Revised CAPRI feed module from Star2

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1 OVERVIEW

Deliverables 5 and 7 of the specific contract 154208.X4 "Development of a stable release for the CAPRI model" identify as the two single most important factors behind the numerical instabilities detected in STAR 1.0 and 1.1 (i) the calibration of fertilizer distribution to crops, and (ii) the calibration of feed distribution to animals. To make a significant improvement in the STAR process these are revised. This might include both the change of the calibration approach or the theoretical models. This documentation critically relies on a feed related deliverable (D3) emerging under the STAR 2 project (specific contract 154208.X39). IFM-CAP also had a feed allocation module partly reliant in CAPRI data. Some parts of this module had been already revised and improved in 2015 by external contractors (i.e. nutrient feed content and animal nutrient requirements). These findings are incorporated in the improvement of the feed allocation routine in CAPRI as described below. The underlying Star 2 deliverable and most part of the revised coding are due to CAPRI expert Markus Kempen, but this documentation was prepared formally independent from the Star 2 project and without responsibility of Markus for any errors.

2 METHODOLOGICAL CHANGES

2.1 General concept

In the current implementation, based on the CAPRI model procedures, the objective in the data consolidation in tasks “build regional database” (capreg base year) and “baseline calibration supply” (capmod, baseline mode) is to cover the daily needs per animal with the available feed stuff (considering the daily feed intake capacity). In CAPRI most parameters determining the actual requirements of animals can be derived from statistics, e.g. milk yield, final live weight, daily gain, Aside from the uncertainty of statistical data, the calculated requirements can be seen as the “true” requirements in a country or region, as the differences between different animal nutrition literature sources are usually small. Nonetheless uncertainty in the data derived parameters can often lead to an over- or underestimation of the requirements. The actual requirements can easily differ in a range of 5-20% from the computed average need. On the other hand the minimum and maximum values presented in many animal nutrition tables can be used to derive lower or upper bounds. This uncertainty may be taken into account when specifying the objective function for the required allocation model in a high posterior density (hpd) approach where the uncertainty on feeding requirements is expressed in terms of a standard deviation. This basic approach also underlies the "pre-star2" feed allocation.

The pre-star2 feed calibration approach also considered two economic indicators that depend on the feed allocation:

- Feed costs and
- Gross margins, in particular the avoidance of negative gross margins

These two criteria have been abandoned because technical plausibility was considered more important for the feed allocation than the derived value items. It may be argued that uncertainty in feed prices should not be transferred to the physical coefficients which is a consequence when considering both in the objective. Furthermore the pmp approach of CAPRI has proven able to cope with negative margins even though it is admitted that they may not be entirely plausible.

In the pre-star2 CAPRI approach minimum and maximum bounds on specified feeding stuffs are specified to ensure technical plausibility, but to prevent infeasibilities they left considerable degrees of freedom. These hard bounds are essentially abandoned in the revised feed allocation. This also holds for the fiber requirements currently in place in CAPRI. These go back to the old CAPRI working paper 97-12. The goal of these constraints was to keep the relation of concentrate feed and roughage in a reasonable range. However, validation of the current results revealed that this goal has not been achieved. It has been decided therefore to skip these constraints. This also removes (in CAPRI) the need to update or to justify the existing set of fibre requirements and fibre feedstuff contents that must be considered obsolete after being in place for two decades without revision.

The revised feed allocation methodology includes several new additional terms in its objective to capture technical plausibility beyond the animal requirements in terms of energy and protein and technical reproducibility of the calibration approach. These will be explained in more detail in the following sections.

1. Technical reproducibility requires that the solution has a hopefully unite optimum for feed coefficients. In particular a degenerate solution with an infinity of possible optima along some constraint set will always jump within that feasible space. It has been decided therefore to introduce prior expectations for feed coefficients with generally moderate penalties for deviations from these expectations. Extra penalties are triggered however, in case that the solution exceeds certain "soft bounds". Furthermore penalty terms have been

introduced for regional variation of feed coefficients of non-ruminants that should not depend on regional fodder supply.

2. A technically plausible solution would also show a reasonable composition of feed (especially regarding the shares of concentrate feed versus fodder). What is reasonable may be specified using IFM-CAP and/or LfL data[1] as prior information. This is technically attractive as additional terms in the objective will not create infeasibilities but may give guidance toward reasonable ratios to the solver. The shares of feed in terms of the aggregates “roughage”, “contentrates” and “other” have been considered therefore in the objective, again in the form of “soft bounds”
3. An important element of feeding recommendations in practice is the composition of the diet. Information on such feeding practices can be derived from IFM-CAP and the LfL tables. It gives the minimum and maximum content of energy and protein of feed aggregates (concentrates, roughage) by animal category. These average contents are therefore target values in the objective together with “soft bounds” triggering extra penalties when certain threshholds are exceeded

2.2 Equations

An overview of the equations used in the old and new feed allocation procedure is given in Table 1. The objective function has changed significantly and more details will be discussed in the following section. Since the criteria used in the optimization changed, several new equations have been added while others could be removed. The equations ensuring consistency among production and consumption of feed are unchanged. Consistency among regions (Nuts0, Nuts1, Nuts2, Farm types) is guaranteed all the time.

Table 1: Equations used in old and new feed allocation routine

equation			
old	**new**	**description**	**comment**
hpdFeed_	**hpdFeed_**	objective function	changed significantly (see following section)

[1] Exact source unknown.

FEDUSE_	**FEDUSE_**	Balance for feeding stuff regional	needed to achieve consistency between produced feed and feed input to all animals and among regional layers
FEDUSEA_	**FEDUSEA_**	Aggregation to regional feed input coefficient to aggregate one	
FEDUSES_	**FEDUSES_**	Fixation for feeding stuff regional in calibration	
REQSE_	**REQSE_**	Requirements of animals written as equality	Calculate nutrient content (energy ENNE and crude protein CRPR) coming from feed stuff
REQSN_		Requirements of animals written as in-equality	Calculation of nutrient content (dry matter and fibre) coming from feed stuff is not needed in the new version
MINSHR_		Maximum feed shares	Constraints on single feed stuff not used as hard bounds in new version
MAXSHR_		Minimum feed shares	Constraints on single feed stuff not used as hard bounds in new version
CST_	**CST_**	Definition of feed cost from feed input coefficients and prices	Feed cost in new version only for monitoring, not in objective or constraints
MEANDEV_		Definition of average deviation from requirements for all herds	In the old approach the sectoral oversupply was pulled against the sectoral average. Skipped and

			replaced by other terms in objective.
	NutContFeed_	Nutrition content in the feed aggregates supplied to an animal category	Calculate the average nutrient content of total feed (per kg dry matter) that is part of the objective
	FEDAGGR_	aggregate to roughage, concentarte feed, etc	Defines feed aggregates from single bulks FEED
	FeedAggrShare_	Calculate share of feed aggregates (roughage, concentrates, other) on total feed	Calculates shares of roughage and concentrate feed in total feed for objective
	MeanFeedTotal_	Calculates regional average for total feed intake in DM	Part of revised objective function

Source: own compilation

The four additional equations developed in the new feed allocation procedure are described in more detail in the following.

NutContFeed_

```
*
*   --- nutrition content in total feed of animal category (energy and protein per kg dry matter: for calibration)
*
     NutContFeed_(RUNR,MAACT,A,REQMSE,FeedAggr) $ (    p_NutContFeed(RUNR,MAACT,A,REQMSE,FeedAggr,"MIN")
                                                   or  p_NutContFeed(RUNR,MAACT,A,REQMSE,FeedAggr,"MAX")
                                                   or  p_nutContFeed(RUNR,MAACT,A,REQMSE,FeedAggr,"MEAN")) ..
*
     v_NutContFeed(RUNR,MAACT,A,REQMSE,FeedAggr) =E=
*           nutrition in feed diveded by dry matter of feed
            SUM((Feed_FeedAggr(FEED,FeedAggr)),
                     v_feedInpCoeff(RUNR,MAACT,A,FEED)
                         * SUM(R_RAGG(RUNR,MSACT),%data%(MSACT,REQMSE,FEED,"Y")))

            / (SUM((Feed_FeedAggr(FEED,FeedAggr)),
                     v_feedInpCoeff(RUNR,MAACT,A,FEED)
                         * SUM(R_RAGG(RUNR,MSACT),%data%(MSACT,"DRMA",FEED,"Y"))) + 0.0001);
```

A recommended nutrient content (energy, crude protein) in the total feed mix or in the concentrate feed is frequently discussed in the animal nutrition literature. It is usually measured per kg of dry matter. The equation NutContFeed_ calculates this based on the estimated feed input coefficients and the data on nutrient content and dry matter per feeding stuff. A small number is added to the denominator to avoid division by zero (e.g. while gams is searching for a feasible solution)

FedAggr_

```
*  ---------- aggregate to roughage, concentrate feed, etc (in DRMA, needed in calibration step) -----
*
   FEDAGGR_(RUNR,MAACT,A,FeedAggr) $ p_technFact(RUNR,MAACT,"LEVL",A) ..
*
     v_feedInpCoeff(RUNR,MAACT,A,FeedAggr)
       =E= SUM(Feed_FeedAggr(Feed,FeedAggr), v_feedInpCoeff(RUNR,MAACT,A,FEED)
                                           * SUM(R_RAGG(RUNR,MSACT),%data%(MSACT,"DRMA",FEED,"Y")));
*
```

An aggregation of specific feeding stuff to aggregates (roughage, concentrates) is done since the prior shares as well as minimum and maximum shares are better rooted in the literature for aggregates than for single feedstuffs. The mapping is shown in Table 2. It has been specified basically by putting into the “other” category all “special” items. Therefore straw is a component of this “other” category rather than “roughage”. Minimum and maximum shares are given based on dry matter of total feed. Hence the estimated feed input coefficients (measured in fresh weight) are multiplied by the dry matter content.

