EuroCARE

EUROPEAN CENTRE FOR AGRICULTURAL,
REGIONAL AND ENVIRONMENTAL POLICY RESEARCH

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"Outlooks on selected agriculture variables for the 2005
State of the Environment and the Outlook Report"

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1 Driving Forces for Projections of Agricultural Variables

Driving forces of quantitative projections can basically be grouped into two categories:

- exogenous inputs into the model used and (e.g. yield increases over time)
- structural relationships within the modelling framework (e.g. identities, constraints).

The type of exogenous inputs depends on the design of the modelling framework: In partial equilibrium models such as CAPSIM, exogenous model inputs still play a decisive role in determining changes over time. Among the exogenous inputs, at least a measure of overall economic growth, population growth, technical change, and a policy framework are required, as all these categories are not endogenously determined in the modelling framework. General equilibrium models[1], on the other hand, yield overall economic growth as an endogenous model output, conditional on other model inputs and on the structure of the General equilibrium model. Because the structure of the model may succeed to represent some of those driving forces represented exogenously in other systems it is useful to consider the structure a driving force of its own. Moreover, dynamic general equilibrium models may be used to explain and to project endogenously factor accumulation (investment) and even endogenous technological progress as a result of human capital accumulation. In a similar vein, population growth is analysed endogenously in certain socio-economic frameworks and even policy is the subject of endogenous modelling in the area of political economic or political sciences.

The problem with more encompassing models is that they tend to be very complex, demanding and intransparent if they strive for the same level of detail as partial models. The latter is rarely the case, so that, for instance, general equilibrium models tend to be more aggregated and more abstract than partial equilibrium models. If the issues at hand, such as the environmental impact of agriculture over time, cannot appropriately dealt with at that high level of aggregation, it will be necessary to relegate some of the driving forces to the exogenous inputs rather than representing them endogenously. The call for tender to this study gives a non-exhaustive list of important driving forces, grouped according to their impact on the demand or supply side of the agricultural sector. The modelling framework used in his study is a version of the modelling system CAPSIM (see Chapter 4) which has been redesigned in view of the extraordinary long run horizon of this study. In the following, the representation of driving forces in CAPSIM is characterised. Principally, exogenous driving forces can be split into demand and supply side factors.

1.1 Demand Side

Population growth is evidently one of the most important exogenous inputs for most economic models, including CAPSIM. It is taken from the set of key assumptions compiled

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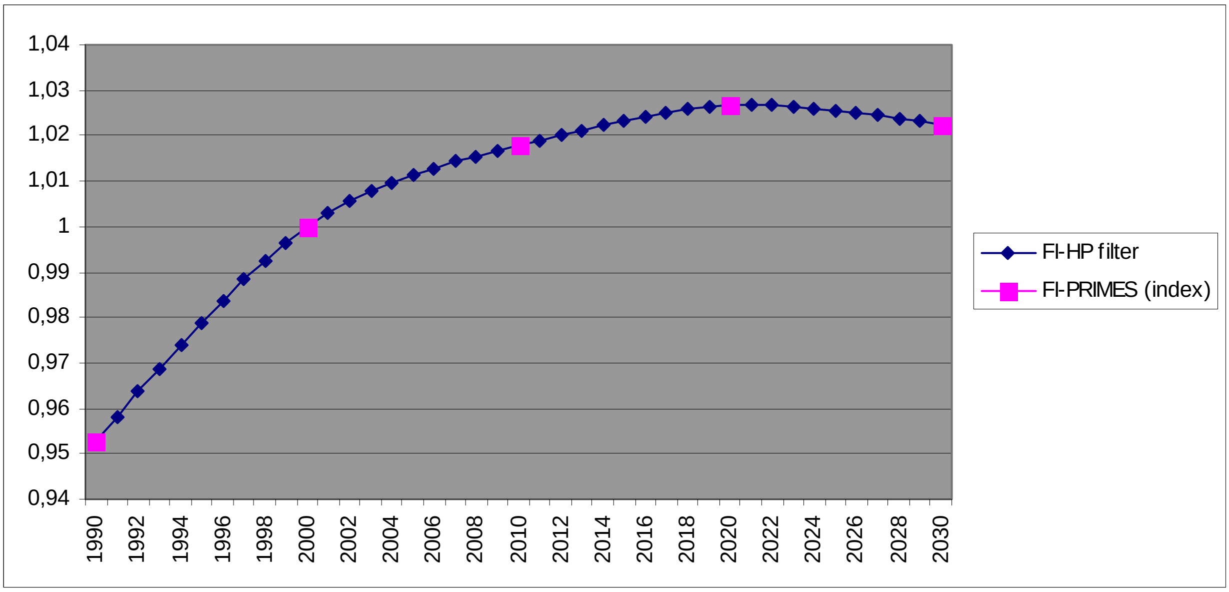
[1] General equilibrium models comprise not only a selection of economic sectors as partial equilibrium models, but the whole economy, including macroeconomic closure rules (e.g. savings equal investment).

by the PRIMES modelling team, given in 10 year steps from 1990 to 2030. Because the ex post data differ from Eurostat population data which provide the bulk of the CAPSIM database, the projections have been expressed in index form (relative to 2000) and smoothed with a Hodrick-Prescott filter to give a continuous series of projections as shown in Graph 1. The population growth according to this index is used in CAPSIM and in the trend projections explained below. The same approach is used for (real) *household expenditure*.

Graph (1) **Population projections for Finland**



Apart from population and expenditure growth, consumption is driven by *price movements* and other shifters (lifestyle, habits) interpreted as preference shifts over time. Price changes are partly endogenous, partly exogenous. Because the current version of CAPSIM is still a net trade model with an exogenous “Rest of the World” the most straightforward approach to market clearing is to assume either

- exogenous international market prices or
- exogenous net trade.

In the latter case prices are determined endogenously, in the former case net trade is endogenous. This rather simple framework is strictly applied only in standard simulations with given parameters. The more relevant task is to develop the reference run which is explained in more detail in Appendix 1. Assumptions on international prices and on EU net trade will be derived from the projections of international agencies which have been surveyed above.

The non agricultural *(general) price index* is an important special case which has to be specified in line with assumptions on the *€/$ exchange rate*. Medium run assumptions on these are also specified by DG Agri in the context of their “Prospects” publication. As any long run assumptions on the exchange rate are very difficult to make, a corresponding sensitivity analysis has been included in this study.

Finally we have to acknowledge that economic models are usually not capable to explain consumption development over time without variable parameters capturing taste shifts. The same approach is followed in the long run version of CAPSIM when the so called "commitment" parameters in the demand function of the linear expenditure system (see the Appendix) are considered functions of time.

1.2 Supply Side

One of the most important driving forces on the supply side in agriculture is *technological change*. Depending on the level of detail in modelling this may be represented partly in explicit form. CAPSIM distinguishes activity levels and yields such that crop yields, for example are an explicit modelling input. Other changes, such as long run shifts in manure and housing systems, can only be incorporated in the form of parameter shifts of the nutrient balance description but cannot be analysed as a separate activity in the framework of this study. Environmental indicators are heavily relying on the CAPRI methodology, see section 4.2.

Regarding *structural change* of the farm size distribution, part time farming and labour force changes, an explicit analysis is equally beyond the scope of our work as these are not explicit dimensions of CAPSIM. However structural change may be considered just a special type of technological change when viewed from an aggregate perspective. Because technological change is such an important driving force considerable efforts have been made to capture the bottom line of these shifts of behavioural functions on the supply and demand side with a sophisticated set of trend projections to be explained in detail in the next section. These trend projections incorporate a great number of technological constraints (nutrient balances, land balance) as well as identities (production = area * yield) to compensate for detailed modelling of the individual contributions to overall technological change such as genetic improvements, capital accumulation, input quality and structural change.

A final driving force effective mainly on the supply side in the EU is the Common Agricultural Policy (CAP). It is sure to have great influence in medium run projections but in the long run it may be expected that policy is endogenously responding to pressure groups and objective constraints, partly imposed by trading partners in the WTO. The partly endogenous character of the CAP renders it a difficult task to specify reasonable assumptions on a "likely" future course of the CAP. Choices must be made on at least two issues:

- Will the reform process initiated in the MacSharry reforms and deepened in the recent MTR decisions continue in the next decades? A liberalised CAP could mean a decoupling of the last coupled forms of support and further cuts in domestic support and external protection.
- Will the second pillar of the CAP and environmental concerns gain in importance in the next decades? While second pillar policies cannot be modelled with CAPSIM a tighter budget for the first pillar can. Equally well it is necessary to make assumptions on the binding character of cross compliance which may even lead to a green "recoupling" of support to production.

We approach the problem of identifying driving forces in different ways: A survey of external sources (FAPRI, FAO, IFPRI, DG Agriculture) in chapter 2 provides a collection of exogenous projections for cropping areas, production, consumption, and feed use. Moreover, we also carry out trend projections on our own, the methodology of which is presented in chapter 3. The result is a set of external projections to be integrated in CAPSIM. We consolidate these 'competing' sets of forecasts using an innovative methodology which is described in chapter 4. Chapter 5 presents the main results of our reference run projection and selected alternative scenarios. Several methodological details are relegated to an Appendix.

2 Survey of Relevant Outlook Work for Important Agricultural Variables

2.1 Introduction

Projections on supply, demand, and trade of agricultural products are highly demanding research. The complexity of the models used relates, roughly spoken, to three dimensions, namely the number of **commodities** and their interactions, the number of **regions** involved, and the **time horizon** over which the projection is carried out.

Commodities: To represent demand for food in sufficient detail, roughly 30 to 50 raw and processed commodities would have to be included in the models. Between these commodities more or less close interactions exist: substitution relations between consumer goods, input-output relations between raw and processed products, feed use of fodder and feed, and competition between crops and livestock products for land and other resources, all of which are adding to the complexity of the models.

Regions: A region in a model is usually treated as a "point market", meaning that a region itself has no spatial attributes, while the spatial aspect enters the model through the trade relations between regions, and how the latter are treated algebraically.[2] The regional dimension of a world model involves more than 200 countries, which are usually aggregated to 10 to 20 "model regions". This aggregation is usually carried out in order to reduce the complexity of the model solution and presentation of results. Important outlook work is also carried out at the European Commission, focussing on the EU15 with a set of pragmatically linked single market models, and on EU25 using the "ESIM model", in the latter case with disaggregated analysis for individual CEEC countries

Time: The time aspect usually enters the models as a number of future projection years, counted from the base year. Some models have a time horizon of ten years (USDA, FAPRI, DG Agri), while others extend their projection period to 30 years (FAO, IFPRI). These models require an additional set of parameters ('shifters') which drive inter-temporal relations in the model, for instance rates of technical progress, population and income growth, inflation, or the availability of land and water.

While problems with the commodity and regional dimension also occur in comparative-static models,[3] problems with handling the time dimension emerge in models which are supposed to deliver results for a certain point in time in the future. First, the driving factors (shift parameters) for several basic variables have to be identified and estimated. Moreover, the

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[2] Trade of regions can be modelled through bilateral trade relations or a pooled world market. All models under consideration use a pooled world market formulation.

[3] Comparative-static models are used to compare two situations, a reference situation and the scenario situation after an exogenous shock. Strictly speaking they have no time dimension, and are thus not thought to represent forecasts of the future.

model builder has to decide on the nature and complexity of the dynamics expressed in the model algorithm.[4] With respect to the degree of being truly dynamic, important differences exist between the models under consideration. However, theoretically convincing dynamics become crucially important as soon as the estimation of shift parameters becomes difficult. The latter may be the case when past trends of the variable under consideration are not straightforward, as it is the case with the Eastern European accession countries to the EU. In that particular case, it may be desirable to 'endogenise', for instance, the yield trend of crops depending on the further macro-economic development or producer price expectations for the crop in question, both of which are genuinely dynamic patterns of a model.

The existing projections pursue different goals. Some of them intend to serve merely as a basis for 'policy experiments in the future'. The projections of USDA, and FAPRI call themselves "baseline assumptions" or "outlooks", and explicitly claim not to be considered as forecasts, but rather as extrapolations of the current setting with a different quantitative framework. The models of the FAO and IFPRI, on the contrary, endeavour to represent at least conditional forecasts, depending on a limited set of basic assumptions. But despite of these different intentions, the results of all of these model systems are perceived of as medium- to long-term forecasts by the interested public. To a certain degree, this is justified. Any extrapolation into the future inevitably contains forecasting efforts, so that the baseline results are rightly exposed to questions regarding their forecasting accuracy.

The following overview contains a short description of the most prominent projection models with special emphasis on their handling of future trends.

2.2 A Survey of the most Relevant Existing Projections

The following brief descriptions of the existing projection systems are partly based on own-documentation by the institutes hosting the models. Moreover, some remarks will be made on the principal approach and transparency of each projection system. The focus will be on worldwide projections, because the major forecasting agencies indeed operate on the global level. The evident exception is DG Agri which will provide the starting point in this survey.

2.2.1 DG Agri

Commission staff is engaged in informal outlook work since the beginning of the CAP because even the yearly price decisions of the pre MacSharry era required some knowledge on the consequences of these decisions. This work has been intensified since the MacSharry reform and the preparation of the Agenda 2000 reform package and led to the publication of a series of working documents for different markets with a common heading ("Situation and Outlook, CAP 2000"). Since 1998 these are consolidated in the "Prospects for Agricultural Markets" over the next 7 years which are published at least once a year.

Since the MTR Impact Analyses volume (February 2002) the single market projections are supplemented with projections using the ESIM model. This is a partial equilibrium model covering 10 CEEC countries, EU 15 and a "Rest of the World" aggregate. In terms of

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[4] 'Dynamic' is an attribute characterising models involving several variables interacting with each other over time.

methodology it tries to be quite detailed regarding the policy coverage but is pragmatic in its reliance on microeconomic theory[5].

Regarding the methodology of the EU15 prospects little information is published. According to remarks in the December 2003 "Prospects" (Footnote 1) and in the February 2003 Mid Term Review Impact Analyses volume (p. 33.) there is "a set of partial equilibrium dynamic models covering the most important arable crops, animal and dairy products in the EU (including cereals, oilseeds, protein crops, beef, pig, poultry, sheep, butter, skimmed milk powder and cheese)". For further information the reader is referred to the methodological annex of the 2002 "Prospects". This Annex explains the important assumptions but gives essentially no additional information on the methodology (equations,…) underlying the DG Agri projections.

Consequently a critical assessment of these projections could only rest on the ex post performance of the forecasts, not on the methodology. On the other hand, given the significant expertise accumulated in DG Agri it would be foolish to engage in projections on EU Agriculture without taking notice of the results of a unit focussing exactly on these issues for years. Apart from experience the DG Agri staff disposes of a unique knowledge on the recent changes of the CAP and their intended consequences. In quantitative terms this study incorporates information derived from the most recent DG Agri "Prospects" as of July 2004.

We are not aware of abundant national outlook work for agriculture as a whole approaching or exceeding the ten year horizon. In Germany there is a group at the German Federal Research Centre[6] this team is focussing on impact analysis, rather than forecasting. Similar work is likely in other national research centres, but it appears that the forecasting business requires a critical mass which is mainly achieved in a few international organisations.

