficients are read from an excel file "utilityCoefficients.xlsx".

Executing the FarmDyn model with farm-specific parametrization of the risk utility function from an R environment is possible by the sequential call of the wrappers "updateFarmData" and "runFarmDynfromBatch".
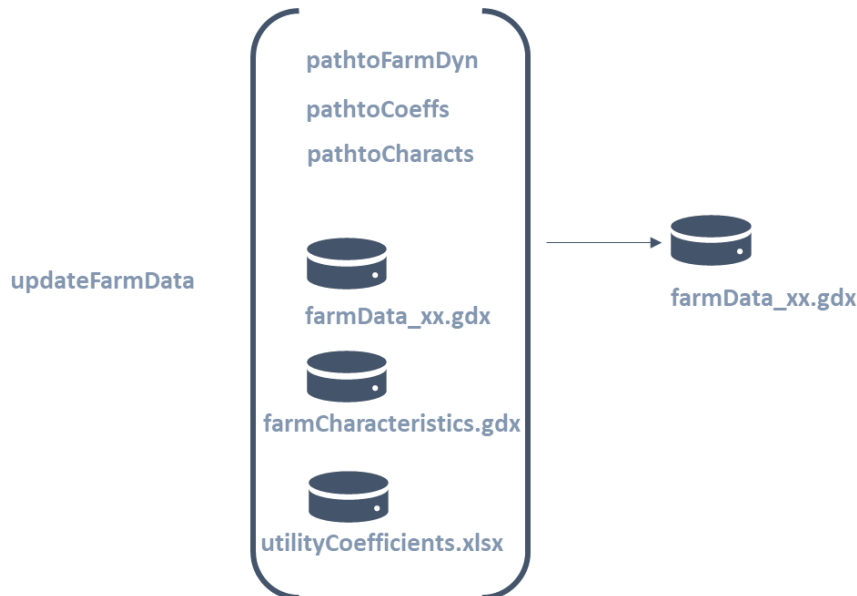
Figure 6 Schematic view of the wrapper "updateFarmData"

4. CONCLUSIONS

The work-flow described in this deliverable 7.2 is an example for the integration of farm-level research activities within the MIND STEP project. It permits the exploitation of empirical results regarding risk attitudes of farmers by creating farm-specific parameterizations of a risk-utility function within the FarmDyn model. This general concept will be extended also to the empirical work in Tasks 3.3 and 3.4.

5. ACKNOWLEDGEMENTS

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