Table 2: Mapping feeding stuff to feed aggregates

	FGRA	FMAI	FOFA	FROO	FCOM	FSGM	FSTR	FCER	FPRO	FENE	FMIL	FOTH
FeedRough	X	X	X	X								
FeedCons								X	X	X	X	
FeedOth					X	X	X					X
FeedTotal	X	X	X	X	X	X	X	X	X	X	X	X

Own compilation

FeedAggrShare_

```
*
*       --- calculate share of concentrate and roughage
*
    FeedAggrShare_(RUNR,MAACT,A,FeedAggr) $ (  p_animReq(RUNR,MAACT,A,"DRMA")) ..
*
            v_feedInpCoeff(RUNR,MAACT,A,FeedAggr) / (v_feedInpCoeff(RUNR,MAACT,A,"FeedTotal") + 1E-12)

                             =E= v_FeedAggrShare(RUNR,MAACT,A,FeedAggr) ;
*
```

MeanFeedTotal_

```
*        *** definition of mean total feed intake across sub regions
*
   MeanFeedTotal_  (RUNAGG,MAACT,A) $  SUM(RUNR, p_AnimReq(RUNR,MAACT,A,"ENNE")) ..
*
          SUM(RUNR , v_actLevl(RUNR,MAACT,A) * v_feedInpCoeff(RUNR,MAACT,A,"FeedTotal"))
        / (SUM(RUNR , v_actLevl(RUNR,MAACT,A)) + 1E-6)

                    =E= v_feedInpCoeff(RUNAGG,MAACT,A,"FeedTotalSubRegionAvg");
```

One of the aggregates calculated is the total feed intake per animal. It is expected that, inspite of regional differences in fodder supply, this total feed intake is mostly a genetic characteristic of animals and hence should not vary markedly across regions. To influence this distribution in the objective, the average across regions needs to be computed.

2.3 Objective function

The objective function is extensively revised. The criteria to be optimised are now:

(1) coverage of animal requirements with feed
(2) regional variation of certain feed input coefficients
(3) concentration of energy and protein in feed mix
(4) shares of feed aggregates (roughage, concentrates, other) in total feed mix
(5) feed input coefficients of all FEED bulks receive prior expectations

The parameters in the objective function are partly means and imputed standard deviations AND so-called "soft" upper and lower limits. The "soft" limits are not used as fixed bounds, but increase the penalty significant when the solver picks values close to or even beyond them.

<u>Coverage of animal requirements with feed</u>

```
*         ---- All relative deviations per animal are weighted with the "importance" of that animal type for the total sector
*              Otherwise the solver may try to fix any balancing needs with modifications on 1-2 'large' activities
*              because this is 'cheaper' in terms of the penalties than fiddling around with all activities

*
*         ---- deviation of requirements from mean of a priori expectation
*
          (
           - 1E5 * SUM( (RUNR,MAACT,A,REQMSE) $ p_AnimReq(RUNR,MAACT,A,REQMSE),
                        SQR( (v_animReq(RUNR,MAACT,A,REQMSE) - p_AnimReq(RUNR,MAACT,A,REQMSE))
                            /  p_AnimReq(RUNR,MAACT,A,REQMSE))
*              weighting:
                        * [(v_actLevl(RUNR,MAACT,A)+.01)*p_AnimReq(RUNR,MAACT,A,REQMSE)*p_animProdDays(RUNR,MAACT,A)]**.1)
```

This part of the objective functions tries to minimize the difference between the requirements calculated from the feed input coefficients (v_animReq) and the expected (mean) requirements (p_animReq) coming from literature. An earlier version expressed the weights for this term as a standard deviation, derived from the expected mean (0.01 * p_animReq). The factor "0.01" has been moved before the expression to facilitate comparisons with other terms, to be explained below. In general it should be noted that the relative weights for the different components of the objective evidently determine the way the different quality criteria are traded off. After finding undesirable deviations of some requirements from their priors their weight has been increased by a factor of 10 (1E4=>1E5). Due to the weighting with number of animals (v_actLevl) and expected requirements (p_animReq) the optimal solution tends to distribute over or under supply of nutrients relatively even over all activities and regions. It has been decided to attach an exponent smaller one to these weights which strongly pulls them towards unity (see: [...]**.1). This tends to give more weight to "less important" animal types compared with untransformed weights. However, the question of a "suitable" weighting is not unambiguous and for some terms it has been decided differently in the "_pw" version (which is described here) and in an alternative "_mak" version. Ultimately a suitable weighting is such a weighting that produces plausible results in a reproducible manner which can only be determined via testing. Results of the currently operational versions are therefore compared in the final section.

<u>Deviation of sub regional total feed intake from regional average</u>

```
---- deviation of sub regional total feed intake from sub regional average (dry intake equal across regions)

  - 1E4 * SUM( (RUNAGG,RUNR,MAACT,A) $ p_AnimReq(RUNR,MAACT,A,"ENNE"),
                SQR( (v_feedInpCoeff(RUNR,MAACT,A,"FeedTotal")-v_feedInpCoeff(RUNAGG,MAACT,A,"FeedTotalSubRegionAvg"))
                   / (v_feedInpCoeff(RUNAGG,MAACT,A,"FeedTotalSubRegionAvg") + 1E-3)))
```

As argued above, we expect that total feed intake in DRMA is mostly a genetic characteristic of animals and hence should not vary markedly across regions. Deviations of (sub-)regional feed intake from the associated regional average (NUTS1 or MS) are therefore penalised.

<u>Deviations of sub regional feed input coefficients of non-ruminants from regional average</u>

```
---- deviation of regional feed intake from aggregate intake for non-ruminants
     (non-ruminants do not depend on regional fodder production, should be similar across regions))

  - 1E4 * SUM( (RUNAGG,RUNR,MNRUMI,A,FEED) $ p_maxFeedShare(RUNR,MNRUMI,A,Feed),
               SQR( (v_feedInpCoeff(RUNR,MNRUMI,A,FEED) - v_feedInpCoeff(RUNAGG,MNRUMI,A,FEED))
                  / (v_feedInpCoeff(RUNAGG,MNRUMI,A,FEED) + 1E-4)))
```

As the comment explains, non-ruminants should have a rather standardised diet across regions.