2.2.2 FAPRI

The US-American FAPRI model is a combination of a set of computer-based international commodity models and an expert consultation system. It mainly covers commodities which are US export products.[7] The regional composition is characterised by single countries which are very important due to size or with which the US have significant agricultural trade relations, completed by a 'rest-of-world' aggregate. The EU 15 as well as most East European accession countries have been part of the FAPRI sample throughout the nineties and the first years of the new millennium. Regarding variables available, FAPRI offers a lot of quantitative and price information on US-American agricultural markets, mostly in non-metric units. International coverage is more narrow and concentrates on areas, yields, production, and demand components. International price levels are not reported as one average world price, but rather as a selection of spot prices on certain locations, most of them on the North American continent.

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[5] See Annex 1 in DG Agri, Analysis of the Impact on Agricultural Markets and Incomes of EU Enlargement to the CEECs, March 2002 or W. Münch, Effects of CEC-EU accession on Agricultural Markets, Frankfurt: Peter Lang, 2000.

[6] http://www.bw.fal.de/en/default.htm

[7] Wheat, rice, coarse grains, oilseeds, cotton, sugar, livestock, and dairy products.

FAPRI is a research consortium with a political assignment, but also committed to the broad dissemination of results. The list of objectives explicitly includes the preparation of projections, which is more ambitious than the preparation of extrapolations, as it suggests that world-wide future trends are incorporated into these projections. FAPRI results are widely available online and in printed formats for free. Among the most prominent FAPRI results are its price forecasts contained in its annual “World Agricultural Outlook”, extending ten years into the future.

While FAPRI results are easily available, documentation on the underlying models exists only in very limited form. Most recently, FAPRI offers supply and demand elasticities online, but it is difficult to download complete sets. The overall structure of the FAPRI projection and simulation system is described as a combination of computer-based econometric models and extensive expert consultations. It is inevitable that this procedure limits the traceability of final results. Nevertheless, the online documentation could make the preparation process of the baseline and of simulations much more transparent (e.g. by adding technical descriptions of the models used, when which models are used during the process, how they precisely interact, the precise way in which expert judgment influences preliminary model results, how the expert system is organised, etc.).

Adding to this lack of transparency, the driving forces behind the trends in the outlook results are hardly mentioned, let alone discussed in outlook reports. It does not become clear how trends are implemented in the commodity models, and what role they are playing in the dynamic features of these models. Trends assumed by FAPRI can only be derived from the projection results themselves. As this is quite typical for projections from other agencies, this study uses a methodology to recover endogenously the implied shifters given a set of expert projections.

Many problems with the transparency and traceability of FAPRI results are intrinsic to the overall task and thus apply also to the other projection models which are described in the following.

Box 1: A short characterisation of FAPRI

The Food and Agricultural Policy Research Institute (FAPRI, established in 1984 by a grant from the U.S. Congress) is a dual-university research program (Iowa State University, University of Missouri-Columbia) using comprehensive data and computer modeling systems. FAPRI prepares baseline projections each year for the U.S. agricultural sector and international commodity markets. The multi-year projections are published as "FAPRI Outlooks", which are intended to serve as a starting point for evaluating and comparing policy and other scenarios.

Objectives of FAPRI relevant for this study include

- preparation of baseline projections;
- analysis of alternative policies and external factors on the farm sector, international markets and the government budget;
- briefing of staff members of the U.S. Senate and House Agriculture Committees on projections for U.S. and world agricultural markets;
- dissemination of research results through printed reports, staff presentations, and on the Web.

FAPRI baseline projections are grounded in a series of assumptions about the general economy, agricultural policies, the weather, and technological change. The projections generally assume that current agricultural policies will remain in force in the United States and other trading nations during the projection period. The projections are also based on average weather conditions and historical rates of technological change.

In estimating the projections, FAPRI begins with a preliminary baseline that is first submitted to a review process before a panel of experts, including employees of several agencies of the U.S. Department of Agriculture, experts from international organizations, individuals throughout the land grant and other university systems, as well as from general extension specialists and industry experts. Their comments and suggestions are taken into consideration in the final baseline, which is used for policy analysis throughout the rest of the year. FAPRI research is enhanced through collaboration with universities across the United States. The participating institutions are University of Arkansas, Texas A&M University, and Arizona State University.

(Section prepared on the basis of http://www.fapri.iastate.edu/about.aspx)

2.2.3 USDA/ERS

The Economic Research Service (ERS) of the United States Department of Agriculture (USDA) also prepares ten-year projections for international agricultural commodity markets ("Agricultural Baseline Projections: Global Agricultural Trade"[8]; "USDA Agricultural Baseline Projections to 2013").[9] Both objectives and the principal approach (a mixture of model results and expert opinion) are quite similar, but not identical, to FAPRI, which also applies to the results. That is why a detailed description is omitted here. The commodity coverage is focused on such products for which US government support programmes exist. In contrast to FAPRI, USDA/ERS projections only report quantities, not prices. USDA/ERS is predominantly providing the executive powers with information, where FAPRI is apparently more frequently used by congressmen.

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[8] http://www.ers.usda.gov/Briefing/Baseline/trade03.htm

[9] http://www.ers.usda.gov/publications/waob041/waob20041.pdf

The driving forces behind resulting trends in the projections of the USDA/ERS are not sufficiently transparent. However, at least the publications mentioned above discuss driving factors in more detail than FAPRI outlook publications.

2.2.4 IMPACT

The IMPACT agricultural world trade model was developed at the International Food Policy Research Institute (IFPRI) in Washington D.C. It is supposed to analyse baseline and alternative scenarios for global food markets on the background of "a lack of a long-term vision and consensus about the actions that are necessary to feed the world in the future, reduce poverty, and protect the natural resource base …" (Rosegrant et al. 2002, Rosegrant et al. 2001). It is a partial, non-spatial, recursive-dynamic equilibrium model which covers 36 regions and 16 commodities. The time horizon of simulation extends to the year 2020. The impact baseline projection covers production, areas, yields, food and feed demand, and average world prices for the commodities in question. Regional aggregates relevant for this study are the EU 15 and an "Eastern Europe" country group consisting of the accession countries without the Baltic states (contained in a CIS aggregate), Cyprus and Malta, but including former Yugoslavia and Albania.

In contrast to the previously described models, IMPACT is relatively well-documented with respect to the algebraic model structure. The results of the simulations have been extensively used for scientific publications focusing on specific questions on the future of global and regional food security, but not for annual routine projections as the US-based projection models. Consequently, the publications based on IMPACT exhaustively incorporate and discuss trends and driving factors of world food markets. These shift factors explicitly enter the model in the following way.

Supply

- growth rates for the harvested area of individual crops
- growth rates for the yields of individual crops
- growth rates for the number of slaughtered livestock
- growth rates of livestock yield

Demand

- growth rate of income
- growth rate of the population

The choice of these growth rates is interesting, as IMPACT is a partial equilibrium model with no repercussions from the non-agricultural part of the economies under consideration. A sound partial model should as far as possible use shift parameters which are truly exogenous in that respect, which is not always the case for IMPACT. While population growth and income per-capita are exogenous in that sense (for income to a lesser extent when the agricultural sector of the national economy is large), the growth rate of crop and livestock yields may be made endogenous as well. The authors claim that they include investment in agricultural research into their considerations, but these do not seem to be expressed in the algebraic structure of the model. Finally, in the case of growth rates of activity levels (cropping areas, numbers of slaughtered livestock), IMPACT imposes growth rates on those endogenous variables which should be completely determined by price response.[10] This is probably the attempt to explain the phenomenon that activity levels increase despite stagnating or slightly falling real output prices.

The problem is that by designing shift parameters in this way, the nature of the relevant driving forces is perverted: cropping areas do not 'miraculously' increase (i.e. without economic explanation feasible within the partial model), but as a result of price changes, land availability,[11] and technical progress. In order to make these phenomena endogenous to the model, assumptions on reduced total production costs (input efficiency) would have to be included, representing the second aspect of technical progress besides higher physical yields. However, these aspects are much more difficult to implement: the algebraic formulation is more complicated, and the sound estimation of the respective trend parameters is so demanding that it is almost infeasible for a team of the size of IMPACT or comparable other science-oriented groups.

The discussion gives rise to the assumption that the projection of agricultural market development still contains many ad-hoc elements. Given the difficult data situation in many developing countries together with capacity problems of the research groups, this is understandable. Trying a more sophisticated dynamic approach on this basis easily leads to non-plausible results, which means that extrapolations are still a second-best solution where more elaborate estimates cannot be realised. Thanks to the available, detailed documentation of IMPACT, this can be proven in case, in contrast to other, less penetrable modelling systems.

2.2.5 FAO-Projections

The FAO follows in the past two different approaches regarding “projections”. Medium-term outlook projections for a time horizon of about 10 years were based on the World Food Model (WFM) which covered 13 commodity and all FAO Member States individually (180). As the models discussed above, it is a recursive-dynamic partial non-spatial equilibrium model. The “projection” was to a large extent based on the views of FAO commodity experts, which together with the operators of the model iteratively adjusted the trend shifters for all model variables until a satisfactory reference run was generated. FAO projections cover quantitative commodity balances according to the framework of “supply and utilisation accounts” (SUAs), but no world price developments so far. Prices were a kind of “residual” outcome of that process. Since some years, no results of the WFM had been published.

A second approach was followed by the “Global Perspective Unit” which until recently did not formally use a modelling framework. A follow up of several publications, labelled “Agricultural at xxxx” discussed extensively possible long-term development in the global food system over a time horizon of 30 years. Various sources inputted in the process of generating these projections, some were quantitative models or approach, some purely expert driven (see a methodological discussion in VAN BRUINSMA, 2003). FAO projections have been made available for this study for the new EU Member States and for an EU15 aggregate.

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[10] Note that shifts in consumer tastes are also not exogenously imposed, but introduced through the income elasticity vectors of each commodity.

[11] IMPACT does not seem to contain a constraint on total land area available.

The slatter have been applied to the EU 15 Member States based on auxiliary assumptions as explained in the Appendix.

Since three years, a quantitative model for world agriculture, labelled '@2030', is under development in order to perform counter-factual scenarios against the expert generated “base line”. The modelling system is a non-spatial, recursive dynamic partial equilibrium model solved on an annual basis for about 35 regions (large single countries or groups of countries), and covers a closed calorie balance. According to BRITZ (2003), considerable efforts have been made to make the model theoretically consistent with respect to the behavioural functions, the consistency of elasticity sets, and the dynamic approach. However, the “baseline” is taken as given, to that certain parameters of the behavioural functions are simply adjusted in order to calibrate the model perfectly to the expert judgements It is yet not clear how the model system will be used in the future to support the generation of the “baseline”.

2.3 Overall Assessment

2.3.1 Transparency

The transparency of a projection system is crucial to evaluate the overall approach taken, and in particular to isolate the driving factors behind the results. The systems portrayed so far are all characterised by a mix of expert judgment and numerical modelling. Expert knowledge is used to identify areas where systematic exogenous shifts occur in the world food system, and to check the plausibility of local projections. The numerical modelling, on the other hand, carries the objective of guaranteeing global consistency of the projections. The emphasis given to these two fundamental elements of forecasting may differ a lot among the systems in question. A short characterisation is given in the following:

- The **FAPRI outlook** seems to use both expert knowledge extensively and modelling extensively. However, the regional experts use regional models to support their regional assessments. The world-wide consistency is then produced by another model. The whole process, however, seems to be relatively non-transparent, even though the events which take place in the course of an outlook process are described. The features of both the regional and global commodity models is not regularly documented, and the interaction between these two levels remains unclear.
- The **USDA/ERS baseline projections** are quite similar to the FAPRI approach, the only remarkable difference being the fact that the ERS results do not mention prices. The problems with lacking transparency also plague the users of ERS information. This does not mean that this information is somehow classified: regional experts' communication details are mentioned in both American systems to answer more detailed questions. However, this is sub-optimal compared to publicly available technical documentation.
- The documentation of **IMPACT** is much more transparent, as the structure of the algebraic model is documented in detail. The driving forces behind the projections are extensively discussed in IMPACT-publications. However, the size and nature of the expert pool is not further disclosed, and procedural details of the expert system are not given at all. One has to keep in mind that the institution hosting IMPACT (i.e. IFPRI)

is the smallest among those discussed here, with probably the tightest resource constraints, particularly when it comes to in-house regional expertise.

- Finally, the **FAO projections** are perhaps those which most of all use expert judgment, even though this originates mostly from within the organisation. The FAO probably commands over the best resources world-wide regarding databases and expertise, so that a heavy reliance on these assets is understandable. The general approach towards projections is critically discussed on a high professional level in the relevant publications. Up to now, however, the projections are not based directly on a quantitative modelling system, even if FAO has initiated the development of the **@2030 model** (e.g. BRITZ/SCHMIDTHUBER 2002).

2.3.2 Performance related to Forecasting Accuracy

As the projection systems described so far differ in their results, it is fair to examine their forecasting accuracy. Unfortunately, only a few attempts have been made to compare projections *ex post* with reality, probably because the task is not very rewarding from a scientific point of view, and quite demanding when it comes to compare the performance of different forecasting systems. WISNER et al. (2001) contrasted both FAPRI and USDA/ERS forecasts on future cereals exports by the US with recent trends. The background of his work was a feasibility study prepared by these two bodies to assess the usefulness of increasing the freight capacity of the Upper Mississippi. WISNER et al. found that the USDA and FAPRI baseline assumptions always predicted increasing US grain exports, even though the long-term trend suggested stagnating grain exports, at best.

The most comprising study has been compiled by MCCALLA and REVOREDO (2001), comparing the results of USDA, FAPRI, IFPRI and FAO. They conclude that projection errors on the global level are relatively small, but increase tremendously on the regional level, particularly for small countries or regions. Particularly Africa, the Middle East, and the transition countries carry the largest forecast errors.

There is a number of potential sources of these errors:

Policy: The forecast of production figures especially for the OECD countries is difficult, as their agricultural policies there heavily influence supply through price support, production quotas, import protection, land set-aside, and other measures.

Economic downturns and disasters: The reason for the errors about Africa and the transition countries is that events like the breakdown of communism or civil wars cannot be predicted.

Uncertainty about future technical progress: in some regions like the middle east, future technical progress may have been overestimated, as oil revenues have plummeted, while populations further increased. Thus has put pressure on the state budgets and consequently decreased the scope for financing technical progress in agriculture.

Trade activities: It is striking that global projections are much more reliable than regional ones. The reason is relatively simple: supply, particularly in high-income countries, is highly demand-driven due to a diminishing demand elasticity with rising incomes. Global as well as industrialised country demand for food can be forecast quite precisely, determining global supply as well. Regional supply estimations are more difficult, but the discrepancies can be levelled out through trade between regions, without requiring regional supply to match regional demand. On the global scale this is not possible, as Earth cannot (yet) trade with Mars.

This short list points at the general problem that these projection models are plagued with: they project on the assumption that current trends continue. By doing this, modellers maximise the probability of not being 'too' wrong in hindsight. On the other hand, any results which, for instance, project world-wide food shortages and increasing prices in the fashion of 'Who will feed China?' by Lester Brown (1995) run the 'risk' of being taken serious, thus influencing decisions working against them, and therefore becoming wrong in the very end.

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2.4 Quantitative Results

The studies surveyed above have been used to compile a small database of expert projections to be used as a priori information in the overall projection run. As an example we may present here the original DG Agri projections on cereal consumption, but similar tables have been compiled for other items and other sources.

