Sensitivity analysis for supply model features in the CAPRI supply model

- Wolfgang Britz, September 2010 -

Background

The behaviour of the CAPRI supply model depends on the interaction between endogenous variables such as production and feeding activities both via the objective function and the constraints. Recently, the template was extended by features such as the land supply curve, substitution between grass and arable land or price dependent inputs and output coefficients for production activities were introduced.

Result interpretation in explicit optimisation models can be cumbersome as no closed form representation of the implicit behavioural equation (such as supply quantities as a function of prices and policy instruments) is available. Even if the exploitation offer a dual analysis of the results, understanding the changes in levels of endogenous variables compared to the baseline is far from trivial. As the directions and size of certain impacts on the reported changes is not known, result analysis carries is the risk of mis-interpretations which might then also lead to wrong conclusions about the impacts of policy instruments and other driver. The analysis can be improved and might draw less on assumptions by systematically analysing the contribution of the different allocative mechanisms in the model. Therefore, a relatively small and easy part for was added to the CAPRI simulation model.

Methodology

The basic idea consists in evaluating how the result at given prices would have looked like if certain endogenous model features would not have been used. Less rich model variants are generated by changing the template, and then used to simulate the impacts. The results of these simpler variants can then be compared to the version used for the real production run.

In order to do so, the full model is first solved to convergence, i.e. the normal iterations between the supply and market module are not changed. Afterwards, the supply models are solved several times again at the final prices, each time switching specific features off, namely:

1. *Price dependent input and output coefficients*, by re-introducing the I/O coefficient from the baseline, i.e. those underlying the calibration point of the model.

2. The *land supply curve*, by treating arable and grass land as fixed endowment.
3. Substitution between *low and high yield technology variants*, by forcing the model to use equal shares of the available technology.
4. The *PMP cross terms between crop groups*, only leaving the diagonal terms while recalibrating the linear term such that the model would still calibrate at baseline price and policies.

Technical implementation

The implementation is highly modular in the sense that it does not really interact with any other code in the system. It consists of four extensions of the existing code basis:

1. A definition file where the necessary parameters and sets are declared (sens\declare_sens.gms)

```
set  sensExperiments "Sensitivity experiments to perform with supply models at given final prices"
                    /

                       curResults
                       withoutPriceChange
                       withoutEndogYields
                       withoutTechF
                       withoutLandSupply
                       withoutPMPCrossTerms

                    /;


scalar p_oldLandIsFixed    "Temporary storage for the flag describing if the land supply model is used";
scalar p_oldFixTechfShares "Temporary storage for the flag describing if the technology shares are endogenous"

Parameter p_sensResults(RALL,COLS,ROWS,sensExperiments) "Results from the sensivity results";
```

2. The file defining the sensitivity experiments and re-running the supply models (sens\sens.gms), which first defines for each sensitivity instruments what to change (an example is given below)

```
if ( sameas(sensExperiments,"withoutLandSupply"),

   --- store the current setting for endogenous land supply

   old_standard_land_market = standard_land_market;

   --- switch off land supply curve and substitution between
       gras and arable land

   standard_land_market = 1;

   --- available hectares in land types as in baseline

   DATA(RU,MCACT,"LEUL","Y") = DATA(RU,MCACT,"LEUL","TRD");
```

   Starts the supply models:

```
*
*       --- run supply model
*
$include 'supply\simu_supply_grid.gms'
```

Stores the activity levels and quantities sold or purchased in a parameters:

```
*
*       --- store major results (currently only activity levels)
*
        p_sensResults(RU,MPACT,"LEVL",sensExperiments)
            = SUM(A $ TECHF(RU,MPACT,"LEVL",A), LEVL.L(RU,MPACT,A));
*
        p_sensResults(RU,"NETF",OMS,sensExperiments)
            = NETTRD.L(RU,OMS) * (1 - 2 $ I(OMS));
```

And finally, aggregates they to activity and product groups, such as in:

```
*
*   --- aggregation from regional units in supply model to higher regional levels
*
    p_sensResults(NUTS2AGG,MPACT,"LEVL",sensExperiments)
     = SUM(Types_to_R(NUTS2Agg,Types), p_sensResults(Types,MPACT,"LEVL",sensExperiments));

    p_sensResults(NUTS2AGG,"NETF",OMS,sensExperiments)
     = SUM(Types_to_R(NUTS2Agg,Types), p_sensResults(Types,"NETF",OMS,sensExperiments));
```

Note: the snippet above show only part of the code.

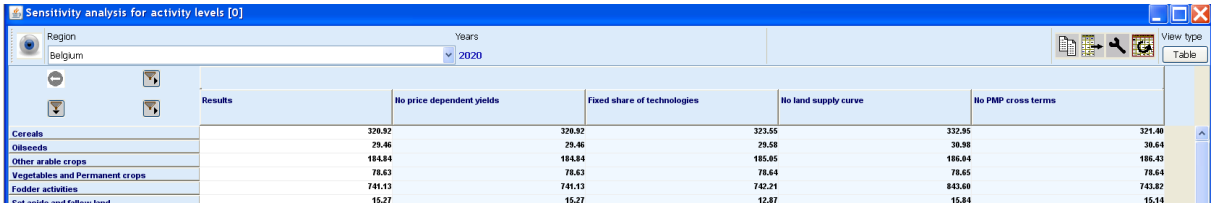
3. Copying the sensitivity results on the parameter carrying all the results exported to GDX (see capmod\set_and_store_dataout.gms):

```
*
*  --- load and store results from sensitivity analysis
*
   execute_load "%scrdir%\sens.gdx" p_sensResults;

   DATAOUT(RS$,sensExperiments,COLS,"LEVL","%SIMY%") = p_sensResults(RS$,COLS,"LEVL",sensExperiments);
   DATAOUT(RS$,sensExperiments,"NETF",ROW$,"%SIMY%") = p_sensResults(RS$,"NETF",ROW$,sensExperiments);


   option kill=p_sensResults;
```

4. Two new tables in the exploitation tools which report the changes (farm->Sensitivity Analysis for Activity Levels, farm->Sensitivity Analysis for Sales and Purchases):



Each column reports the results which were obtained if one of the features would have been switched off.