<u>Concentration of energy and protein in feed aggregates</u>

```
---- deviation of nutrition content from expected feeding practices (typical energy/protein density for aggregates)

   - 1E2 * SUM( (RUNR,MAACT,A,REQMSE,FeedAggr) $ p_nutContFeed(RUNR,MAACT,A,REQMSE,FeedAggr,"MEAN"),
              SQR( (p_nutContFeed(RUNR,MAACT,A,REQMSE,FeedAggr,"MEAN")-v_nutContFeed(RUNR,MAACT,A,REQMSE,FeedAggr))
                 / (p_nutContFeed(RUNR,MAACT,A,REQMSE,FeedAggr,"MEAN")))
     weighting:
             * [(v_actLevl(RUNR,MAACT,A)+.01)*p_AnimReq(RUNR,MAACT,A,REQMSE)*p_animProdDays(RUNR,MAACT,A)]**.1)

---- nutrient content in feed: high penalty for the part of the estimates over or under the lower/upper limits

  - 1E3 * SUM( (RUNR,MAACT,A,REQMSE,FeedAggr) $ ( p_nutContFeed(RUNR,MAACT,A,REQMSE,FeedAggr,"MAX")
                                               $ p_aprDistAnimReq(RUNR,MAACT,A,"ENNE","MEAN")),
             SQR( (-ncpcm(-v_nutContFeed(RUNR,MAACT,A,REQMSE,FeedAggr),
                          -p_nutContFeed(RUNR,MAACT,A,REQMSE,FeedAggr,"MAX"),
                          max(.01,.05*p_nutContFeed(RUNR,MAACT,A,REQMSE,FeedAggr,"MAX")))
                 -p_nutContFeed(RUNR,MAACT,A,REQMSE,FeedAggr,"MAX"))
               / MAX(.1,ABS(p_nutContFeed(RUNR,MAACT,A,REQMSE,FeedAggr,"MAX")))
     weighting:
            * [(v_actLevl(RUNR,MAACT,A)+.01)*p_AnimReq(RUNR,MAACT,A,REQMSE)*p_animProdDays(RUNR,MAACT,A)]**.1)

   - 1E3 * SUM( (RUNR,MAACT,A,REQMSE,FeedAggr) $ ( p_nutContFeed(RUNR,MAACT,A,REQMSE,FeedAggr,"MIN")
                                                $ p_aprDistAnimReq(RUNR,MAACT,A,"ENNE","MEAN")),
             SQR( ( ncpcm( v_nutContFeed(RUNR,MAACT,A,REQMSE,FeedAggr),
                           p_nutContFeed(RUNR,MAACT,A,REQMSE,FeedAggr,"MIN"),
                           max(.01,.05*p_nutContFeed(RUNR,MAACT,A,REQMSE,FeedAggr,"MIN")))
                 -p_nutContFeed(RUNR,MAACT,A,REQMSE,FeedAggr,"MIN"))
              / MAX(.1,ABS(p_nutContFeed(RUNR,MAACT,A,REQMSE,FeedAggr,"MIN")))
     weighting:
            * [(v_actLevl(RUNR,MAACT,A)+.01)*p_AnimReq(RUNR,MAACT,A,REQMSE)*p_animProdDays(RUNR,MAACT,A)]**.1)
```

This part of the objective functions tries to minimize the difference between the nutrient content of feed aggregates (v_nutContFeed) and the expected nutrient (p_nutContFeed(…"MEAN")) coming from literature or IFM-CAP. The imputed standard deviation had been set to 0.1 * p_nutContFeed(…"MEAN"), giving a factor of 1E2 for this penalty term. Compared to the previous terms with factors of 1E4 – 1E5 this is quite low such that the optimal solution might differ more significantly from the expected mean. This is to some extend anticipated since the literature suggests often a range of reasonable nutrient contents rather than a specific value. However, to avoid an unreasonable large deviation, lower and upper limits are introduced (MIN, MAX), where the penalty in the objective function increases significantly (factors 1E3). The extra penalties rely on the GAMS built-in smooth approximation of the min operator (Chen-Mangasarian smoothing function ncpcm()) which is also used in the CAPRI market model. The values for mean and upper and lower limits are presented in Table 3.

Table 3: expected nutrient content in total feed per animal category

	Energy			Crude protein		
	MEAN	**MIN**	**MAX**	**MEAN**	**MIN**	**MAX**
DCOL	6,7	6,4	7	0,155	0,14	0,17
DCOH	6,8	6,6	7,2	0,155	0,14	0,17
BULL	6,7	6,2	7	0,155	0,14	0,17
BULH	6,8	6,4	7,2	0,155	0,14	0,17
HEIL	6,3	5,8	7	0,155	0,14	0,17
HEIH	6,8	6,2	7,2	0,155	0,14	0,17

SCOW	6,4	6	7	0,155	0,14	0,17
HEIR	6,4	6	7	0,155	0,14	0,17
CAMF	6,6	6,6	7,2	0,155	0,14	0,17
CAFF	6,6	6,6	7,2	0,155	0,14	0,17
CAMR	6,6	6,6	7,2	0,155	0,14	0,17
CAFR	6,6	6,6	7,2	0,155	0,14	0,17
PIGF	8	7,8	8,2	0,155	0,14	0,17
SOWS	8	7,8	8,2	0,155	0,14	0,17
SHGM	6,3	5,8	7	0,155	0,14	0,17
SHGF	6,3	5,8	7	0,155	0,14	0,17
HENS	8	7,8	8,2	0,18	0,14	0,2
POUF	8	7,8	8,2	0,18	0,14	0,2

Own compilation

Shares of feed aggregates in total feed intake in DRMA

```
 ---- shares of feed aggregates: high penalty for the part of the estimates over or under the lower/upper limits

   - 1E4 * SUM( (RUNR,MAACT,A,FeedAggr) $ ( p_maxFeedShare(RUNR,MAACT,A,FeedAggr)
                                          $ p_aprDistAnimReq(RUNR,MAACT,A,"ENNE","MEAN")),
              SQR( (-ncpcm(-v_FeedAggrShare(RUNR,MAACT,A,FeedAggr),
                          -p_maxFeedShare(RUNR,MAACT,A,FeedAggr),
                          max(.02,.05*p_maxFeedShare(RUNR,MAACT,A,FeedAggr)))
                     -p_maxFeedShare(RUNR,MAACT,A,FeedAggr))
                   / MAX(.1,ABS(p_maxFeedShare(RUNR,MAACT,A,FeedAggr))))
     weighting:
                 * [  max(SUM(R_RAGG(RUNR,MSACT),p_feedInpCoeffDRMA(MSACT,maact,A,FeedAggr,"Adjusted")),.1)
                  *  (v_actLevl(RUNR,MAACT,A)+.01)*p_animProdDays(RUNR,MAACT,A)]**.1)

   - 1E4 * SUM( (RUNR,MAACT,A,FeedAggr) $ ( p_minFeedShare(RUNR,MAACT,A,FeedAggr)
                                          $ p_aprDistAnimReq(RUNR,MAACT,A,"ENNE","MEAN")),
              SQR( ( ncpcm( v_FeedAggrShare(RUNR,MAACT,A,FeedAggr),
                            p_minFeedShare(RUNR,MAACT,A,FeedAggr),
                            max(.02,.05*p_minFeedShare(RUNR,MAACT,A,FeedAggr)))
                     -p_minFeedShare(RUNR,MAACT,A,FeedAggr))
                   / MAX(.1,ABS(p_minFeedShare(RUNR,MAACT,A,FeedAggr))))
     weighting:
                 * [  max(SUM(R_RAGG(RUNR,MSACT),p_feedInpCoeffDRMA(MSACT,maact,A,FeedAggr,"Adjusted")),.1)
                  *  (v_actLevl(RUNR,MAACT,A)+.01) *   p_animProdDays(RUNR,MAACT,A)]**.1)
```

The shares of roughage and concentrate feed are only controlled by upper (p_maxFeedShare) and lower (p_minFeedShare) limits. The literature suggests that ruminants can digest at most 40% of concentrate feed (or at least 60% roughage). Higher shares of concentrate feed are almost not possible from the physiology of the ruminants. The upper and lower limits are partially taken from IFM-CAP, literature and expert knowledge of Markus Kempen. (Actual values see table 4)

Table 4: Maximum and minimum shares of feed aggregates

	Maximum shares		Minimum shares	
	FeedRough	FeedCons	FeedRough	FeedCons
DCOL	0,85	0,4	0,75	0,1
DCOH	0,7	0,45	0,6	0,1
BULL	0,8	0,4	0,65	0,1
BULH	0,8	0,4	0,65	0,1
HEIL	0,9	0,3	0,65	0,1
HEIH	0,9	0,3	0,7	0,1
SCOW	0,95	0,3	0,7	0,05
HEIR	0,9	0,3	0,7	0,05
CAMF		0,3		0,15
CAFF		0,3		0,15
CAMR		0,3		0,1
CAFR		0,3		0,1
PIGF		1		0,95
SOWS		1		0,9
SHGM		0,3		0,05
SHGF		0,3		0,05
HENS				0,99
POUF				0,99

* own compilation

For „other feed“ there are no lower bounds but rather low upper bounds: 10% for adult cattle, 5% for calves and sheep, 1% for pigs and 1E-6 (so near zero) for poultry.