Table 2.4-1: Soft wheat projections from recent DG-Agri "Prospects"

Table A.4: Soft wheat balance sheet in the European Union, 2002-2011 (mio t)

		2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Usable production		**114.6**	**97.9**	**115.2**	**117.6**	**119.1**	**120.5**	**121.7**	**121.0**	**122.2**	**123.2**
of which	EU-15	94.0	82.0	94.7	95.5	96.7	97.8	98.7	98.4	99.3	100.0
	EU-N10	20.6	15.9	20.5	22.1	22.4	22.7	23.0	22.6	22.9	23.2
Consumption		**105.9**	**101.7**	**104.9**	**104.9**	**105.4**	**106.1**	**106.9**	**107.9**	**108.1**	**108.4**
of which	EU-15	87.3	82.6	84.3	84.5	85.0	85.6	86.2	87.1	87.3	87.4
	EU-N10	18.6	19.1	20.6	20.3	20.4	20.5	20.6	20.7	20.8	20.9
Imports		10.4	3.7	4.0	5.5	5.5	5.5	5.5	5.5	5.5	5.5
Exports		17.6	6.7	14.0	14.7	17.9	19.5	20.0	19.8	20.0	20.3
Beginning stocks		17.1	18.7	11.9	12.2	15.7	17.0	17.4	17.7	16.6	16.2
Ending stocks		18.7	11.9	12.2	15.7	17.0	17.4	17.7	16.6	16.2	16.3
of which intervention		1.3	0.2	1.1	0.0	1.2	1.5	1.7	0.4	0.0	0.0

EU-N10: Ten new Member States

Source: DG Agri, Prospects for Agricultural Markets 2004 – 2011, Update for EU-25, July 2004, Brussels, p. 14.

The demand side projections have been applied to all CAPSIM demand components after conversion to index form (relative to the base period) to avoid distortions caused by different definitions (See also Appendix 1). The change factors for old and new Member States have been applied uniformly to all members of the respective group. This uniformity is a auxiliary assumption on top of the original DG Agri projection which will be addressed again when explaining the methodologz of our projections.

The next Table 2 compiles selected change factors for EU 15 variables as derived from our main expert sources, DG Agri, FAPRI, FAO and IFPRI for those commodities for which results from at least three sources were available. These changes between the base year and the projected year are fed into the estimation procedure which produces the consolidated rates of change. In the case of crops (only cereals were sufficiently covered by the various sources), projections cover harvested area, human consumption, feed and net trade. For livestock products, only production, human consumption and net trade are reported. The differences between the various sources are usually moderate in the case of supply and demand variables, whereas the projections differ tremendously when it comes to net trade. This is to be expected as small differences in the projections on the supply and demand side frequently lead to large (percentage) changes in their difference.

Table 2.4-2: A comparison of change factors for quantitative results for the EU15 / EU23 compared to the base year across different sources of external projections

		DG Agri	*FAO*	*FAPRI*	*IFPRI*
Soft wheat	Area	1.021	1.014	1.013	0.993
	Human consumption	1.013	0.949	1.009	1.012
	Feed	1.056	1.068	1.065	0.963
	Net trade	1.271	2.779	1.255	1.647
Durum wheat	Area	1.036	0.923	1.013	0.907
	Human consumption	1.203	0.923	1.009	0.967
	Feed	0.914	1.629	1.065	1.422
	Net trade	-0.301	2.459	1.39	1.551
Barley	Area	0.92	0.942	1.02	1.016
	Human consumption	1.157	0.734	1.114	0.787
	Feed	0.95	0.875	1.04	1.055
	Net trade	1.127	1.637	1.187	1.285
Maize	Area	0.974	0.937	0.963	0.959
	Human consumption	1.124	1.103	1.108	0.975
	Feed	1.157	1.017	1.01	0.986
	Net trade	4.16	0.791	0.291	-1.045
Oats	Area	0.946	0.937	0	0.967
	Human consumption	1.124	1.103	1.108	0.975
	Feed	1.157	1.017	1.01	0.986
	Net trade	0.89	1	0	1.501
Rye	Area	0.6	1.013	0	1.054
	Human consumption	1.118	0.953	0	1.027
	Feed	1.212	1.03	0	1.079
	Net trade	-0.379	1.674	0	1.614
Other cereals	Area	0.945	0.869	0	0.908
	Human consumption	1.25	0.825	0	1.066
	Feed	1.115	1.089	0	0.998
	Net trade	-2.89	-8.086	0	3.5
Paddy rice	Area		1.032	0.88	1.041
	Human consumption	1.381	0.976	1.21	1.031
	Feed	1.317	0.979	1.21	1.02
	Net trade		0.95	1.554	0.923
Beef	Production	0.987	0.995	0.945	1.037
	Human consumption		0.99	1.014	1.025
	Net trade	-0.468	1.625	-0.294	1.73
Veal	Production	0.96	0.989	0.945	1.022
	Human consumption	0.935	1.014	0.985	0
	Net trade	-2.903	3.676	-0.926	3.029
Pork	Production	1.083	1.021	1.052	1
	Human consumption	1.033	1.071	1.003	0
	Net trade	1.185	0.962	0.892	1.004
Poultry	Production	1.011	1.048	1.036	1.092
	Human consumption		1.065	1.088	1.087
	Net trade	0.728	0.99	0.155	1.538
Sheep and goat meat	Production	0.951	1.041	1.029	1.111
	Human consumption		1.057	1.082	1.067
	Net trade	1.178	1.024	1.306	0.909
Butter	Production	0.844	0	0.941	1.023
	Human consumption	0	0	0.956	1.023
	Net trade	1.962	0	0.755	-1.101

Note: Change factors for non trade positions are for EU 15 as we tried to use the most precise information available. Net trade indices are for EU 23, because here only the largest aggregate appeared useful

3 Default assessment with trend projections

As mentioned in the driving forces section 1 technological, structural and preference changes all combine with changes in exogenous inputs to determine the future development of agriculture. This section explains in detail the methodology used for this purpose. Before entering into these details it should be stated that ultimately almost any projection may be reduced to a particular type of trend projections, at least if the exogenous inputs, such as population, prices or household expenditure are also projected (usually by other research teams) as functions of time. In this sense trend projection may provide a firm ground on which to build projections and this is exactly their purpose in our work.

The overall projection tool (CAPSIM) is sourced both by forecasts from different experts or modeling tools, as well by trend forecasts using data from the “CoCo” database[12] as ex post information. The purpose of these trend estimates is at the one hand to compare expert forecast with a purely technical prolongation of time series. On the other hand, they provide a fall back position in case no values from external projection are available.

Instead of using rather naively independent trend forecasts for each time series, our trend estimates include consistency conditions such as closed area and market balances. The resulting estimator is hence a system estimator under constraints whose properties are discussed in the following. Nonetheless it is to be acknowledged here that the trend remain mechanical in that they try to respect technological relationships but remain ignorant about behavioural functions or policy developments[13].

3.1 Trend curve

The first ingredient in the estimator is the trend curve itself which is defined as:

Equation 1 $$X_{r,i,t}^{j,Trend} = a_{r,i,j} + b_{r,i,j}\ t^{c_{r,i,j}}$$

where the parameters *a*, *b* and *c* are to be estimated so that the deviation between given and estimated data are minimized. The *X* stands for the data and represents a five dimensional array, spanning up products *i* and items *j* (as feed use or production), regions *r*, points in time *t* and different data status as *“Trend”* or *“Observed”*. The trend curve itself is a kind of Box-Cox transformation, as parameter *c* is used as the exponent of the trend. For c equal 1, the resulting curve is a straight line, for c between 0 and 1, the curve is concave from below, i.e. increasing but with decreasing rates, whereas for c > 1, the curve is convex from below, i.e. increasing with increasing rates. In order to prevent differences between time points to increase sharply over the projection period, the parameters *c* are restricted to be below 1.2.

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[12] Britz, W., Wieck, C., Jansson, T. (2002): National framework of the CAPRI-data base - the CoCo – Module, CAPRI Working Paper 02-04, Institute of Agricultural Policy, Bonn.

[13] The only exception is the quota regime on the milk market which has been recognised in the trend projections in that the milk production has been derived from the quota endowments (where current quotas are assumed to persist until 2025).

In a first prototype of the module, a polynomial trend curve of degree two was evaluated. However, a quadratic function is not necessarily monotone on the forecast interval so that a trend curve may for example show increasing yields for the first part of the projection period and afterwards a decrease. As such outcomes are purely technical and not motivated by a priori knowledge, it was deemed more plausible to switch to the formulation shown above with the same number of free parameters as a quadratic trend curve, but with monotony guaranteed.

The ex post period covers the period from 1985 towards 2000. In order to cut down the size of the resulting problem, the ex ante period is defined in five years steps (2005, 2010, 2015, 2020, 2025, 2030), as intermediate years can be simply calculated once the estimated parameters are known.

3.2 Consistency constraints in the trend projection tool

The constraints in the trend projection enforce mutual compatibility between trend forecasts for individual series in the light of relations between these series, either based on definitions as “production equals yield times area” or on technical relations between series as the balance between energy deliveries from feed use and energy requirements from the animal herds. The set of constraints is deemed to be exhaustive in the sense as any further restriction would either not add information or require data beyond those available. The underlying data set takes into account all agricultural activities and products according to the definition of the Economic Accounts for Agriculture.

The constraints discussed in the following can be seen a minimum set of consistency conditions necessary for a projection of agricultural variables. As discussed above in detail, the full projection tool features further constraints especially relating to price feedbacks on supply and demand.

3.2.1 Constraints relating to market balances and yields

Closed market balance define the first set of constraints and state that the sum of imports (*IMPT*)[14] and production (*GROF*) must be equal to the sum of feed (*FEDM*) and seed (*SEDM*) use, human consumption (*HCOM*), processing (*INDM,PRCM*), losses (*LOSM*) and exports (*EXPT*):

Equation 2

$$\begin{aligned} X_{r,i,t}^{,IMPT,Trend} + X_{r,i,t}^{GROF,Trend} &= \\ X_{r,i,t}^{FEDM,Trend} + X_{r,i,t}^{SEDM,Trend} &+ X_{r,i,t}^{PRCM,Trend} + X_{r,i,t}^{INDM,Trend} \\ X_{r,i,t}^{LOSM,Trend} + X_{r,i,t}^{HCOM,Trend} &+ X_{r,i,t}^{,EXPT,Trend} \end{aligned}$$

Where *r* are the Member States of the EU, *i* are the products, *t* the different forecasting years. All elements of the market balances are expressed as primary product equivalents according to the concept of “supply utilization accounts”. Human consumption of wheat does hence include floor, bread, pasta etc. recalculated into what equivalent based on conversion factors.

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[14] The codes are identical to the one used in the CAPSIM model.

Secondly, production (*GROF*) is equal to yield times area/herd size (*LEVL*) where *acts* are all production activities:

Equation 3 $$X_{r,i,t}^{GROF,Trend} = \sum_{acts} X_{r,i,t}^{acts,Trend} X_{r,LEVL,t}^{acts,Trend}$$

A set of equations relates to the hectares for groups of crop activities (cereals, oilseeds, industrial crops, vegetables, fresh fruits, total vineyards, fodder production on arable land). It defines e.g. that the total hectares of cereals is equal to the sum of hectares for the individual cereals as soft wheat, durum wheat, barley and so forth.

Equation 4 $$X_{r,LEVL,t}^{crop\_grp,Trend} = \sum_{j \in crop\_grp} X_{r,LEVL,t}^{j,Trend}$$

Equally, the market balance positions for certain products enter adding up equations for group of products (cereals, oilseeds, industrial crops, vegetables, fresh fruits, total vineyards, fodder production, meat). As an equal, total cereal production is equal to the sum over the produced quantities of the individual cereals.

Equation 5 $$X_{r,pro\_grp,t}^{MrkBal,Trend} = \sum_{i \in pro\_grp} X_{r,i,t}^{MrkBal,Trend}$$

3.2.2 Constraints relating to agricultural production

Adding up over the individual crop areas defines the total utilizable agricultural area (*UAAR,LEVL*):

Equation 6 $$X_{r,LEVL,t}^{UAAR,Trend} = \sum_{crops} X_{r,LEVL,t}^{crops,Trend}$$

Further constraints link the different animal activities over young animal markets:

Equation 7 $$X_{r,oyani,t}^{GROF,Trend} = \sum_{iyani \leftrightarrow oyani} X_{r,iyani,t}^{GROF,Trend}$$

Where *oyani* stands for the different young animals defined as outputs (young cows, young bulls, young heifers, male/female calves, piglets, lambs and chicken). These outputs are produced by raising processes, and used as inputs in the other animal processes (fattening, raising or milk producing).

Finally, balances for energy and protein requirements for animals are introduced as:

Equation 8 $$\sum_{i} X_{r,i,t}^{FEDM,Trend} X_{r,i,t}^{Cont,Trend} = 0.996^{t} \sum_{j \in Aact} X_{r,LEVL,t}^{j,Trend} \frac{X_{r,Yield,t}^{j,Trend}}{X_{r,Yield,t}^{j,BAS}} X_{r,Reqs,t}^{j,Bas}$$

where *FEDM* is feed use and *Cont* are the contents in terms of enery and crude protein. The left hand side of the equation defines total delivery of energy or protein from the current feed use in region r, whereas the right hand side total need derived from animal herds (*LEVL*) and animal specific requirements multiplied with the change in main output (meat, milk, eggs, piglets born). The animal requirements are derived from engineering functions as implemented in the CAPRI modeling system, and scaled so that the balance holds for the basis period. The factor in front of the requirements introduces some input saving technical progress of -0.4% per annum.

3.2.3 Constraints relating to prices, production values and revenues

The check of external forecasts revealed that for some products, price projections are not available. It was decided to include prices, value and revenues per activity in the constrained estimation process. The first equation defines the value (EAAG, position from the Economic Accounts for Agriculture) of each product and product group as the product of production (GROF) times the unit value prices (UVAG):

Equation 9 $X_{r,i,t}^{EAAG,Trend} = X_{r,i,t}^{GROF,Trend} \; X_{r,i,t}^{UVAG,Trend}$

The revenues of the activities (TOOU, total output) for each activity and group of activities *acts* are defined as:

Equation 10 $X_{r,TOOU,t}^{acts,Trend} = \sum_{o} X_{r,o,t}^{acts,Trend} \; X_{r,o,t}^{UVAG,Trend}$

As for the market balances, the values for certain aggregate product groups must add up:

Equation 11 $X_{r,pro\_grp,t}^{EAAG,Trend} = \sum_{i \in pro\_grp} X_{r,i,t}^{EAAG,Trend}$

Consumer prices (UVAD) are equal to producer prices (UVAG) plus a margin (CMRG):

Equation 12 $X_{r,i,t}^{UVAD,Trend} = X_{r,i,t}^{UVAG,Trend} + X_{r,i,t}^{CMRG,Trend}$

3.2.4 Constraints relating to consumer behavior

Human consumption (*HCOM*) is defined as per head consumption multiplied with population

Equation 13 $X_{r,i,t}^{HCOM,Trend} = X_{r,i,t}^{INHA,Trend} \; X_{r,LEVL,t}^{INHA,Trend}$

Consumer expenditures per caput (EXPE) are equal to human consumption per caput (INHA) times consumer prices (UVAD):

Equation 14 $X_{r,i,t}^{EXPE,Trend} = X_{r,i,t}^{INHA,Trend} \; X_{r,LEVL,t}^{UVAD,Trend}$

As for the market balances, the per caput expenditure (EXPE) for certain aggregate product groups – including an aggregation over all products - must add up:

Equation 15 $X_{r,pro\_grp,t}^{EXPE,Trend} = \sum_{i \in pro\_grp} X_{r,i,t}^{EXPE,Trend}$

3.2.5 Constraints relating to processed products

Marketable production (MAPR) of secondary products (*sec*) - cakes and oils from oilseeds, molasses and sugar, rice and starch - is linked to processing of primary products (PRCM) by processing yields (PRCY):

Equation 16 $X_{r,sec,t}^{MAPR,Trend} = \sum_{i \vee sec \leftarrow i} X_{r,i,t}^{PRCM,Trend} \; X_{r,sec,t}^{PRCY,Trend}$

In case of products from derived milk (*mlkseco*) – butter, skimmed milk powder, cheese, fresh milk products, cream, concentrated milk and whole milk powder -, fat and protein content (MLKCNT) of the processed milk (COMI – cow milk, SHGM – sheep & goat milk) must be equal to the content of the derived products:

Equation 17
$$X_{r,COMI,t}^{PRCM,Trend} X_{r,COMI,t}^{MLKCNT,Trend} + X_{r,SHGM,t}^{PRCM,Trend} X_{r,SHGM,t}^{MLKCNT,Trend} = \sum_{mlk\sec o} X_{r,mlk\sec o,t}^{MAPR,Trend} X_{r,mlkseco,t}^{MLKCNT,Trend}$$

3.2.6 Constraints relating to aggregation from Member States to EU

Three further types of equations link the results for the EU to the results from the individual Member States. The first own add ups the production values (EEA) for each product and product group over Member States to the EU:

Equation 18
$$X_{EU,i,t}^{EAAG,Trend} = \sum_{MS} X_{MS,i,t}^{EAAG,Trend}$$

The second one works on the market balance positions:

Equation 19
$$X_{EU,i,t}^{Mrkbale,Trend} = \sum_{MS} X_{MS,i,t}^{MrkBale,Trend}$$

and the last one on the activity levels:

Equation 20
$$X_{EU,LEVL,t}^{acts,Trend} = \sum_{MS} X_{MS,LEVL,t}^{acts,Trend}$$

3.2.7 Constraints relating to growth rates

During estimation, some safeguards regarding the size of the implicit growth rates had been introduced:

a. Total agricultural area is not allowed to decline at a rate exceeding -0.5 % per annum.

b. Changes in human consumption per caput for each of the products cannot exceed a growth rate of +/- 2% per annum. Due to some strong and rather implausible trends for total meat and cereals consumption, the growth rate here was restricted to +/- 0.8 % per annum for meat and +/- 0.4% per annum for cereals assuming that trend shifts between single items are more likely than strong trends in aggregate food groups.

c. Changes in prices are not allowed to exceed a growth rate of +/- 2% per annum.

d. The number of calves born per cow is not allowed to exceed a range of +/5 % around the base period value.

e. Final fattening weights must fall into a corridor of +/- 20% around the base period value.

f. ThreeStrong increases in pork production in the past are restricted by environmental legislation in force, notably the nitrate directive. Accordingly, increases were restricted to +1% (+0.5% for Denmark and The Netherlands) per annum.

g. Milk yields per dairy cows were restricted by a upper bounds of 12.000 litre per cow and year.

3.3 Two-stage procedure for trends

The estimation process is a two-stage procedure, where results from previous steps feed into the current on.

3.3.1 Step 1: Unrestricted trends

The first stage estimates unrestricted trend curves The optimal values of the estimated trend parameter *a*, *b* and *c* are defined by minimizing squared errors normalized with the mean of the time series (the tatter for technical reasons, solely), using the trend as weights:

Equation 21
$$SSQ = \sum_{r,i,j,expost} \left(\frac{X^{j,"Data"}_{r,j,expost} - a_{r,i,j} + b_{r,i,j} t^{c_{r,i,j}}_{expost}}{X^{j,"Data"}_{r,i,mean}} \right)^2 t_{expost}$$

The weighting with the trend was introduced after a careful analysis of the results of the first step. First of all, it reflects the fact that statistics from the early years (mid eighties) are often less reliable then those from later years. Secondly, is moves the centre of gravity of the estimation in direction of the base period which is used as a kind of fallback position the worse the fit of the above equation.

The resulting parameters provide firstly a starting point for the constrained estimations. Secondly, the variance of the resulting error terms defines the weights for the next two steps. And thirdly, the trend estimate together with R² from that first step is used to define the “support point” for the next steps:

Equation 22
$$X^{i,"Support"}_{r,j,exante} = R^2 \left(a_{r,i,j} + b_{r,i,j} t^{c_{r,i,j}}_{exante} \right) + \left(1 - R^2 \right) X^{i,"Data"}_{r,j,bas}$$

The support point is hence weighted average of the trend forecast and the base year values, defined as a five year average around 1998 -2002. In the case of yields, the reference point was re-defined, as the average of the two highest observations of the last ten years to take into account the state of technical progress already available ex-post which becomes visible in years with exceptional weather conditions.

3.3.2 Step 2: Constrained trends at Member State level

The second step adds the consistency conditions discussed above. In almost all cases, the unrestricted trend estimates from the first step would violate one or several of the consistency conditions. We need hence now to find estimates which both fit into the consistency constraints and exploit in a technical feasible way the information comprised in the ex-post development. Take the second type of consistency constraints as an example, which defines production as hectares/herd sizes times yield. Clearly, we would like our ex ante trend estimates to fulfill that condition. However, running independent trend estimates for barley area, barley yield and barley production will almost certainly produce estimates where production is not equal to yield times area. One solution would be to drop one of the three estimates, say yield, and replace it instead by the division of forecasted production by forecasted acreage. However, by doing so, we deliberately throw away the information comprised in the development of barley yield over time. Adding the kind of definitional relations between the time series does hence help us to exploit more information than is comprised in single series, and refrains from throwing away ex-ante parts of the information available.

However, when estimating simultaneously the different trends, we need to reflect if the sum of squares (SSQ) as a penalty function still works reasonable. A nice property is the fact that strong trends – i.e. such with a high explanatory power – will dominate weak ones. However, as our last forecasted point is far away from the mean, changing slightly the parameters could lead to drastic differences in the estimates without a sizeable effect especially on the SSQ when it is already small. Especially shaky trends will show values at the tails which can be far away from these observed ex post. We need hence a safeguard which draws our estimates to a “reasonable” value in such cases.

The confidence interval from the trend estimate will not help, as it will be centered around the tail value and simply be quite large for bad R². However, we may use the argumentation underlying the usual test statistics for the parameters related to the trend (*a,b,c*). These statistics test the probability of (*a,b,c*) being significantly different from zero. It can be shown that these tests are strongly related to R² of the regression. If the zero hypotheses would be true, i.e. if the estimated parameters would have a high probability of being zero, we would not use the trend line, but the mean of the series instead.

The reasoning behind the test statistics is the basis for the supports defined above. We modified it however to match the problem at hand. First of all, we used a three-year average based on the last known values as the fallback position and not the mean of the series. Secondly, in typical econometric analysis, test statistics would only be reported for the final estimation layout, some variables would have been dropped from the regression beforehand if certain probability thresholds are undercut. For our applications, we opted for a continuous rule as it would simply be impossible to analyze manually each and every trend line and decide upon an alternative estimation. The continuous rule draws the estimates stronger in direction of our H0 – the value is equal to the three year average around the last known points – the more shaky the estimated parameters are.

The resulting penalty function is defined as minimization of the squared deviations from the supports defined above, weighted with the variance of the error terms from the first step:

Equation 23 $$Penalty = \sum_{r,i,j,exante} \left(\frac{X_{r,j,exante}^{j,"Trend"} - X_{r,i,exante}^{j,"Support"}}{\sqrt{X_{r,i,"varErr"}^{j,"Step1"}}} \right)^2$$

The value used by that penalty function for each time point consists hence of two elements:

(1) the difference between the trend estimate fitting into the consistency conditions and the supports derived from the unrestricted trends, and

(2) the variance of the error terms from the trends estimates.

For all unrestricted trend lines, the mean error will be zero so that it cannot be used as a criterion. Instead, the variance of the error term is used as a measurement for the magnitude of the error terms. It is decreasing with the mean of the explanatory variable and with a better fit of trend curve. Normalizing with the variance of the error terms will hence ensure that relative rather then absolute deviations are penalized, and that deviations from the support are penalized stronger where the trend had a high explanatory power.

How is the first element of the term motivated, i.e. the squared difference between the restricted trend estimates and the supports? If R^2 for a certain time series is 100%, the penalty is defined as the squared difference between the restricted trend estimate and the unrestricted one (see definition of the support above). In other words: for a perfect fit, the restricted trend estimates is drawn towards the unrestricted trend estimate.

If R^2 is zero, and the trend curve does not explain any of the variance and the probability for (a,b,c) being equal to zero becomes maximal. Consequently, we let the solver find the minimal squared difference between the “base data” points and the restricted trend estimate as the support becomes equal to the “base data”. The “base data” represent a three-year average around the last three known years.

For all cases in between, we minimize squared difference from the weighted average of the unrestricted trend estimate weighted with R^2 and the three-year average weighted with ($1-R^2$). The weights ensure that deviations for lines with a secure unrestricted fit are smaller then for time series with more shaky trends. Generally, all trend estimates are restricted to the non-negative domain.

For selected variables, instead of using solely the mechanistic corridors shown above, additional estimations corridors had been introduced as discussed above.

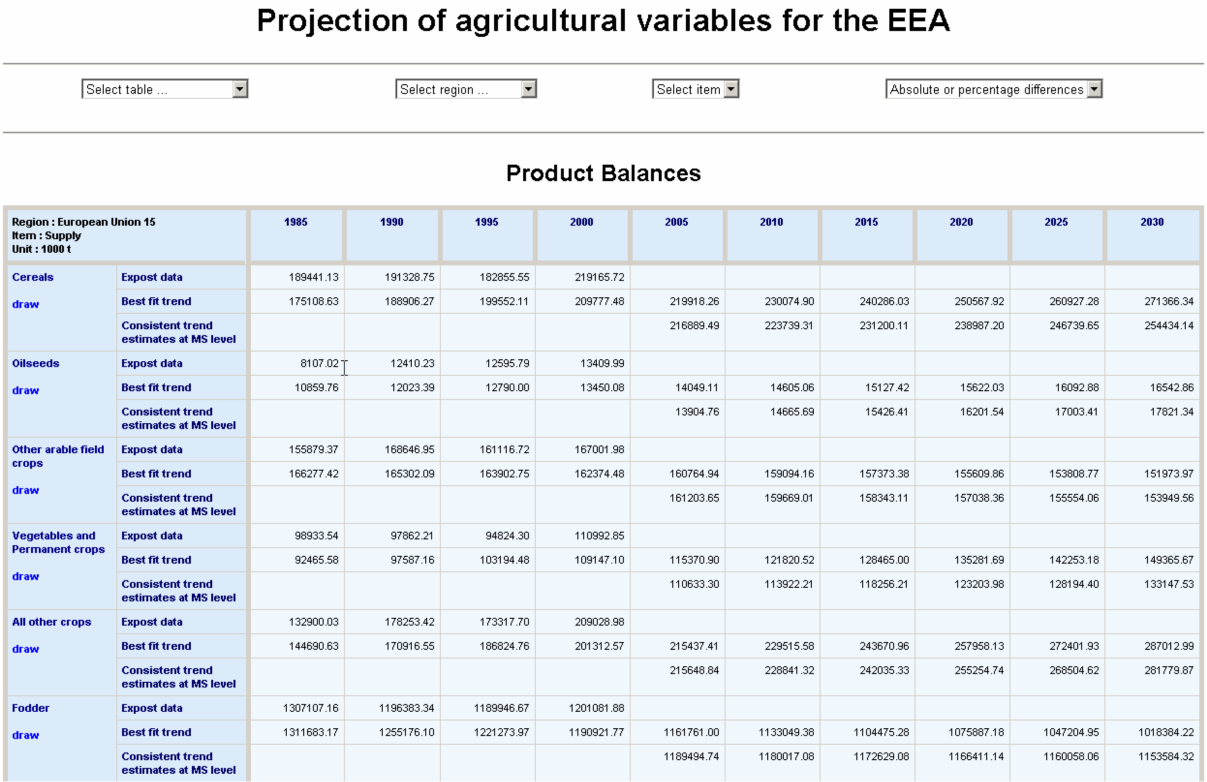
Originally, it was foreseen to add a third step where aggregation to EU level should be added as an additional layer of information, with some elements as net trade and imports/exports not panned to be included in estimation step at Member State level. However, during the development of the tool, the number of simultaneously estimated items and their relations captured by the constraints increased such that an integration of the individual Member States modules into one framework which additional adding up constraints to EU became technically not longer feasible. Instead, the elements planned to be solely included in the EU aggregation step, namely the positions relating to net trade, where added to the individual Member State modules.

3.3.3 Exploitation tools

An important aspect of quality control in a process as described above which produces interlink estimates for several thousand time series is that of exploitation. It is simply impossible to check each and every series individually based on tables. Instead, a combined tabular/graphic exploitation based on XSLT/XML was developed. The given data and estimates for 5-year steps (1985,1990,…,2025,2030) for each Member State and the EU are stored separately for each step in XML-files, including aggregation results to group of activities and products. A XSLT transformation program combines these data found in the different files back into tables.

The columns show the results from the different years, the lines the given data and the results from the different steps so that the effect of adding the restrictions and using the different penalty function in Step 2 can be analyzed. Results are shown for product aggregates as cereals and their components.

Table 3.3-1: Example output from the XSLT/XML tool



Projection of agricultural variables for the EEA

Product Balances

Region : European Union 15 Item : Supply Unit : 1000 t		1985	1990	1995	2000	2005	2010	2015	2020	2025	2030
Cereals draw	Expost data	189441.13	191328.75	182855.55	219165.72						
	Best fit trend	175108.63	188906.27	199552.11	209777.48	219918.26	230074.90	240286.03	250567.92	260927.28	271366.34
	Consistent trend estimates at MS level					216889.49	223739.31	231200.11	238987.20	246739.65	254434.14
Oilseeds draw	Expost data	8107.02	12410.23	12595.79	13409.99						
	Best fit trend	10859.76	12023.39	12790.00	13450.08	14049.11	14605.06	15127.42	15622.03	16092.88	16542.86
	Consistent trend estimates at MS level					13904.76	14665.69	15426.41	16201.54	17003.41	17821.34
Other arable field crops draw	Expost data	155879.37	168646.95	161116.72	167001.98						
	Best fit trend	166277.42	165302.09	163902.75	162374.48	160764.94	159094.16	157373.38	155609.86	153808.77	151973.97
	Consistent trend estimates at MS level					161203.65	159669.01	158343.11	157038.36	155554.06	153949.56
Vegetables and Permanent crops draw	Expost data	98933.54	97862.21	94824.30	110992.85						
	Best fit trend	92465.58	97587.16	103194.48	109147.10	115370.90	121820.52	128465.00	135281.69	142253.18	149365.67
	Consistent trend estimates at MS level					110633.30	113922.21	118256.21	123203.98	128194.40	133147.53
All other crops draw	Expost data	132900.03	178253.42	173317.70	209028.98						
	Best fit trend	144690.63	170916.55	186824.76	201312.57	215437.41	229515.58	243670.96	257958.13	272401.93	287012.99
	Consistent trend estimates at MS level					215648.84	228841.32	242035.33	255254.74	268504.62	281779.87
Fodder draw	Expost data	1307107.16	1196383.34	1189946.67	1201081.88						
	Best fit trend	1311683.17	1255176.10	1221273.97	1190921.77	1161761.00	1133049.38	1104475.28	1075887.18	1047204.95	1018384.22
	Consistent trend estimates at MS level					1189494.74	1180017.08	1172629.08	1166411.14	1160058.06	1153584.32

The tool was taken from large parts from the CAPRI project. However, for the problem at hand, a graphic presentation was added to the tool as shown in the next graph. The graphic tool is based on SVG (Scalable Vector Graphics)[15].