Feed input coefficients for single feed bulks

```
---- penalty for deviation from expected feed input

  - 1E2 * SUM( (RUNR,MAACT,A,FEED) $ (p_feedInpCoeff(RUNR,MAACT,A,FEED,"STDE") $ p_maxFeedShare(RUNR,MAACT,A,Feed)),
               SQR( (v_feedInpCoeff(RUNR,MAACT,A,FEED) - p_feedInpCoeff(RUNR,MAACT,A,FEED,"Mean"))
                  /  p_feedInpCoeff(RUNR,MAACT,A,FEED,"STDE"))
    weighting:
             * [(v_actLevl(RUNR,MAACT,A)+.01) *  p_animProdDays(RUNR,MAACT,A)]**.1)

---- high penalty for the part of the estimates over or under the lower/upper limits

  - 1E4 * SUM( (RUNR,MAACT,A,Feed) $ (p_FeedInpCoeff(RUNR,MAACT,A,Feed,"UppLim")),
                SQR((-ncpcm(-v_FeedInpCoeff(RUNR,MAACT,A,Feed),
                     -p_FeedInpCoeff(RUNR,MAACT,A,Feed,"UppLim"),
                      max(2,0.02*p_FeedInpCoeff(RUNR,MAACT,A,Feed,"UppLim")))
                     -p_FeedInpCoeff(RUNR,MAACT,A,Feed,"UppLim"))
                  / MAX(.1,ABS(p_FeedInpCoeff(RUNR,MAACT,A,Feed,"UppLim")))
    weighting:
              * [(v_actLevl(RUNR,MAACT,A)+.01) * p_animProdDays(RUNR,MAACT,A)]**.1)

   - 1E5  * SUM( (RUNR,MAACT,A,Feed) $ ( p_FeedInpCoeff(RUNR,MAACT,A,Feed,"LowLim")
                                       $ p_aprDistAnimReq(RUNR,MAACT,A,"ENNE","MEAN")),
                  SQR( ( ncpcm(v_FeedInpCoeff(RUNR,MAACT,A,Feed),
                          p_FeedInpCoeff(RUNR,MAACT,A,Feed,"LowLim"),
                          max(2,0.05*p_FeedInpCoeff(RUNR,MAACT,A,Feed,"LowLim")))
                        -p_FeedInpCoeff(RUNR,MAACT,A,Feed,"LowLim"))
                      / MAX(.1,ABS(p_FeedInpCoeff(RUNR,MAACT,A,Feed,"LowLim")))
    weighting:
                * [(v_actLevl(RUNR,MAACT,A)+.01) * p_animProdDays(RUNR,MAACT,A)]**.1)
```

Apart from plausibility of the results a second objective of the revision has been reproducability. The previous specification essentially gave random results within the feasible set because no prior expectations had been specified. This has been revised with penalties for deviations of feed input coefficients from their assumed MEAN (specification to be explained below). However, just like is the case for the nutrient content of feed aggregates or their shares in the total, this prior information has to be considered quite imprecise which is reflected in rather low factors (1E2) attached to these terms. The penalties are increased if the solver tries to approach or exceed “soft” lower or upper limits. As the lower limits also turned out useful to prevent the solver from ending up in infeasible corners a higher factor has been attached to them (1E5).

It should also be reported that in many cases of infeasible solutions encountered in the extensive testing of this and previous specifications the last iteration result reported from the solver had often all feed input coefficients for some animal type zero or near zero. To avoid these cases the solution attempt starts with hard lower bounds:

```
      Lower bounds close to zero are maintained as this turned out to help the solver
v_feedInpCoeff.lo(RUNR,maact,A,FEED) $ p_feedInpCoeff(RUNR,MAACT,A,FEED,"lowLim")
    = p_feedInpCoeff(RUNR,MAACT,A,FEED,"lowLim")
    * ( 1.E-1 $ ( (not sameas(feed,"fstr")) $ SAMEAS(R_LEVL,"TOP"))
      + 1.E-3 $ ( (not sameas(feed,"fstr")) $ SAMEAS(R_LEVL,"MS")));
```

In case of infeasibilities after x trials these are removed:

```
    After x trials we further relax the lower bounds here, but independent from marginals and for all coefficient:
v_feedInpCoeff.lo(RUNR,maact,A,FEED)  $ (p_feedInpCoeff(RUNR,MAACT,A,FEED,"lowLim") $ (p_nSolved(RAGG) gt 5))
  = v_feedInpCoeff.lo(RUNR,maact,A,FEED)  / 10;
v_feedInpCoeff.lo(RUNR,maact,A,FEED)  $ (p_feedInpCoeff(RUNR,MAACT,A,FEED,"lowLim") $ (p_nSolved(RAGG) gt 10))
  = 0;
```

This procedure led to an acceptable or at least considerably improved stability of the feed calibration in tasks “build regional database” as well as “baseline calibration supply models”.

2.4 Priors for feed input coefficients

The priors for feed input coefficients are specified in a new include file capri\gams\feed\fedtrm_prior.gms:

```
*  calculate share of single feed in feed aggregate
p_FeedShareInAggr(RallInMS,MAACT,"T",Feed,FeedAggr,"RegMean") $ ( Feed_FeedAggr(FEED,FeedAggr)
                                                          $ p_feedQuantDRMA(RallInMS,FeedAggr,"FEDM"))
  = p_feedQuantDRMA(RallInMS,FEED,"FEDM") / p_feedQuantDRMA(RallInMS,FeedAggr,"FEDM");
---------------------------------------------------------------------------- 4 line(s) not displayed --------------------
*  prior expectation for annual feed intake in DM per animal type and feed stuff:
*  = adjusted DRMA from feed aggregate  times regional share of feed stuff in aggregate
*  ATTENTION: does not account for animal specific diets
*             Example 1: pigs should have about 20% FPRO and 80% FCER in their concentrate, independent of national mean mix
*             Example 2: calves for raising should receive a higher share of liquid raw milk FCOM than calves for fattening
p_feedInpCoeffDRMA(RallInMS,maact,"T",Feed,"PRIOR") $ p_maxFeedShare(RallInMS,MAACT,"T",FEED)
  = sum((MAP_RR(MS,RallInMS),Feed_FeedAggr(FEED,FeedAggr)), p_feedInpCoeffDRMA(MS,maact,"T",FeedAggr,"Adjusted")
                                                         * p_FeedShareInAggr(RallInMS,MAACT,"T",Feed,FeedAggr,"RegMean"));
```

The shares of feed aggregates in the diets of animal types may build upon recommendations from the literature (see the previous section). They are adjusted to be in line with the statistical ex post data or the baseline projections, giving the “adjusted” aggregate feed input coefficients shown in the code snippet above. However, feed recommendations do not exist for single feedstuffs because these are easily substitutable. Stability of the feed calibration requires however some priors. A simple default assumption made has been therefore: the composition of feed aggregates in terms of their components is the same for all animals. This is evidently a simplification such that the penalties for deviations from these priors have been set rather low.

2.5 Nutrient content

For the nutrient contents of feeding stuff the standard values (in file dat\fedcof.gms) have been compared to those from IFM-CAP (in file dat\NutCont.gdx). Due to the small differences the older standard values have been retained.

2.6 Requirements

Requirement functions are unchanged so far since they do not differ highly significant from IFM-CAP.

2.7 Calibration of pmp

The calibration of pmp terms for feeding coefficients is unchanged. But the constraints of minimum and maximum shares of feeding stuffs and some contents (fibre, lysin, etc) have been removed. The pmp terms have therefore a considerably increased role in simulations: Whereas the feed mix was so far steered by technical constraints, at least to a significant extent, all of these are gone except the equality constraints on feed energy and protein. The feed mix in simulation is therefore critically determined by the feed related pmp terms. In case of undesirable simulation behaviour it might be considered to include at least bounds for the total feed intake in terms of dry matter where feed recommendations apparently provide some bounds for plausible values.

3 SELECTED RESULTS OF STABILITY TESTING

Stability testing has been undertaken in a similar fashion as is generally done in the stable release context, but with a focus on feed related outputs. As indicator variables determining most others we have selected to monitor the daily feed intake of animals in DM as well as feed energy and protein intake on a checking parameter "p_feed". A frequent finding has been that some instabilites are still present but mainly for "minor" items. To counteract the effect that tiny feed coefficients may experience a huge sensitivity to starting values in terms of their relative deviations, a second checking parameter has been created where 0.1% of daily DM intake has been added to all input coefficients. This is irrelevant for major feedstuffs (such as FCER,FPRO, FGRA, FOFA, FMAI) but may considerably moderate the computed percentage changes for tiny quantities.

```
*    Second checcking parameter to pick up only relevant differences:
     parameter p_feedPlus001DM  "Second monitoring param for feed stability testing = ori+.001*feedTotal perDayDry";

     p_feedPlus001DM(RallInMS,maact,A,feedReqm,"perDayDry") $ (not sum(sameas(feed,feedReqm),1))
       = p_feed(RallInMS,maact,A,feedReqm,"perDayDry");
     p_feedPlus001DM(RallInMS,maact,A,feed,"perDayDry") $ ( p_feedDetail(RallInMS,maact,A,"FeedTotal","perDayDry")
                                                          $ p_feedDetail(RallInMS,maact,A,Feed,"TotalPrior"))
       = p_feedDetail(RallInMS,maact,A,Feed,"perDayDry")
       + .001*p_feedDetail(RallInMS,maact,A,"FeedTotal","perDayDry");
```

The testing has been undertaken for the following options regarding starting values:

- clean = default starting values
- restart1 = building on starting values produced from the clean run
- restart2 = same as restart1
- g247= same as restart1, but using GAMS24.7 rather than 24.9
- randstart: default starting values perturbed by a uniform distribution between 50% up and down from default

The comparison points has been always the restart1 version. Both in tasks "regional database" as well as "baseline calibration supply" the largest differences were usually occurring when comparing "clean" with "restart1" such that we will only present results for this comparison in the following.