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[15] A tool “GAMSVIEW” is also available to visualize the GAMS listing files directly, but this is less user-friendly compared to the XSLT/XML tools and not thought to be used by the end user.

Figure 3.3-1: Using the graphical interface on the XSLT/XML tool on trend projections for fallow land in Spain

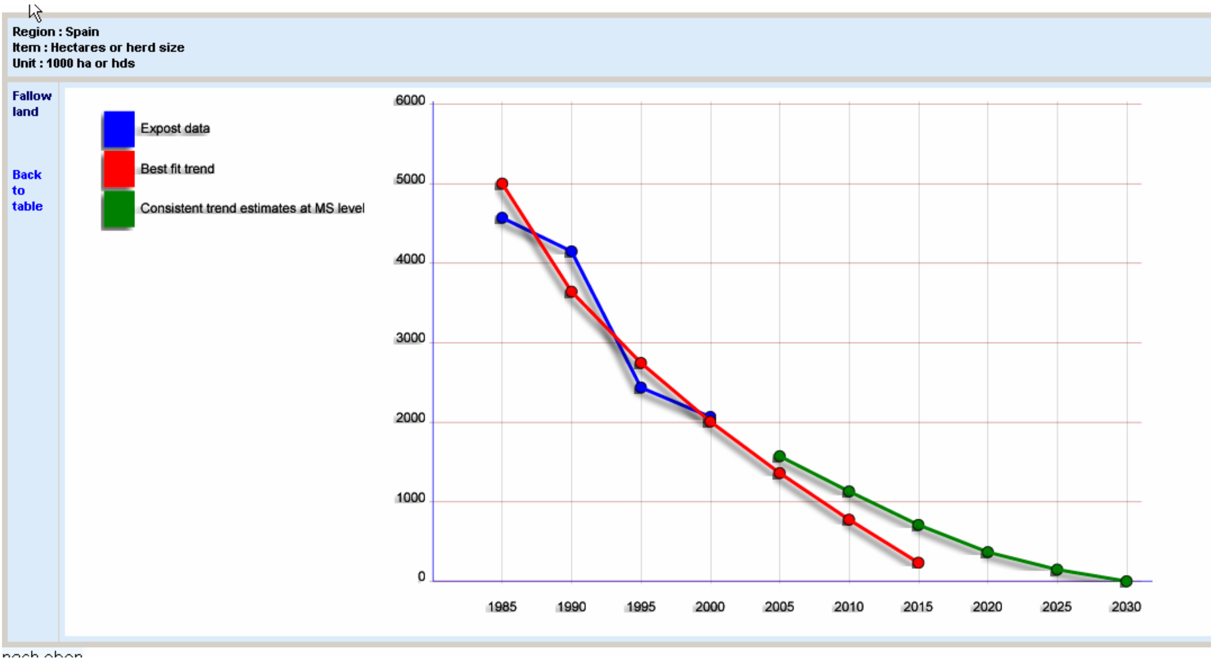
Region : Spain
Item : Hectares or herd size
Unit : 1000 ha or hds

Figure 3.3-1 illustrates not only the graphical interface but also assets and drawbacks of our trend estimates. First of all it is evident that simple trends would have resulted in negative fallow land areas after 2015 because the trend was falling strongly. This is prevented by standard lower bounds on the areas thus illustrating that a mechanical procedure may filter unreasonable results even though it is impossible to check all series visually. However the example also illustrates draw backs of our procedure: The decline is exaggerated due to the particular data situation in Spain and this could only be detected by careful manual checking and detailed knowledge about the situation in Spain[16].

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[16] The authors are grateful to Jan-Erik Petersen for a hint to this problem which certainly has introduced some distortion in our reference run projection for Spain.

4 Integrating trend forecasts with expert information in an agricultural sector model

The projection methodology basically combines two components: the standard structure of the agricultural sector model CAPSIM and certain amendments to systematically integrate external forecasts. Regarding CAPSIM this is a straightforward partial equilibrium modelling tool with behavioural functions for activity levels, input demand, consumer demand and processing. It is designed for policy relevant analysis of the CAP and consequently covers the whole of agriculture of EU (15) Member States in the concepts of the Economic Accounts (EAA) in a high level of disaggregation, both in the list of included items as well as in policy coverage. Complete coverage of the whole of agriculture permits to include the set of technical relationships explained above in the context of trend forecasts, e.g. adding up of total areas (Equation 6) or balancing of feed contents and animal requirements (Equation 8).

4.1 Core relationships in CAPSIM

The sector model framework adds behavioural equations for mayor endogenous variables which are firmly based on microeconomic theory. Firm theoretical underpinnings are considered useful to increase the plausibility of simulation behaviour, and to understand the model's properties which is particularly useful for long run analysis.

Yields of activities on the supply side have been specified as unresponsive to prices such that the revenues per activity are taken to be exogenous "price variables" $X^{PVAR}_{r,i,t}$ (in region r, for product i, in year t) from the viewpoint of farmers. According to many empirical studies the responsiveness of yields to prices is quite low, and definitely smaller than the responsiveness of crop areas such that this simplification may be tolerable. Simplification is definitely necessary for the reference run scenario because model turned out to become quite large (see below). Nonetheless the split of production into yields and activity levels permits to link CAPSIM results to environmental indicators which typically relate to activity levels. Other price variables are input prices which determine the supply side variables of CAPSIM, so called "netputs" combining both activity levels ($X^{NETP}_{r,i,t} > 0$) and input demands ($X^{NETP}_{r,i,t} < 0$).

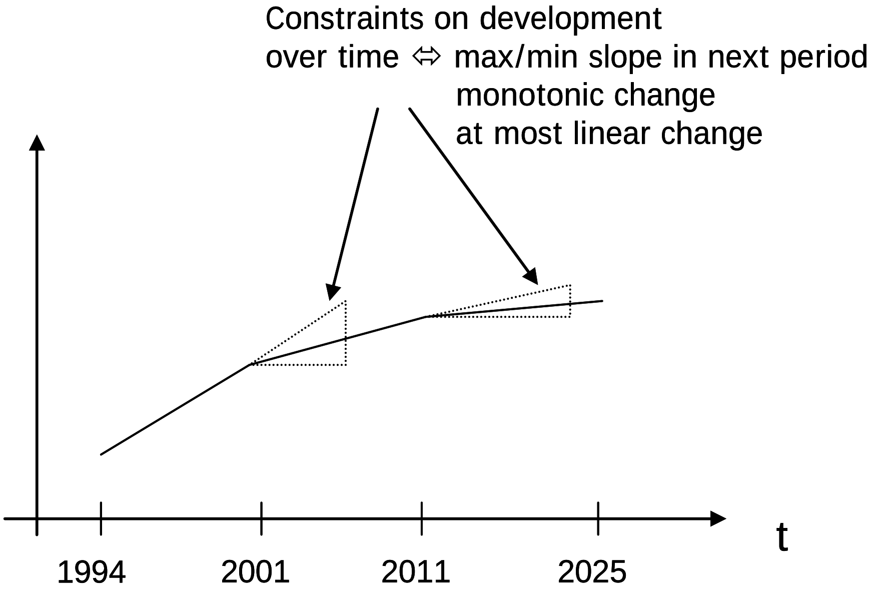
Equation 24 $X^{NETP}_{r,i,t}(\boldsymbol{X}^{PVAR}_{r,t}) = \alpha^{NETP}_{r,i,0,t} + \sum_{j} \alpha^{NETP}_{r,i,j} X^{PVAR}_{r,j,t}$

Note that the constants of the behavioural functions (derived from a so-called "Normalised Quadratic profit function") carry a time index. They may shifted over time to form monotonic spline trend curves which are at most linear (falling or increasing):

Equation 25 $\alpha^{NETP}_{r,i,0,t} - \alpha^{NETP}_{r,i,0,t-1} = mon^{NETP}_{r,i,t}\left(\alpha^{NETP}_{r,i,0,t-1} - \alpha^{NETP}_{r,i,0,t-2}\right)$

Where the monotonicity parameter *mon* is restricted to the range [mon_{lo}, 1]. This permits a flexible translation of behavioural functions to reflect linear or nonlinear impacts of technological or structural change:

Figure 2: **Example spline trend line for a constant term αr,i,t**



The monotonicity restriction has been imposed on the constants of behavioural functions for netputs, processing demand and human consumption. It renders it difficult for CAPSIM to track a non-monotonic development of, say, an activity level over time, at least if this development is not due to price changes. Equally CAPSIM will not be able to trace an geometrically growing series. The idea incorporated in this way is that any growth found in recent trends is more likely to taper off than to continue forever or even to explode, at least if we have to ignore short run stochastic influences and focus on the mean expectation. Not all variables will behave monotonically with tempered trends in the future. However, it is expected that the gain in plausibility for the majority of variables outweighs the distortions affecting the minority of variables.

The constraining character of the trend lines for shifters may be grasped easily if we consider the case of perfectly free constants a_{0t} for each year t. Assume that the ex post value for a variable in 1994 was 110, the base year value in 2000 was 100 and the single external projection value for 2020 is 150. All price changes are assumed to cancel in their effect such that the sum of all price related effects is 80 in each year. The free constants would assume values of $\alpha_{r,i,0,1994} = 30$, $\alpha_{r,i,0,2000} = 20$, $\alpha_{r,i,0,2020} = 70$ to reproduce the supports for the ex post year and for the future simulation year and to be in line with the base year. However, the sequence 30, 20, 70 would represent a non-monotonic development which could not be reproduced with a monotonic trend line and CAPSIM would have to look for a monotonic compromise sequence, say 15, 20, 60, which implies some deviations from the supports. These kind of forced deviations are occurring therefore in particular where the expert forecasts are non-monotonic or where the forecasted growth is not tapering off.

For t = base year (= three year average 2000/2002) the constant term $\alpha^{NETP}_{r,i,0,t}$ is calculated to give exactly the base year quantity at base year prices such that the model reproduces the base year situation:

Equation 26 $$X^{NETP}_{r,i,t_{bas}}(\mathbf{X}^{PVAR}_{r,t_{bas}})=\alpha^{NETP}_{r,i,0,t_{bas}}+\sum_j \alpha^{NETP}_{r,i,j}X^{PVAR}_{r,j,t_{bas}}$$

The key driving forces operating on the supply side are thus technology shifts in a wide interpretation, yield developments and price variables. Depending on the trade regime the latter are determined from the interaction with the demand side or derived from inter.

Policy is strongly modifying the incentives on the supply side. Gross revenues of activities stem from market revenues and different types of *premiums*. They are scaled downwards in case that national ceilings for outlays or entitlements are exceeded but farm level ceilings are ignored. The MTR specification of premiums may be approximated with uniform premiums for most crops (compare Witzke 2003 or Britz, Wieck, Perez 2003). This anticipates that those EU Member States who are currently still hesitating to fully decouple the premiums would do so in the long run, simply because farmers would learn that they loose income with coupled support. As it is difficult to make projections for policy up to 2025 we have maintained the MTR specification up to 2025 in the reference run.

Obligatory set aside is specified according to the July 2004 DG Agri projections. Non-food production is treated in the same manner.

The *milk quota regime* is handled in a standard way: Production is fixed which indirectly also fixes the herd size due to exogenous yields. This requires a shadow revenue for the behavioural function and to initialise the model, an estimate of the base year percentage quota rent. Given that the recent Luxembourg compromise on the MTR has confirmed the quota system until 2014/15 it may be a reasonable guess to assume that it would also be maintained thereafter. However, in an alternative livestock sector liberalisation scenario the quota regime has been abandoned after a cut in support prices (see section 5).

CAPSIM has been used in an extensive study of reform options for the EU *sugar CMO* up to 2011 (Henrichsmeyer et a. 2003a,b). As a consequence, several characteristics specific to the sugar Common Market Organisation (CMO) are being reflected in CAPSIM. Even though the Commission proposal[17] is very likely to be modified in the ongoing discussion it appeared more reasonable to implement the proposed cut in quotas and prices that to maintain the unsustainable status quo, given the EBA initiative of the EU.

The main endogenous domestic demand components (see Equation 2) apart from feed demand are processing of agricultural raw products and human consumption, as feed demand is included in the supply side behavioural functions already. Processing demand $X^{PRCM}_{r,i,t}$ results from linear behavioural functions of unit margins $X^{UMAP}_{r,i,t}$ in processing, calculated as the difference of the value of derived products and the associated raw product cost:

Equation 27 $$X^{PRCM}_{r,i,t}(\boldsymbol{X}^{UMAP}_{r,t})=\alpha^{UMAP}_{r,i,0,t}+\sum_j \alpha^{PRCM}_{r,i,j}X^{UMAP}_{r,j,t}$$

As is the case for the supply side behavioural equations we permitted to the constant terms to shift over time along smooth monotonic trend functions. Production of secondary products is derived from processed raw products with (base period) processing coefficients.

A special case relates to milk products. Similar to the case for the feed technology it is considered useful to explicitly control the balances on milk fat and protein. This is achieved

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[17] EU Commisssion: Accomplishing a sustainable agricultural model for Europe through the reformed CAP – sugar sector reform, COM(2004) 499, Brussels, 14.7.2004

through associated endogenous prices of milk fat and protein. Production of secondary milk products responds to margins calculated as secondary product value net of milk fat and protein cost. Otherwise the behavioural functions correspond to the standard case in Equation 27.

Human consumption $X^{HCOM}_{r,i,t}$ is determined according to the rather robust "Linear expenditure system":

Equation 28 $$X^{HCOM}_{r,i,t}(X^{EXPD}_{r,t}, \mathbf{X}^{UVAD}_{r,t}) = X^{INHA}_{r,t} \cdot \left(\alpha^{HCOM}_{r,i,0,t} + \frac{\alpha^{HCOM}_{r,i,1,t}}{X^{UVAD}_{r,i,t}} \left(X^{EXPD}_{r,t} - \sum\nolimits_j \alpha^{HCOM}_{r,j,0,t} X^{UVAD}_{r,j,t} \right) \right)$$

as a function of total final consumer expenditure $X^{EXPD}_{r,t}$, inhabitants $X^{INHA}_{r,t}$, the vector of consumer prices (calculated as unit valus) $\mathbf{X}^{UVAD}_{r,t}$, and so-called "commitments" $\alpha^{HCOM}_{r,i,0,t}$ which may be interpreted for food items quite neatly as price independent subsistence consumption levels. As for the other behavioural functions we allow the commitment parameters to shift over time. In addition we have incorporated the well known tendency of expenditure elasticities to decline over time (compare Lampe 1999, Rosegrant et al. 2001).

Demand and supply side interact on markets. For tradable products international prices (border prices) are linked to EU prices using a price transmission equation based on the law of one price. Without border measures, these international prices would directly apply to EU markets. Price policy instruments are *tariffs* or, until tariffication is complete, *administered prices* with associated *flexible levies* or *export subsidies*. For nontradable products (fodder, calves) market clearing occurs on the level of Member States.

4.2 Integration of external projections

The outlook in the SoEOR2005 context requires an optimal compromise between possibly conflicting pieces of available information (different expert forecasts, trend forecasts and the model structure), if we want to systematically build upon the existing projections rather than merely adding another one. A well known interpretation of an "optimal" compromise is provided by a cross entropy approach (Golan, Judge, Miller 1996) which requires to collect the external forecasts (expert forecasts, trend forecasts) on a set of "*supports*" and to associate an *a-priori probability* with each support. The cross entropy forecast of a given variable (region r, product i, time t, item j), say the production of beef in the EU, would be calculated as the expected mean of the supports:

Equation 29 $$X^{j,Est}_{r,i,t} = \sum_s Sup^j_{r,i,s,t} \cdot pr^j_{r,i,s,t}$$

The cross entropy objective would be to minimise the distance of pre-specified a-priori and the endogenous posteriori probabilities. In the final version we used a modified objective function (see the Appendix) but the basic framework is the same: Find those forecasts which stay at close as possible to the mean of the supports while meeting all constraints (equations) of the sector model. The example below (Figure 4.2-1) shows the EU23 average of the inner supports and the final projection for beef production in EU23. It illustrates several characteristics of the forecasting approach chosen:

- The simulation result may deviate from the a-priori mean of the external forecasts. The simulation result will differ from the a-priori expectation, if certain constraints prevent an exact "fit" or if this deviation helps to bring another related variable, say the suckler cow herd, closer to the mean of its supports. In this case it is likely that the calves balances built both into CAPSIM and in the default trend estimation, pulls down the beef production given a reduced supply from dairy cows and a limited responsiveness of the suckler cow herd.

- The base year result is not simulated but the parameters of the model are calibrated in such a way that an exact fit is imposed for the base year. Actually carrying out the base year simulation together with the other simulation results would increase the number of equations and variables beyond the technical limits[18]. By construction "base year supports" of the external sources would also coincide with the base year observation from the database, because we re-express all expert forecasts from the original sources in the form of change indices relative to the base year (see the appendix for details).
- To track the supports the model may endogenously shift the constants in behavioural functions along monotonic spline curves. Due to the requirement of monotonic, tempered trends (see Figure 2) the fit will usually be less than perfect. These constraints are introduced on purpose because otherwise (say with unrelated constants specific top each year) the model could track an arbitrary set of external projections as long as they meet the technical consistency relations explained in Chapter 3.
- The number of supports may differ from year to year and from variable to variable. Many supports are usually available for 2011 for important agricultural variables, such as beef production. Their associated a-priori probabilities are currently set equal, except for the trend support which receives only 50% of the probability weight of the expert supports.
- Occasionally the supports may differ a lot. In this case the variance of the supports will be large and deviations are punished only moderately in the objective function. This has certainly contributed to our forecasts moving away from the mean of the expert supports.

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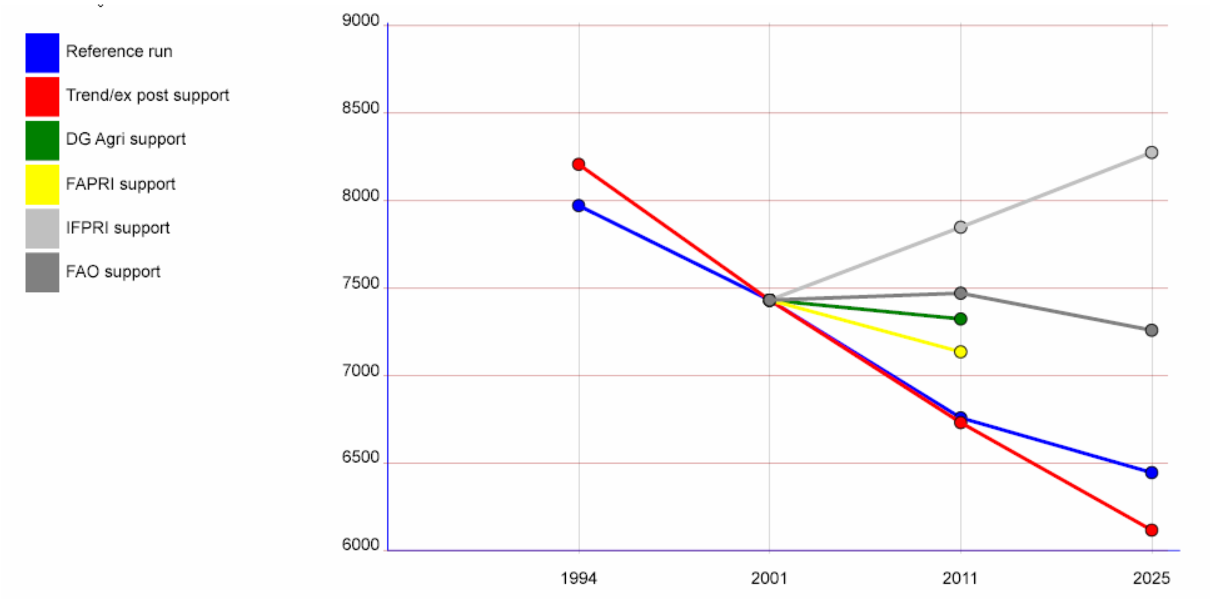
[18] The complete model for EU23 Member States had already about 45000 equations and 52000 variables.

Figure 4.2-1: "Supports" and simulation result for beef production in EU23



A number of technical issues related to the introduction of expert forecasts are discussed in an appendix. Basically our approach combines elements of a conventional econometric estimation with a simultaneous forecast: "Observations" are both the ex-post data as well as external projections and as in any econometric estimation some measure of "fit" is maximised which pulls the simulations as close as possible to the supports. The objective to achieve a good "fit" both for the ex post data as well as for the external projections on future developments introduces a resistance of CAPSIM to reproduce arbitrary external projections if they are in conflict with the economic relationships in CAPSIM. The best compromise estimates for future time periods represent our projections.

Expert forecasts are introduced for the most important variables in CAPSIM (activity levels, production, demand components, net trade, EU prices). Other variables are largely determined according to these key variables. Producer prices on the Member State level, for example, follow in most cases from the EU prices through a fixed factor of proportionality. Income may be calculated once prices and quantities are known. In this manner the closed sector model framework helps to conveniently complete the quantitative prediction in line with the predictions on key variables.

4.3 Definition of environmental indicators

The ultimate goal of this outlook is to provide deeper insights into environmental consequences of ongoing and alternative developments. CAPSIM has been augmented with a simplified calculation of selected environmental indicators building on the base year specification in the CAPRI model[19] which uses the same database. These indicators will be explained shortly but it has to be recognised that important environmental concerns cannot be addressed in our study which operates on the aggregate level of whole Member States with a

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[19] Current entry: http://www.agp.uni-bonn.de/Agpo/rsrch/dynaspat/dynaspat_e.htm.

certain bias towards the main CAP products. Without additional assumptions and informed reasoning it is impossible to draw conclusions for biodiversity, landscape characteristics and erosion, to mention the most important omissions. Furthermore our database does not permit to identify irrigated areas, organic farming, and environmental programs. Our main indicators will be nutrient balances (N, P, K) and gaseous emissions (NH3, N20, CH4).

4.3.1 Nutrient balances

The components of the nutrient balances may be explained at the example of nitrogen in the Netherlands

Table 4.3-1: Nutrient balance components for the Netherlands, ex post simulation 1994 and base year 2001

Region : Netherlands **Product : Nitrogen**	**1994**	**2001**
Production by animals kg/ha	299.75	281.15
Organic supply to crop production kg/ha	56.29	63.06
Mineral fertiliser purchases kg/ha	178.82	151.24
Total fertiliser supply to crops kg/ha	235.11	214.3
Bio fixation + atmospheric origin kg/ha	41.54	41.19
Gaseous losses as NH3 kg/ha	89.34	83.38
Net exports in harvested material kg/ha	162.82	166.37
Relative overfertilisation index	1.44	1.29
Nutrient surplus kg/ha	267.95	223.83

The nutrient balance starts with total *production by animals*, which is linked in the original CAPRI calculation to protein requirements, live weights and yields of animals (see the CAPRI website) at a lower level of disaggregation than in CAPSIM. For this study the CAPRI coefficients have been aggregated to the CAPSIM level. Because the main yield effect over time will be the increase in milk yields the yield dependency of manure production has been inferred from the comparison of the coefficients of the two CAPRI activities “high yield cows” and “low yield cows” in each EU Member State.

Only a part of total nutrient production is available for *organic supply to crop production* whereas the remainder is released to the atmosphere, to the ground water or accumulated in various soil layers. The share thus lost is determined by stable systems which are calculated in the CAPRI database at a level of detail which exceeds the possibilities within CAPSIM. For the projection we have calculated trend functions of the availability shares which reflect the ongoing changes in housing systems, but only in implicit form. In a “best practice” alternative scenario these availability factors have been increased to reflect improved management, see section 5.

Losses of various forms are anticipated by farmers when they supplement the available organic supply with *mineral fertilizer purchases*. Total mineral fertilizer purchases have been split up into urea and other nitrogen fertilizers according to historical trends in their shares[20]. In the past the *total fertilizer supply* has typically exceeded the *net exports in harvested material* by a certain amount. This *overfertilisation* characterises farmers behaviour and is equally projected by trends which are usually falling over time. It may be seen in the table that farmers in the Netherlands have reduced this overfertilisation which contributed to the improvement in the nutrient balance.

The part of organic nitrogen released as NH3 to the atmosphere is steered by another set of coefficients depending on stable systems and animal types. They are related to the manure coefficients for projection purposes such that a change in manure production automatically changes the forecasted emission of NH3. These animal related coefficients are equally changed in the best practice scenario. NH3 losses related to mineral fertilizer use are determined as a share of total mineral fertilizer use which is again determined from the CAPRI database and reduced in the best practice scenario. The sum of NH3 losses from organic and mineral fertilizer gives the total *gaseous losses as NH3.*

Finally supply of nitrogen from *biological fixation and atmospheric deposition* is added and projected with coefficients held constant over time.

The balances for potassium and phosphate are calculated in a similar fashion with a few elements of the balance becoming irrelevant.

4.3.2 Gaseous emissions

Emissions of NH3 have been discussed already above such that we only need to address methane and nitrous oxide.

Methane is calculated with a set of aggregated CAPRI coefficients applied to the CAPSIM activities. Their yield dependency has been inferred from the differences of the CAPRI coefficients for high and low intensity cows similar to the treatment of manure output coefficients.

Emissions of N2O are linked in the CAPRI database to losses during application (with different coefficients for mineral and organic fertilizer), to losses in manure management (specific to management systems, regions, and animal types), to grazing farming systems and losses related to waste and crop residues. These different sources have been linked partly to activity coefficients, partly to mineral fertilizer use and partly to manure production to incorporate the effects of a changed composition of the total nutrient supply on N2O emissions.

The following table gives an overview on the ex post development of environmental indicators in the Netherlands.

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[20] The results are available in the demand balances under “Feed/nonfeed input use”.

Table 4.3-2: Environmental indicators for the Netherlands, ex post simulation 1994 and base year 2001

Region : Netherlands Item : Environmental indicator per ha (kg/ha)	1994	2001
Nitrogen	267.95	223.83
Potassium	142.8	113.16
Phosphate	104.21	86.23
Ammonium	89.34	83.38
Methane	214.42	194.43
Nitrous oxide	10.12	9.71

It should be mentioned that all indicators have been calculated per ha of agricultural area used, that is net of fallow land or set aside.

5 Overview on EU results

5.1 The reference run

5.1.1 Main developments in the crop sector

The total area under ***cereals***, during the last decade to a larger extent modulated by changes in the set-aside regime, is forecasted to fall slightly in line with DG-AGRI projections from current levels by -1.2 Mio ha to 51.7 Mio ha in 2011, and to recover again to 52.4 Mio ha in 2025. The recovery is due to rather optimistic price forecasts in world cereals markets in the medium term FAPRI and long run IFPRI projections.

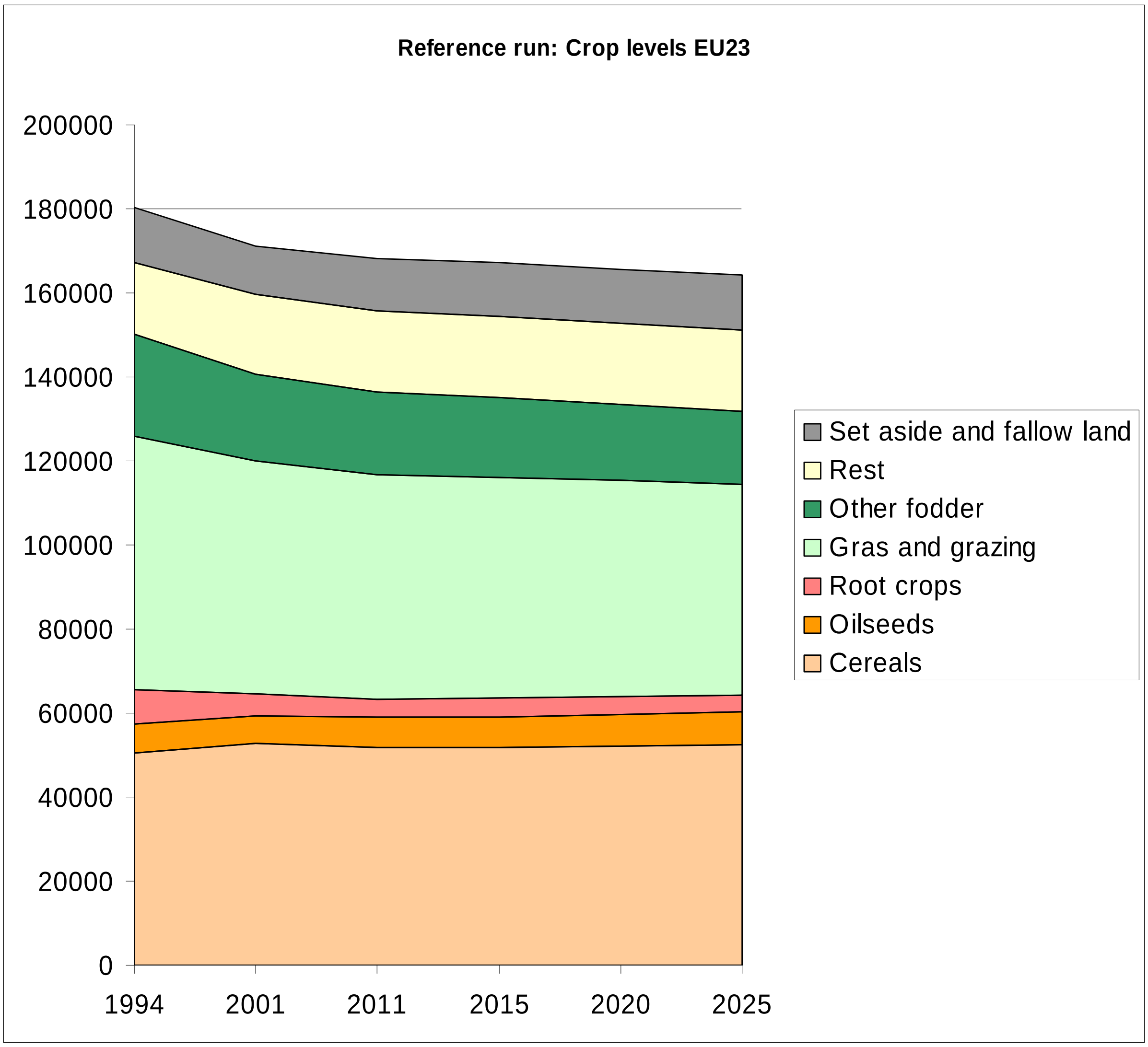
Soft wheat, with about 19 Mio ha the most important cereal, dominates the developments, whereas barley areas are forecasted to fall over the whole period from 13.4 Mio ha in 2001 to 12.2 Mio ha in 2025. Rye areas are projected to decline from 3.4 Mio ha in 2001 to 3.3 Mio ha in 2011 as market intervention are abolished in the 2003 CAP reform package, and to stay stable afterwards. A continuous increase is shown by grain maize from 6.1 Mio ha in 2001 to 6.8 Mio ha in 2025 and other cereals from 2.3 Mio ha to 2.7 Mio ha, in line with long term trends. In the new Member States, changes in relative terms are stronger compared to EU15, total cereal areas are projected to decline from about 16 Mio ha in 2001 by -1 Mio ha to 2011, with soft wheat areas even falling stronger, but grain maize and other cereals increasing.