We may first look in the following Table 5 at the test results from the standard star2 version as was in place in November 2018 when selecting %feedversion%==[empty]. It should be remembered that this “standard” version is already improved in many aspects compared to the feed allocation methodology in place in the trunk. Unlike the results in subsequent Tables it may be observed that the test results with 0.1% of total DM intake added to all FEED quantities makes little difference to the distribution of % differences.

Table 5: Percentage differences between the “clean” and “restart1” versions in task “build regional database” from the standard star2 code version

		p_feedPlus001DM									p_feed								
		>zero	>0.001	>0.01	>0.1	>1	>10	>100	infinite	# of Comparisons	>zero	>0.001	>0.01	>0.1	>1	>10	>100	infinite	# of Comparisons
2012	BL	2750	985	949	744	122	64	48	41	2942									
2012	SE	1784	960	471	227					1837	1549	955	471	231					1837
2012	DK	194								206	152								206
2012	DE	7348	148	87	41	18	18	18	18	8081	5373	148	87	41	18	18	18	18	8081
2012	EL	3209								3428	2580								3428
2012	ES	4411	51	15	4	3	3	3	3	4643	3680	54	18	5	3	3	3	3	4643
2012	FR	5565	838	234	37	18	9	8	8	5966	4319	812	238	39	19	10	8	8	5966
2012	IR	561								621	403								621
2012	IT	4954	832	247	108	26	2	2	2	5412	3700	793	247	109	27	2	2	2	5412
2012	NL	3142								3538	2394								3538
2012	AT	2292								2478	1745								2478
2012	PT	1650								1823	1435								1823
2012	FI	1197								1335	971								1335
2012	UK	2275								2492	1716								2492
2012	CY	188								204	151								204
2012	EE	212	132	86	37	5	3	3	3	213	194	127	86	37	5	4	3	3	213
2012	LV	187								210	146								210
2012	LT	180								212	147								212
2012	MT	177								192	143								192
2012	PL	4241								4797	3287								4797
2012	SK	905								987	714								987
2012	BG	1364	773	275	112	39	10	4	3	1482	1085	684	266	113	42	10	5	3	1482
2012	CZ	1766								1880	1398								1880
2012	HU	2004	577	499	367	94	47	31	25	2110	1740	487	432	360	96	48	32	25	2110
2012	SI	208	154	86	28	3				213	186	153	86	28	4				213
2012	RO	1703								1866	1248								1866
2012	CS	202								213	159								213
2012	AL	148								174	106								174
2012	MO	160	60	33	13					183	118	54	34	17					183
2012	HR	186								211	142								211
2012	BA	168								188	117								188
2012	MK	187	165	100	48	3	2	2	2	191	160	148	99	48	3	2	2	2	191
2012	KO	181	102	55	35	2				200	138	94	55	35	3				200
2012	TU	6934	447	348	159	77	77	77	77	7529	5132	447	348	159	77	77	77	77	7529
2012	NO	4325								4612	3544								4612

It may be seen that the standard version generates hundreds of deviations larger than 10%. These deviations are strongly reduced in the “_pw” version (Table6), in fact to zero when inspecting p_feedPlus001DM. Overall the results from the “capreg” base year 2012 testing show a quite good result with most deviations being smaller than 1%. The 9 remaining cases with deviations larger than 1% but smaller than 10% are shown both for the original “p_feed” parameter as well as for the “p_feedPlus001DM”parameter that reduces the percentage changes for tiny quantities. It may be concluded therefore that these instabilities are potentially “serious”, but they have been found to be rather harmless: either they were close to 1% or the affected feed coefficients were small in magnitude, even though not tiny.

Table 6: Percentage differences between the "clean" and "restart1" versions in task "build regional database" from code version "_pw"

		p_feedPlus001DM					p_feed								
		>zero	>0.001	>0.01	>0.1	# of Comparisons	>zero	>0.001	>0.01	>0.1	>1	>10	>100	infinite	# of Comparisons
2012	BL	3500	4			3500									
2012	SE	2106	3			2106	2106	3							2106
2012	DK	248				248	248								248
2012	DE	9993	4			9993	9993	5							9993
2012	EL	4250				4250	4213								4213
2012	ES	5750	8			5750	5729	12							5729
2012	FR	7250	7	3		7250	7245	7	3						7245
2012	IR	744				744	744								744
2012	IT	6493	2			6493	6459	5							6459
2012	NL	4216	3			4216	4214	3							4214
2012	AT	3000	3			3000	2994	4							2994
2012	PT	2236	5	2		2236	2212	6	2						2212
2012	FI	1638				1638	1638								1638
2012	UK	2976				2976	2976								2976
2012	CY	235				235	234								235
2012	EE	250				250	250								250
2012	LV	250				250	250								250
2012	LT	250				250	250								250
2012	MT	221				222	221								222
2012	PL	5748	6			5750	5748	6							5750
2012	SK	1080	2			1080	1080	2							1080
2012	BG	1750				1750	1750								1750
2012	CZ	2088	2			2088	2088	2							2088
2012	HU	2500	2			2500	2500	2							2500
2012	SI	250				250	250								250
2012	RO	2250				2250	2250								2250
2012	CS	229				230	229								230
2012	AL	205				205	203								205
2012	MO	218				218	218								218
2012	HR	249				250	249								250
2012	BA	220				220	217								220
2012	MK	250				250	249								250
2012	KO	212				212	212								212
2012	TU	8732	2			8732	8732	2							8732
2012	NO	5879	8	2		5879	5801	9	2						5801

As has been mentioned in the text above small changes in the settings may shift the balance between stability and attaining other goals relevant for a "good" feed allocation procedure. The settings from the _mak version also give a considerably improved stability (Table 7) even though with a bit more deviations than in the _pw version shown above[2].

[2] Unfortunately the tests have been performed with Gams25.0 for the standard and _pw versions whereas the _mak results stem from Gams24.9.

Table 7: Percentage differences between the “clean” and “restart1” versions in task “build regional database” from code version “_mak”

		p_feedPlus001DM						p_feed						
		>zero	>0.001	>0.01	>0.1	>1	# of Comparisons	>zero	>0.001	>0.01	>0.1	>1	>10	# of Comparisons
2012	BL	3500					3500							
2012	SE	2101					2106	2101						2106
2012	DK	248					248	248						248
2012	DE	9993	45	3			9993	9922	82	4	1			9941
2012	EL	4249	15	3			4250	4219	15	14	8			4222
2012	ES	5750	34	21	15		5750	5733	35	21	21			5733
2012	FR	7250					7250	7222						7230
2012	IR	744					744	744						744
2012	IT	6469	21	4	3	1	6493	6176	38	5	3	2		6246
2012	NL	4215					4216	4194						4195
2012	AT	2999					3000	2975						2986
2012	PT	2236	22	6	3		2236	2222	22	6	6	1		2222
2012	FI	1638					1638	1638						1638
2012	UK	2976	2				2976	2976	2					2976
2012	CY	235					235	235						235
2012	EE	250					250	250						250
2012	LV	248					250	245						250
2012	LT	228					250	227						250
2012	MT	222					222	222						222
2012	PL	5746	4	2			5750	5702	4	3	1			5723
2012	SK	1057					1078	1010						1067
2012	BG	1750	14	5	5	2	1750	1732	14	5	5	2		1750
2012	CZ	2029					2088	2016						2088
2012	HU	2500	4	3	1		2500	2493	4	3	1	1		2500
2012	SI	247					250	247						250
2012	RO	2250					2250	2249						2250
2012	CS	230					230	230						230
2012	AL	205					205	205						205
2012	MO	218					218	218						218
2012	HR	239					250	239						250
2012	BA	193					220	193						220
2012	MK	250					250	250						250
2012	KO	212					212	212						212
2012	TU	8732					8732	8609						8613
2012	NO	5875	5	3	1		5879	5870	5	3	1			5878

In the baseline calibration the “noise” is much stronger. This might be due to the different treatment of straw losses in the baseline calibration as opposed to capreg but clear evidence for this speculation has not been found. Tables 8 and 9 first show the results from the standard version. It may be seen that the standard version has thousands of deviations larger than 10% both for 2015 as well as 2030 as calibration years.