Table 5.1-1: Reference run development for crop levels

	1994	2001	2011	2015	2020	2025
Cereals	50391	52892	51675	51863	52154	52411
Oilseeds	7014	6554	7188	7304	7517	7800
Root crops	8149	5073	4410	4331	4252	4187
Gras and grazing	60410	55355	53532	52564	51368	50169
Other fodder	24191	20820	19509	18927	18107	17237
Rest	17064	19125	19486	19433	19358	19301
Set aside and fallow land	13014	11315	12443	12642	12833	13008

Compared to cereals, ***oilseeds*** account with 6.5 Mio ha in 2001 for a much smaller part of the arable crop area, rape seed with 3.5 Mio ha being the most important crop. In line with DG-AGRI projections, rape areas are forecasted to continue their past expansion to 4.5 Mio ha in 2025, whereas forecasted sunflower areas follow past trends and fall slightly from their 2.1 Mio ha level in 2001 to 2 Mio ha in 2025. The area under ***pulses*** increases slightly in the projection by +0.1 Mio ha due to the specific premium in the MTR to around 2 Mio ha in 2011, and remains constant afterwards. As market are saturated and yields continue to grow, projected ***potato*** areas follow their long term trends of continuous decrease starting of from 2.7 Mio ha in 2001 to 2.3 Mio ha in 2025. Projected developments in the ***sugar-beet*** sector, the other major root crop, are determined by the combination of yield increases and sugar market liberalization necessitating from the “Everything but arms” agreements with prices and quotas dropping: from the 2.4 Mio ha level in 2001 to 1.9 Mio ha left in 2025, with the share of out-of-quota production increasing.

Figure 5.1-2: Reference run development for crop levels



Fodder area accounts for the biggest part of the agricultural land base in EU23, with around 55 Mio ha of permanent grass land and pasture in 2001 plus another 20.8 Mio ha of arable land used for fodder maize, silage, clover etc. Fodder area show a long term falling trend which is projected to continue with a reduction of -9 Mio ha from 2001 to 2025, thus accounting for the major share of land being lost for urbanization. About a quarter of that changes occurs in the New Member States. The development in fodder areas is linked to reduced fodder demand from ruminants as both supply of beef meat and cow number are projected to drop in the long term.

Changes in ***perennial crops*** and other crops not discussed so far are mixed: vineyards continue their decline, but at a somewhat slower pace from 3.6 Mio ha in 2001 to 3.4 Mio ha in 2025. The drop in fruits, starting off with a similar level as vineyards in 2001, is estimated to be somewhat stronger with a reduction of around -0.7 Mio ha. Areas under olive trees

(4.2 Mio ha in 2001) continue their increase in the projection, but only slightly with about +0.1 Mio ha over the whole forecast period, as do vegetables with +0.05 Mio ha to 2.5 Mio ha in 2025. The past development of increased production of specialty crops (horticulture, flowers and pharmaceutical crops) is projected to continue, with their land base increasing from 1.9 Mio ha in 2001 to 2.5 Mio ha in 2025.

Set-aside areas are coupled to Grandes Culture areas as set-aside obligations are assumed to prevail over the projection period, and are fixed to DG-AGRI projection until 2011. Whereas obligatory set-aside areas are assumed to be stable for EU15 after 2011 and thus fixed to their 2011 levels, structural change in the new Member States is assumed to shift Grandes cultures areas from small farms which are exempt from set-aside to larger ones. That shift is assumed to double set-aside obligations in EU8 until 2025 or increasing total obligatory set-aside at EU23 level by +1.3 Mio ha from 2011 to 2025. Voluntary set-aside, accounting for 2.2 Mio ha in 2001, is projected to grow to 2.7 Mio ha in 2025. ***Fallow land*** stays more or less constant around 6 Mio ha over the projection period.

Productivity developments shown as yield increases are forecasted to continue their modest growth over the projection period, with around +1 % p.a. for cereals and +0.8 % p.a. for oilseeds. Nevertheless, given the long projection horizon, average yields increase in the projection by +26% for cereals and +21% for oilseeds from 2001 to 2025.

5.2 Main developments in the animal sector

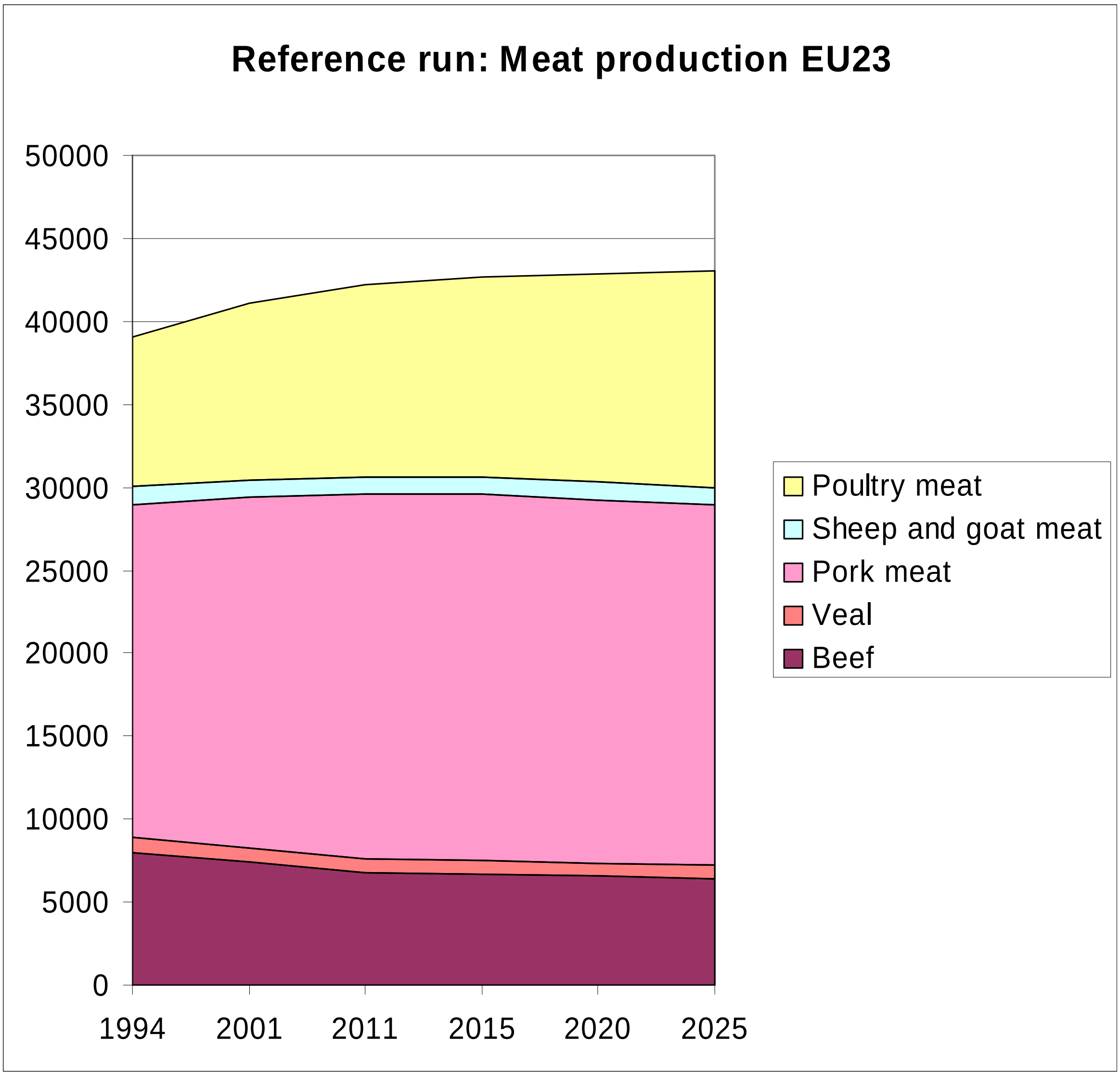
Changes in the ***beef sector*** depend on the one hand on the interplay of the assumed continuation of the milk quota regime with projected milk yield increases (+31% from 2001 to 2025 or to 7.500 kg in average per dairy cow), and on the other hand on the long term demand shift from beef to pig and poultry meat. The dairy cow herd is forecasted to drop by about -24 % from 2001 level to 19.1 Mio animals in 2025, accompanied by an increase in suckler cows of +21% to 14.9 Mio heads. Accordingly, calves availability is reduced and impacts on the forecasted beef cattle herd. Following decreases in fattened beef cattle and cow numbers, beef meat production is estimated to drop by about -1 Mio t from current 8.3 Mio t to 7.3 Mio t in 2025.

Table 5.2-1: Reference run development for meat production

	1994	2001	2011	2015	2020	2025
Beef	7971	7432	6758	6666	6540	6445
Veal	890	847	821	816	811	809
Pork meat	20041	21099	21993	22075	21916	21652
Sheep and goat meat	1169	1090	1061	1063	1049	1024
Poultry meat	8975	10658	11530	12039	12579	13111

Rather prominent increases in ***pork*** meat production in the seventies and eighties have already cooled down in the last decade, and the EU production of 21 Mio t in 2001 is projected to increase only slightly to 21.6 Mio t, following modest increases in demand and keeping the EU net trade rather stable below 2 Mio t a year.

Figure 5.2-2: Reference run development for meat production

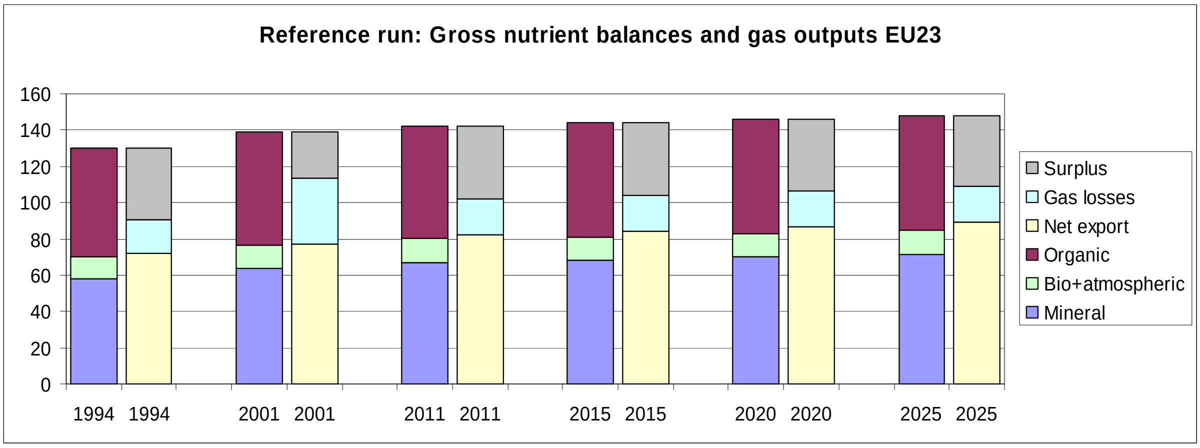


In opposite to beef and pork, ***poultry*** meat demand and production continue in the projection their stronger increasing pattern, to reach 13 Mio t in 2025 starting from 10.6 Mio t in 2001, with net trade stable around 0.5 Mio t a year. In both cases, relative increases are stronger in the new Member States. Forecasted demand and production of sheep and goat meat remain a small and decreasing part of EU meat markets, dropping from the current 1.1 Mio t to 1 Mio t in 2025, with stable net imports of around 0.2 Mio t.

5.3 Development of gross nutrient balances and gas outputs

Projected amounts of nitrogen produced in animal manure remain almost stable over the projection period (-2.5% from 2001 to 2025) at about 10.5 Mio t of pure N per annum, as the effect of dropping herd sizes in cattle is countervailed by increases in poultry and to lesser extent in pig herds. Forecasted yield increases and, somewhat less important, changes in crop patterns, let nitrogen export by crops and thus crop need increase by about +14% from current levels until 2025.

Figure 5.3-1: Development of gross nutrient balances and gas outputs in the reference run



Changes in efficiency regarding manure handling and fertilizing practices are assumed to be relatively small, nevertheless, on the long run, the ***Nitrogen surplus*** is reduced by -13%. Apart from downward tending “over-fertilisation” this is due to the fact that a higher part of crop need is covered by anorganic fertilizer where losses are smaller compared to organic N, whose supply is projected to drop as discussed above. ***Ammonia losse***s stay more or less stable, as the shift from beef to pig and poultry offsets the effects of total organic N reduction. The picture for ***Phosphate*** is more optimistic: surpluses are forecasted to drop from current 2.7 Mio t to 1.8 Mio t in 2025, as past trends of improved management practices continue, mainly reflecting the assumption that more farmers account for organic Phosphate when determining anorganic fertilizer application rates.

Whereas the effect of the changes in herd size and compositions on Ammonia output is minor, ***Methane*** output drops by around -5% over the projection period as cattle, sheep and goat numbers decrease. ***Nitrous oxide emissions*** are coupled to a large extent to total Nitrogen application, with higher losses occurring when using organic N. The projected increase in total crop N need of +14% thus provokes a small increase in nitrous oxide output of +2%.

When judging about environmental effects, the efficiency of the total agricultural system should be kept in mind: the mix of crop yield increases, changes in demand and thus herd and cropping patterns and changes in management practices allows provision of food for an increased EU population with higher per capita food consumption (given minor changes in agricultural net trade) without significant increase of negative impacts on the environment.