Table 8: Percentage differences between the "clean" and "restart1" versions in task "baseline calibration supply" for 2015 from the standard star2 code version

		p_feedPlus001DM									p_feed								
		>zero	>0.001	>0.01	>0.1	>1	>10	>100	infinite	# of Comparisons	>zero	>0.001	>0.01	>0.1	>1	>10	>100	infinite	# of Comparisons
2015	BL	2665	15	11	2					2890									
2015	SE	1728								1822	1429								1822
2015	DK	193								206	152								206
2015	DE	7011	329	219	126	54	45	40	40	8010	4999	311	214	128	54	45	40	40	8010
2015	EL	3223	17							3389	2604	17							3389
2015	ES	4360	2356	1467	617	173	89	63	60	4610	3649	2105	1415	616	175	90	68	60	4610
2015	FR	5655	3398	2531	1553	453	248	107	50	5888	4784	3076	2409	1551	455	255	118	50	5888
2015	IR	572								622	427								622
2015	IT	4830	321	122	47	17	14	12	11	5382	3664	296	107	47	17	14	12	11	5382
2015	NL	3174	1901	1352	727	163	95	42	26	3483	2612	1648	1263	730	164	97	49	26	3483
2015	AT	2242	60	26	8	3				2374	1788	54	26	8	3				2374
2015	PT	1660	1							1821	1378	1							1821
2015	FI	1297	314	112	54					1336	1160	317	115	55					1336
2015	UK	2346								2495	1798								2495
2015	CY	192								207	156								207
2015	EE	196								209	172								209
2015	LV	203								214	183								214
2015	LT	204	2							213	171	2	2						213
2015	MT	161								177	125								177
2015	PL	4403	1316	499	117	23	13	5	5	4723	3371	1236	497	118	23	13	6	5	4723
2015	SK	899								970	709								970
2015	BG	1382	407	175	75	36	11	10	10	1468	1099	396	176	76	36	11	10	10	1468
2015	CZ	1743								1845	1373								1845
2015	HU	1984	1109	768	428	125	55	27	14	2064	1680	973	731	427	125	55	29	14	2064
2015	SI	196								210	169								210
2015	RO	1717								1872	1316								1872
2015	CS	196								210	163								210
2015	AL	152								173	114								173
2015	MO	157								163	122								163
2015	HR	159								211	129								211
2015	BA	170								186	124								186
2015	MK	173								187	130								187
2015	KO	183	45	17	6					204	133	43	17	6					204
2015	TU	7152	2168	1068	285	30	18	2	2	7523	5556	1997	1042	286	31	19	2	2	7523
2015	NO	4284	2353	1572	783	179	64	17	8	4547	3660	2083	1483	771	179	67	28	8	4547

The picture is very similar for 2030 as a calibration year.

Table 9: Percentage differences between the "clean" and "restart1" versions in task "baseline calibration supply" for 2030 from the standard star2 code version

		p_feedPlus001DM									p_feed								
		>zero	>0.001	>0.01	>0.1	>1	>10	>100	infinite	# of Comparisons	>zero	>0.001	>0.01	>0.1	>1	>10	>100	infinite	# of Comparisons
2030	BL	2642	20	6	6	2	2	2	2	2876	1946	20	6	6	2	2	2	2	2876
2030	SE	1637								1796	1332								1796
2030	DK	202								207	185								207
2030	DE	6924	300	160	91	41	25	19	19	7747	5090	296	159	92	41	27	19	19	7747
2030	EL	3167	5							3351	2545	5							3351
2030	ES	4286	1926	1103	484	108	53	31	28	4590	3537	1783	1067	487	109	57	34	28	4590
2030	FR	5687	3449	2435	1511	410	255	99	58	5929	4808	3129	2335	1516	414	260	119	58	5929
2030	IR	578								619	435								619
2030	IT	4969	281	94	49	6	2	2	2	5425	3600	255	96	49	6	2	2	2	5425
2030	NL	3064	94	47	24	10	4	4	4	3394	2411	94	47	24	10	4	4	4	3394
2030	AT	2234	70	46	32	12	12	12	12	2378	1747	70	47	34	12	12	12	12	2378
2030	PT	1621								1765	1263								1765
2030	FI	1257								1303	1108								1303
2030	UK	2325								2448	1774								2448
2030	CY	156								188	125								188
2030	EE	195								205	168								205
2030	LV	204								215	188								215
2030	LT	198								209	176								209
2030	MT	170								189	141								189
2030	PL	4331	2237	1518	850	228	110	57	49	4766	3497	2038	1463	851	232	114	63	49	4766
2030	SK	927								970	762								970
2030	BG	1410	946	523	186	22	14	8	6	1475	1152	790	511	186	22	14	8	6	1475
2030	CZ	1701								1840	1335								1840
2030	HU	1906	973	713	411	98	57	24	24	2072	1568	795	683	412	100	57	27	24	2072
2030	SI	194								207	169								207
2030	RO	1665								1850	1322								1850
2030	CS	182								209	155								209
2030	AL	156								173	114								173
2030	MO	151								163	120								163
2030	HR	198								212	157								212
2030	BA	174								187	131								187
2030	MK	180								187	142								187
2030	KO	184	150	56	10	2				204	134	124	52	10	2				204
2030	TU	7308	7016	6072	3553	1253	724	521	497	7469	6609	6535	5939	3557	1263	749	532	497	7469
2030	NO	4290	1873	1263	488	103	42	24	13	4546	3623	1692	1208	485	103	45	28	13	4546

The new feed specifications achieve significant improvements in stability also in the baseline calibration. When looking at 2015 and check parameter p_feedPlus001DM only 10 cases of deviations larger than 10% have remained (Table 10), but for 2030 the remaining instability is non-negligible (101 differences >10%, see Table 11, parameter p_feedPlus001DM).

A point to note is that not all countries are unstable, even in the standard version. Furthermore there are examples like DK that apparently have lost in stability in the _pw version through the re-specification. There were 21 cases of deviations > 0.1% for parameter p_feedPlus001DM and 22 cases for parameter p_feed in the "_pw" Version for DK but none with the standard version of the code. However the reader is pointed to the fact that the number of comparisons is larger for the "_pw" version meaning that the feed allocation had fewer zero cells of combinations of FEED x MAACT. In other words the revised feed specification gives a more even feed allocation and less specialisation.

Table 10: Percentage differences between the "clean" and "restart1" versions in task "baseline calibration supply" for 2015 from code version "_pw"

		p_feedPlus001DM					p_feed								
		>zero	>0.001	>0.01	>0.1	# of Comparisons	>zero	>0.001	>0.01	>0.1	>1	>10	>100	infinite	# of Comparison
2015	BL	3480	2			3480									
2015	SE	2090				2090	2090								2090
2015	DK	248	20	1		248	248	21	1						248
2015	DE	9941	1			9941	9941	1							9941
2015	EL	3988				3988	3965	1							3965
2015	ES	5720	18			5720	5693	13							5694
2015	FR	7210	6			7210	7205	6							7205
2015	IR	744				744	744								744
2015	IT	6465				6465	6432								6432
2015	NL	4192	1			4192	4191	1							4191
2015	AT	2809				2809	2804								2804
2015	PT	2226	116	57	9	2226	2199	134	111	61	11	4	4	3	2199
2015	FI	1607				1607	1607								1607
2015	UK	2976				2976	2976								2976
2015	CY	218	33	5		218	218	42	12	3					218
2015	EE	250	12	1		250	250	13	2						250
2015	LV	250	21	7		250	250	25	10	2					250
2015	LT	250	21	4		250	250	33	12						250
2015	MT	209	23	3		209	209	26	3						209
2015	PL	5718				5718	5718								5718
2015	SK	1007				1007	1007								1007
2015	BG	1738				1738	1738								1738
2015	CZ	2072				2072	2069								2072
2015	HU	2488				2488	2488								2488
2015	SI	250	26	4		250	250	31	9						250
2015	RO	2234	28	5		2234	2234	49	26	11	2				2234
2015	CS	230	18	6		230	230	18	12	1					230
2015	AL	205	25	2		205	205	34	6	2	1	1			205
2015	MO	218	23			218	218	30							218
2015	HR	250	42	9		250	250	43	14	2					250
2015	BA	220	21			220	220	29	5	2	1	1			220
2015	MK	250	33	2	1	250	250	38	11	1					250
2015	KO	212	5			212	212	6							212
2015	TU	8684				8684	8684								8684
2015	NO	5495	6			5495	5419	6							5419

Table 11: Percentage differences between the "clean" and "restart1" versions in task "baseline calibration supply" for 2030 from code version "_pw"

		p_feedPlus001DM					p_feed								
		>zero	>0.001	>0.01	>0.1	# of Comparisons	>zero	>0.001	>0.01	>0.1	>1	>10	>100	infinite	# of Comparison
2030	BL	3480	4			3480	3478	4							3478
2030	SE	2090				2090	2090								2090
2030	DK	248	26	9	3	248	248	30	14	6					248
2030	DE	9941				9941	9939	1							9939
2030	EL	3988	109	20	9	3988	3965	191	92	37	2	2	2	2	3965
2030	ES	5720	11			5720	5677	31	10	5	5	5	4	4	5679
2030	FR	7210	2			7210	7203	3							7203
2030	IR	744	41	10	3	744	744	48	43	13	3	2			744
2030	IT	6458	168	76	26	6458	6425	268	114	53					6425
2030	NL	3954	99	37	16	3954	3953	130	79	32					3953
2030	AT	2809				2809	2802								2802
2030	PT	2226	315	188	26	2226	2196	373	208	72	10	9	1	1	2196
2030	FI	1614				1614	1614								1614
2030	UK	2976	145	15		2976	2976	145	20	6					2976
2030	CY	206	24	3		206	206	33	5	1					206
2030	EE	250	47	18	6	250	250	48	25	11					250
2030	LV	250	20	5	2	250	250	26	8	3	1				250
2030	LT	236	22	5		236	236	32	5	2					236
2030	MT	209	28	8		209	209	30	9						209
2030	PL	5718				5718	5718								5718
2030	SK	1007				1007	1007								1007
2030	BG	1738	113	59	8	1738	1738	118	70	27	1				1738
2030	CZ	1916				1916	1916								1916
2030	HU	2488	23			2488	2488	44	16	6					2488
2030	SI	250	49	24	1	250	250	54	30	13					250
2030	RO	2234	57	11		2234	2234	85	62	19					2234
2030	CS	230	22	13	1	230	230	22	18	11	2	2	2		230
2030	AL	205	26	2		205	205	34	6	3	1	1			205
2030	MO	218	20			218	218	25							218
2030	HR	236	38	4		236	236	38	4						236
2030	BA	220	23			220	220	33	8	2	1	1			220
2030	MK	250	33	2		250	250	36	9	1					250
2030	KO	212	5			212	212	5							212
2030	TU	8684				8684	8684								8684
2030	NO	5495	10			5495	5405	11							5414

For the previously shown baseline calibration results we have both for 2015 and 2030 many cases of relative deviations exceeding 10%. It may be seen that these are more rare if parameter p_feedPlus001DM is inspected, indicating that many of those differences are affecting minor feed items. Typical examples are FROO and FENE, the latter probably responsible for 90% of the deviations larger than 10%. In those cases with deviations on p_feedPlus001DM it has been checked in the detailed comparison results which items are affected and in all cases they were found to be minor. In other words adding not only 0.1% of DM to each feed input coefficient but 1% of DM would have eliminated all or nearly all of them. This test has not been carried out though.

The next Table 12 shows that at the example of the baseline calibration for 2030 stability is best for the code version _mak as there are only 49 cases of deviations larger than 10% for non-tiny items (parameter p_feedPlus001DM). However we will also remember that stability was better in the capreg step for the _pw version. The evidence is therefore so far inconclusive.

Table 12: Percentage differences between the "clean" and "restart1" versions in task "baseline calibration supply" for 2030 from code version "_mak"

		p_feedPlus001DM						p_feed						
		>zero	>0.001	>0.01	>0.1	>1	# of Comparisons	>zero	>0.001	>0.01	>0.1	>1	>10	# of Comparisons
2030	BL	3480	18	12	1		3480							
2030	SE	2090					2090	2090						2090
2030	DK	248					248	248						248
2030	DE	9941					9941	9940						9940
2030	EL	3986	6	5	1		3988	3972	6	5	5	1		3974
2030	ES	5398	52	21	6		5398	5393	59	21	20	1		5393
2030	FR	7204					7210	7199						7207
2030	IR	744					744	744						744
2030	IT	6458	140	56	10		6458	6414	149	74	70	6		6415
2030	NL	3953	5	4	2		3954	3953	5	4	4	2		3954
2030	AT	2772					2809	2770						2809
2030	PT	2226	29	9	4		2226	2212	52	31	10	6	1	2212
2030	FI	1630					1630	1630						1630
2030	UK	2976					2976	2976						2976
2030	CY	206					206	206						206
2030	EE	237					250	237						250
2030	LV	246					250	246						250
2030	LT	184					250	169						250
2030	MT	209					209	209						209
2030	PL	5718	69	32	11		5718	5711	72	42	30	6		5713
2030	SK	1007					1007	1007						1007
2030	BG	1738	32	18	10	1	1738	1738	32	19	11	5	1	1738
2030	CZ	1916					1916	1916						1916
2030	HU	2488	4	3	1		2488	2488	4	3	3	1		2488
2030	SI	249					250	247						250
2030	RO	2234	29	13	1		2234	2234	49	24	13	3		2234
2030	CS	227					230	227						230
2030	AL	205					205	205						205
2030	MO	218					218	218						218
2030	HR	236					236	236						236
2030	BA	220					220	220						220
2030	MK	250					250	250						250
2030	KO	210					212	210						212
2030	TU	8676	26	1			8676	8654	34	5				8654
2030	NO	5495	9	5	1		5495	5494	10	5	1	1		5494

Finally we show in the next two tables the regional variation in major feed intake components which is another quality criterion: All else equal, we would prefer a more homogenous total and energy feed intake.

Table 13: Regional variation of the calibrated feed allocation for 2030 in code versions "_mak" and "_pw" for adult cattle

		FeedRough		FeedCons		FeedTotal		Energy	
		_mak	_pw	_mak	_pw	_mak	_pw	_mak	_pw
DCOL	Mean	14.93	14.22	2.45	2.70	18.00	17.63	101.48	100.00
DCOL	StdDev	4.78	5.02	2.66	1.56	3.75	4.59	20.25	24.60
DCOL	q1	11.82	10.75	0.54	1.73	15.19	14.38	90.70	84.61
DCOL	q3	17.92	17.70	3.36	3.29	20.07	20.90	113.01	115.57
DCOL	min	2.35	2.44	0.05	0.38	8.60	6.60	52.62	41.85
DCOL	max	28.44	33.60	15.87	9.32	29.56	35.79	200.07	230.00
DCOH	Mean	17.51	15.43	4.66	5.85	22.89	22.19	133.30	133.10
DCOH	StdDev	7.37	6.42	4.49	3.21	5.78	6.15	32.35	34.72
DCOH	q1	12.11	11.20	1.22	3.68	18.97	18.64	114.07	114.00
DCOH	q3	22.82	19.50	6.81	7.54	26.00	25.84	151.19	155.33
DCOH	min	1.83	2.34	0.02	0.74	8.58	8.17	52.71	41.95
DCOH	max	38.66	40.82	30.44	17.59	40.81	45.03	303.57	293.86
BULL	Mean	7.70	7.27	1.07	1.11	9.27	8.74	51.41	48.84
BULL	StdDev	1.92	1.50	1.02	0.57	1.26	1.17	6.36	6.40
BULL	q1	6.75	6.53	0.26	0.73	8.51	8.07	47.81	44.81
BULL	q3	8.65	8.20	1.48	1.31	9.96	9.49	53.49	52.86
BULL	min	1.39	1.26	0.04	0.21	5.98	3.89	35.93	27.77
BULL	max	15.69	11.76	5.33	4.28	15.85	12.85	82.19	79.82
BULH	Mean	8.58	7.19	2.01	1.97	11.15	9.54	64.74	55.74
BULH	StdDev	3.04	1.97	1.70	0.88	1.82	1.57	8.43	8.73
BULH	q1	6.54	5.98	0.49	1.31	9.96	8.56	58.69	50.80
BULH	q3	10.50	8.41	2.99	2.43	12.13	10.47	69.48	60.41
BULH	min	1.15	1.29	0.06	0.38	6.59	5.58	45.55	32.39
BULH	max	18.39	16.37	7.10	5.60	18.56	18.22	102.79	117.10
HEIL	Mean	6.96	6.92	0.65	0.70	8.06	7.94	43.80	43.49
HEIL	StdDev	1.54	1.45	0.63	0.33	1.23	1.27	6.99	7.16
HEIL	q1	5.89	6.19	0.19	0.46	7.13	7.04	39.46	38.82
HEIL	q3	8.09	7.86	0.86	0.83	8.86	8.70	47.71	47.78
HEIL	min	1.83	1.14	0.04	0.19	5.31	2.48	28.76	16.61
HEIL	max	12.01	10.62	3.71	2.53	12.47	11.31	68.65	63.73
HEIH	Mean	7.59	6.81	1.43	1.41	9.48	8.56	54.19	48.89
HEIH	StdDev	2.32	1.61	1.22	0.61	1.52	1.22	8.29	6.42
HEIH	q1	6.18	5.95	0.37	0.93	8.27	7.66	48.31	44.35
HEIH	q3	9.08	7.82	2.08	1.72	10.61	9.30	58.23	52.85
HEIH	min	1.19	1.42	0.10	0.39	6.20	4.54	37.61	32.62
HEIH	max	14.21	11.08	5.81	3.60	14.39	12.31	83.95	70.22
SCOW	Mean	8.23	8.52	1.15	1.21	9.87	10.14	54.79	56.45
SCOW	StdDev	2.04	2.30	1.00	0.60	1.34	1.85	6.32	9.50
SCOW	q1	7.16	7.21	0.34	0.80	8.91	9.05	52.03	50.53
SCOW	q3	9.46	9.80	1.58	1.47	10.62	11.14	56.63	61.15
SCOW	min	1.55	2.18	0.06	0.31	6.79	4.50	37.39	29.60
SCOW	max	16.29	16.71	5.24	3.47	16.47	17.71	94.38	111.62
HEIR	Mean	5.49	5.55	0.73	0.80	6.61	6.61	36.38	36.80
HEIR	StdDev	1.43	1.42	0.65	0.38	1.04	1.16	5.06	5.66
HEIR	q1	4.76	4.78	0.20	0.52	5.93	5.90	33.20	33.16
HEIR	q3	6.24	6.37	0.97	0.96	7.04	7.25	39.64	39.86
HEIR	min	0.96	1.07	0.04	0.18	4.65	2.95	26.16	20.79
HEIR	max	13.31	10.88	3.88	2.29	13.47	11.68	69.91	61.74

Table 14: Regional variation of the calibrated feed allocation for 2030 in code versions "_mak" and "_pw" for animals other than adult cattle

		FeedRough		FeedCons		FeedTotal		Energy	
		_mak	_pw	_mak	_pw	_mak	_pw	_mak	_pw
CAMF	Mean	2.82	3.01	0.37	0.41	3.55	3.69	20.73	21.65
CAMF	StdDev	0.98	0.87	0.34	0.23	0.97	0.95	5.23	5.44
CAMF	q1	2.25	2.45	0.16	0.26	3.01	3.11	17.50	18.14
CAMF	q3	3.32	3.44	0.44	0.46	3.89	4.13	22.80	24.92
CAMF	min	0.90	0.54	0.03	0.15	1.78	1.25	11.62	8.33
CAMF	max	7.74	6.17	2.30	1.41	7.99	7.10	41.06	38.67
CAFF	Mean	3.30	3.44	0.42	0.46	4.13	4.20	24.25	24.69
CAFF	StdDev	1.10	0.92	0.39	0.27	1.05	0.98	5.82	6.00
CAFF	q1	2.54	2.97	0.18	0.28	3.39	3.62	20.38	20.64
CAFF	q3	3.92	4.10	0.52	0.52	4.74	4.81	27.80	28.60
CAFF	min	0.97	0.54	0.04	0.15	1.90	1.25	11.83	8.36
CAFF	max	7.85	6.15	2.51	1.64	8.12	7.11	43.74	42.36
CAMR	Mean	2.59	2.98	0.75	0.80	3.72	4.09	23.04	25.22
CAMR	StdDev	1.02	0.76	0.50	0.36	0.63	0.57	2.53	3.46
CAMR	q1	1.89	2.53	0.39	0.55	3.32	3.75	22.05	22.94
CAMR	q3	3.29	3.47	0.99	0.91	4.10	4.40	23.93	27.23
CAMR	min	0.25	0.60	0.09	0.20	2.34	2.11	15.69	14.44
CAMR	max	6.00	5.94	2.49	2.04	6.42	6.92	38.83	45.36
CAFR	Mean	2.48	2.84	0.72	0.77	3.55	3.91	22.00	24.26
CAFR	StdDev	0.97	0.72	0.47	0.37	0.60	0.56	2.42	3.56
CAFR	q1	1.83	2.39	0.37	0.52	3.17	3.57	21.05	21.93
CAFR	q3	3.12	3.31	0.95	0.87	3.91	4.22	22.84	26.20
CAFR	min	0.27	0.57	0.09	0.18	2.24	2.00	14.97	13.38
CAFR	max	5.74	5.42	2.37	2.25	6.14	6.27	37.08	41.14
PIGF	Mean			2.18	2.07	2.18	2.07	18.00	17.13
PIGF	StdDev			0.38	0.32	0.38	0.32	3.20	2.76
PIGF	q1			2.04	1.92	2.04	1.92	16.97	15.89
PIGF	q3			2.46	2.25	2.46	2.25	20.29	18.75
PIGF	min			1.16	1.37	1.16	1.37	9.64	11.02
PIGF	max			3.13	3.24	3.13	3.24	26.13	26.91
SOWS	Mean			4.07	3.81	4.07	3.81	33.43	31.47
SOWS	StdDev			0.58	0.42	0.58	0.42	4.48	3.22
SOWS	q1			3.78	3.59	3.78	3.59	31.46	29.69
SOWS	q3			4.48	4.05	4.48	4.05	36.79	33.73
SOWS	min			2.49	2.48	2.49	2.48	20.70	21.13
SOWS	max			5.28	4.87	5.28	4.87	41.98	38.87
SHGM	Mean	0.77	0.90	0.18	0.19	1.04	1.14	5.92	6.49
SHGM	StdDev	0.24	0.28	0.12	0.09	0.19	0.24	0.94	1.33
SHGM	q1	0.66	0.75	0.09	0.12	0.94	1.01	5.19	5.74
SHGM	q3	0.88	1.01	0.24	0.24	1.12	1.23	6.30	6.92
SHGM	min	0.15	0.14	0.02	0.04	0.66	0.44	4.44	2.97
SHGM	max	1.85	2.36	0.62	0.58	2.16	2.53	10.51	15.80
SHGF	Mean	0.56	0.60	0.12	0.13	0.75	0.78	4.20	4.49
SHGF	StdDev	0.19	0.19	0.08	0.05	0.19	0.18	0.91	0.94
SHGF	q1	0.42	0.48	0.05	0.10	0.62	0.65	3.70	3.88
SHGF	q3	0.69	0.74	0.16	0.17	0.88	0.93	4.91	5.27
SHGF	min	0.08	0.09	0.01	0.04	0.25	0.25	1.67	1.63
SHGF	max	1.32	1.06	0.49	0.36	1.44	1.24	7.04	6.83
HENS	Mean			97.63	88.62	97.63	88.62	813.96	733.99
HENS	StdDev			9.83	7.66	9.83	7.66	82.04	65.52
HENS	q1			90.80	82.00	90.80	82.00	748.79	676.13
HENS	q3			105.70	94.73	105.70	94.73	879.10	784.64
HENS	min			70.89	70.57	70.89	70.57	588.87	617.40
HENS	max			126.68	122.06	126.68	122.06	1029.07	1028.89
POUF	Mean			104.47	100.00	104.47	100.00	858.84	827.12
POUF	StdDev			23.07	17.65	23.07	17.65	195.30	151.19
POUF	q1			90.28	87.75	90.28	87.75	743.53	723.85
POUF	q3			124.43	113.55	124.43	113.55	1039.80	954.58
POUF	min			52.05	50.80	52.05	50.80	413.52	444.26
POUF	max			147.62	149.34	147.62	149.34	1210.07	1237.29

Table 13 shows that the _mak version achieves a greater stability (lower StdDev) for cows (DCOL,DCOH,SCOW, HEIR) and ewes than the _pw version, whereas the stability is sometimes reversed for the single components FeedRough and FeedConc. This might point to exaggerated weights for the prior feed allocation in the _pw version, which could prevent substitution, if the regional supply side conditions for roughage would suggest some compensation via more or less concentrates (than according to the prior values). It may also be seen that for cattle fattening processes and for pigs and poultry the regional homogeneity is higher for the _pw version, so the evidence is inconclusive also by this (quality) criterion.

Finally we may point to the similarity of the extreme values (min/max) under the two specifications. This is due to the importance of the regional activity levels, regional fodder supply and national feed demand for non-fodder items at the Member state level which are given that the point of determining the feed allocation (under the given code structure). Even though the baselines have been obtained in different working copies and with different Gams versions many (problematic) characteristics of regions appear to be given and responsible for partly incredible results.

4 Conclusion

For the time being the "_pw" version will become the default feed specification, but less so due to clear advantages compared to the _mak version, but more due to its more "cleaned up" status in the current star2 branch. Further improvements of the coding may lead to a revision of this preliminary decision or a merge of both versions to capture the best settings from both.