5.4 Counterfactual scenarios

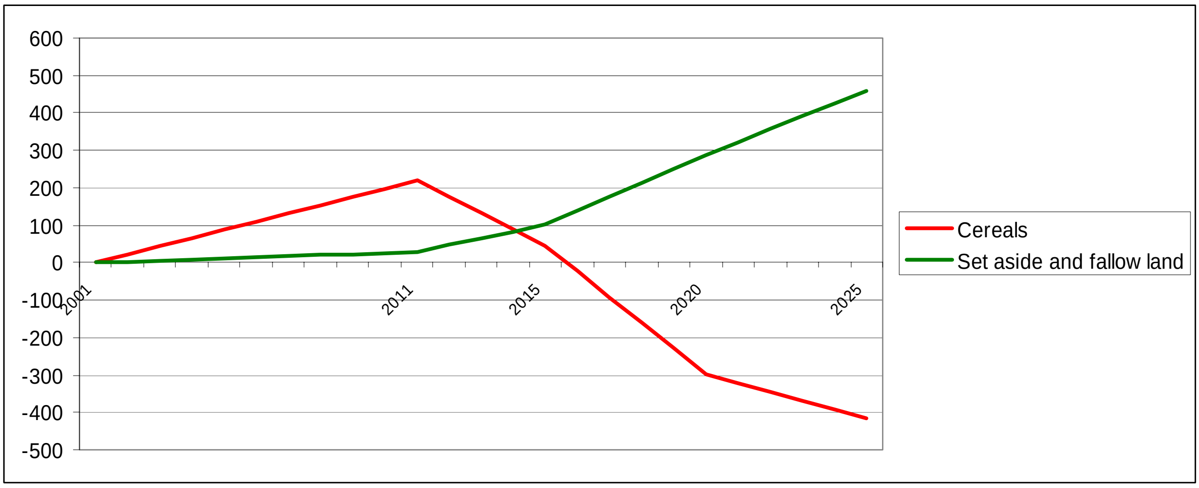
5.4.1 A stronger Euro

The exchange rate in the reference run is fixed at 0.9 €/US$ from 2011 onwards, based on the last (July 2004) DG-AGRI outlook, thus the Euro is weaker as under current market conditions. The first counterfactual scenario analyses possible effects of a stronger Euro of 0.75 €/US$, close to levels observed during the year 2004. A stronger Euro decreases both export and import prices for agricultural goods in the EU, whereas prices for inputs not produced by agriculture itself (fertilizer, energy etc.) are assumed to stay unchanged at reference run levels. The same holds for a few special products assumed to be protected against exchange rate fluctuations (wine, olive oil). The overall effect is hence that of lower terms of trade for agricultural goods, where differences between agricultural commodities depending firstly on the size of import tariffs, which are assumed to work as specific ones and thus dampen the price transmission between world and EU markets, and secondly, on the existence and level of administrative prices. Because land prices are adjusting downwards but remain above the “trigger level” for large scale land abandonment, partly due to per ha farm premiums from the last CAP reform package, there is only a mild impact on total area use.

The overall effect of the stronger Euro on cropping pattern and herd sizes is rather small. For cereals, the major arable cash crops, world market prices in the reference run in 2011 are close to administrative prices, so that price decreases resulting from a stronger Euro would not be transmitted into EU market.

For most other crops, price drops are in the range of -15%, so that the relative competitiveness of cereals increases which let cereal areas expand slightly by +0.5% in 2011, whereas the share of oilseed and pulses drops by about -1.5%. Fallow land would somewhat increase (+0.3%), changes in other crops are mixed, but mostly small, and depend on the existing of Common Market Organizations which stabilize prices.

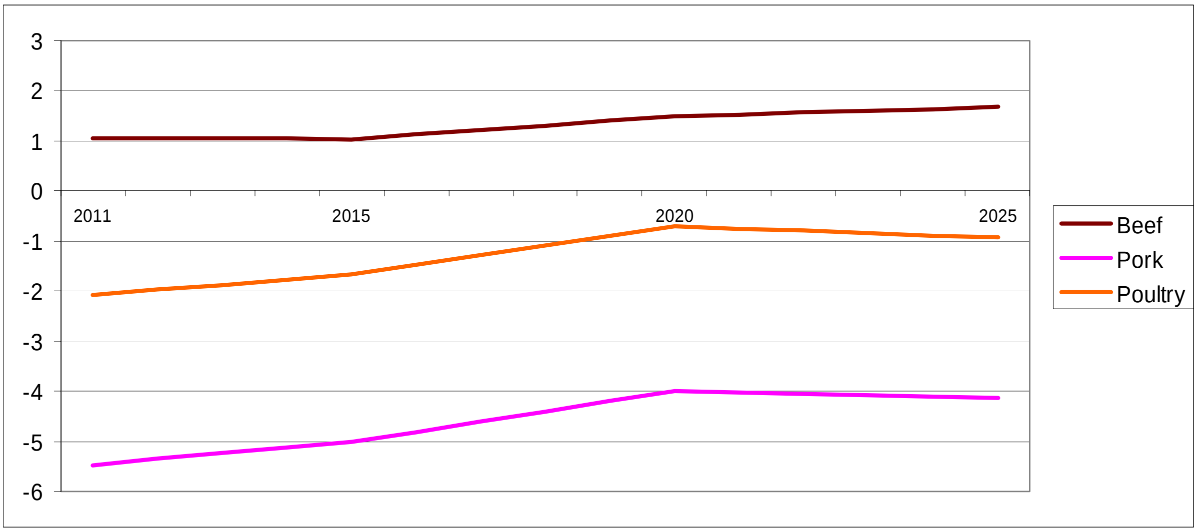
Figure 5.4-1: Differences in area use for cereals and set aside / fallow land in the low exchange rate scenario compared to the reference run in EU 23



Effects are different in 2025 as the continuation of the projected world market price increases for cereals would render the administrative prices irrelevant even under the stronger Euro. Consequently, on top of many other crops without administrative price scheme where price are reduced both in 2011 and 2025, changes in border prices for cereals would in 2025 be transmitted into EU market as well and thus provoke a drop in cereal prices by about -17%. Consequently, both areas under cereals (-0.8%) and oilseeds/pulses (-0.5%) would drop compared to the reference run, and fallow land would increase by (+6%).

The effect on the animal sector depends again on the existence of price stabilizing policy interventions. In the beef sector, the intervention price for beef is the relevant price both in 2011 and 2025 in the reference run, any changes in border prices would hence not impact on internal markets. Together with the stabilizing effect of the milk quota regime, the relative competitiveness of beef cattle thus increases compared to other animal products with price drops, an effect amplified by lower feed prices and increased competitiveness of fodder production on arable land.

Figure 5.4-2: Percentage difference scenario run to reference run for beef, pork and poultry production in EU 23



Beef supply is simulated to increase by about +1.5% both in 2011 and 2025 compared to the reference run. In opposite to beef, pig markets are closer linked to EU border prices, EU market prices are assumed to fall with a stronger Euro by about -15% compared to the reference run, and pig meat supply drops by about -5.5% in 2011 and about -4% in 2025. Price (-10%) and supply (-2%, -1%) changes in poultry markets are somewhat smaller. As for beef, the supply reactions depend not only on decreased output prices, but on lower feed costs as well with prices for cereals, oil cakes etc. dropping. Consequently, the relative changes against the reference run are somewhat stronger in 2011 compared to 2025, as the intervention system for cereals keeps cereal prices constant and thus prevents stronger feed price reductions in 2011.

The latter effect explains why the decrease in Nitrogen supply is more pronounced in 2011 (-0.7%) as in 2025 (-0.1%). In 2011, organic N output (-1.3%) and Ammonia losses (-1.3%) decrease somewhat compared to the reference run, with rather stable cropping patterns, mineral fertilizer Nitrogen is thus increased (+0.5%) to replace the lower availability of organic Nitrogen. As the share of crop available Nitrogen in anorganic Nitrogen is higher compared to organic one, switching from organic to anorganic Nitrogen application reduces losses and thus improves the Nitrogen balance. The picture in 2025 is somewhat different: the reduction in organic Nitrogen is smaller (-0.5%) as herd sizes of pig and poultry are higher compared to 2011, and crop needs are reduced as well, so that mineral fertilizer Nitrogen application drop as well (-0.5%), explaining the rather small effect on the balance (-0.2%). For Phosphate, results are very similar: a somewhat stronger reduction in the medium term (-1%) compared to 2025 (-0.2%).

Regarding agricultural gases output, ammonia is reduced by -1.5% in 2011 and -0.9% in 2025 compared to the reference run, whereas Methane output stays stable in 2011 and even increases in 2025 (+0.5%). The latter is due to the fact that beef supply is expanded.

Overall, even if changes for specific products may be relevant, changes in the exchange rate have little impact on the broad picture. Consequently, the exchange rate assumption in the reference run is of minor importance for the results, at least for environmental indicators where many product specific effects cancel out each other. Evidently this would not hold for monetary variables such as agricultural income.

5.4.2 Liberalization of animal product markets

To a larger extent, negative externalities of agricultural production are linked to emissions from animal production as methane output or ammonium losses and nitrate leaching linked to organic Nitrogen stemming from animals. The current CAP, assumed to be continued in the reference run, increases prices for animal products both by border protection and market interventions beyond the level which would prevail in the absence of Common Market Organizations for these commodities. The scenario discussed in the following tries to determine the impact of that aspect of the CAP in the reference run for the year 2025 on selected environmental indicators, and thus shows the possible outcome of the end point of continued liberalization in the context of WTO negotiations for animal products markets.

In the scenario, the quota regime for milk is abolished in the year 2025 accompanied with a gradual drop of administrative prices for butter and skimmed milk powder and tariffs for dairy products, starting after 2011. Equally, market interventions for beef meat are eliminated, and tariffs for the different meats and eggs are removed. Consequently, EU market prices are assumed to be identical with border prices in the year 2025. It is assumed that the milk regime leads to rents both at farm and dairy level, the later assumed to account for 10% of current differences between market prices for dairy products, and the fat and protein value linked to the price of raw milk. Quota rents for milk cows in the base year are a stylised aggregate of various studies.

Reducing administrative prices for dairy and removing tariffs provokes adjustments both at farm and dairy level: the lower prices for dairy products decrease demand for raw milk by the dairies, which will results in lower milk prices. The reduction in milk prices will decrease quota rents, and once these are zero, dairy cow herds (-10%) adjust till marginal production costs are equal to the reduced milk price (-33%). Equally, the lower prices of beef meat (-30%) compared to the reference run will reduce beef production (-4%). At the same time, market prices for pig (-13%) and poultry (-28%) meat will line up with world markets, and herds adjust (-5% for pigs and –11% for poultry). The reduced herds lower the demand for fodder, and allow a reduction of fodder area (-2%), which in turn leads to an expansion of other crops (cereals: +1%).

In terms of environmental indicators the liberalization matters but with a 4% improvement of the nitrogen surplus the impact turns out smaller than might be expected by many observers.

Table 5.4-3: Nitrogen balances in the “animal liberalisation” scenario compared to the reference run in EU 23

Region : European Union Product : Nitrogen		2001	2011	2015	2020	2025
Production by animals	**Reference run**	62.3	62.25	62.79	63.21	63.63
kg/ha	**Animal product lib**	62.3	62.25	62.04	61.66	59.91
Organic supply to crop production	**Reference run**	20.63	20.5	20.63	20.69	20.75
kg/ha	**Animal product lib**	20.63	20.5	20.37	20.17	19.49
Mineral fertiliser purchases	**Reference run**	63.9	69.11	70.37	72.12	73.84
kg/ha	**Animal product lib**	63.9	69.11	70.63	72.48	74.6
Total fertiliser supply to crops	**Reference run**	84.54	89.6	91	92.81	94.59
kg/ha	**Animal product lib**	84.54	89.6	91	92.66	94.09
Bio fixation + atmospheric origin	**Reference run**	12.79	12.89	12.9	12.9	12.91
kg/ha	**Animal product lib**	12.79	12.89	12.88	12.86	12.79
Gaseous losses as NH3	**Reference run**	19.45	19.68	19.87	20.04	20.21
kg/ha	**Animal product lib**	19.45	19.68	19.66	19.62	19.22
Net exports in harvested material	**Reference run**	76.91	82.16	84.05	86.53	89.04
kg/ha	**Animal product lib**	76.91	82.16	84.05	86.38	88.56
Nutrient surplus	**Reference run**	42.64	42.4	42.14	41.66	41.12
kg/ha	**Animal product lib**	42.64	42.4	41.84	41	39.52

Only moderate improvements are also the main result for the other environmental indicators.

Table 5.4-4: Environmental indicators in the “animal liberalisation” scenario compared to the reference run in EU 23

Region : European Union Item : Environmental indicator per ha (kg/ha)		2001	2011	2015	2020	2025
Nitrogen	Reference run	42.64	42.4	42.14	41.66	41.12
	Animal product lib	42.64	42.4	41.84	41	39.52
Potassium	Reference run	31.44	29.54	29.12	28.52	28.01
	Animal product lib	31.44	29.54	28.79	27.85	26.88
Phosphate	Reference run	15.89	14.44	14.02	13.42	12.8
	Animal product lib	15.89	14.44	13.85	13.07	12.17
Ammonium	Reference run	19.45	19.68	19.87	20.04	20.21
	Animal product lib	19.45	19.68	19.66	19.62	19.22
Methane	Reference run	48.82	47.52	47.78	48	48.31
	Animal product lib	48.82	47.52	47.28	46.93	45.67
Nitrous oxide	Reference run	2.98	3.07	3.11	3.16	3.21
	Animal product lib	2.98	3.07	3.1	3.13	3.14

5.4.3 Best practice scenario for fertilizer handling

The third scenario checks for the sensitivity of the results regarding the assumed management practices when handling fertilizer, changing three sets of parameters: ammonia losses linked to organic nitrogen output from animals, crop available N, P and K from organic fertilizer application and the overall efficiency of farms when balancing crop nutrient needs and fertilizer applications. The ammonia losses for each animal type and country in the reference run are kept stable at base year levels relative to manure production per animal. They depend among other on the share of the time animals spend grazing or in the stable, the type of storage system used and the application technique. Losses during the time animals are in the stable relate to the animal and housing type, and are between 10 and 20% in the reference run. Generally, it is assumed that the majority of farmers uses uncovered storage facilities, so that between 3 and 6 % of the nitrogen entering storage is lost. Emissions under the application techniques of manure in the reference run are set to 20% of the nitrogen remaining after storage. The crop availability of the remaining N, and the P and K in manure applied is a regional specific factors determined by balancing crop needs and known pure nutrient availability ex post.

In the “best practice scenario”, these assumptions are changed as follows: the crop availability from organic application is increased to 80% of the Nitrogen not lost as ammonia, and 95% for P and K. Ammonia losses in stables are cut by half or to 8%, whatever the smaller, storage losses down to factors between 0.06% to 0.12% depending on the animal type which would require full covered storage facilities and improved manure handling in the stable, especially more frequent sampling into storage. Better application techniques as injections are assumed to reduce ammonia losses during application to 5%. No changes are assumed regarding the grazing practice and the related ammonia losses. Depending on the animal and country, compared to the reference run, ammonia losses stay stable – in cases where animals are grazing the year round, as in many cases for sheep and goat – or are cut down by up to 70%. Losses of P, K are cut down by about -80% to -95%, where the picture for Nitrogen is more mixed, with a reduction by about -50% for most countries.

The improved management practice reduces the “over fertilization” factors giving the ratio of total supply to exports with harvested material. Here it has been assumed that the best practice farming would imply an “over-fertilisation” of 5%. In all countries with higher over-fertilisation the factor has been reduced accordingly in 2025. Given that such improvements would be achievable only gradually through a slow spread of better farming practices, it is assumed that this development would begin in the base period (2001).

Given in the new Member States nutrients have been supplied at very low levels these historical data heve not been used as a basis for the over-fertilisation factors. Rather we have assumed that they would return to more normal farming practices as observed in EU 15 (with an over-fertilisation factor of 1.1, which has been reduced to 1.05 in the best practice scenario. The results on environmental indicators are strongly influenced by these assumptions as shown in the following tables on the nitrogen balances

Table 5.4-5: Nitrogen balances in the “best practice” scenario compared to the reference run in EU 15

Region : EU 15 Product : Nitrogen		2001	2011	2015	2020	2025
Production by animals	**Reference run**	68.3	68.28	69.01	69.64	70.28
kg/ha	**Best practice**	68.3	68.28	69.01	69.64	70.28
Organic supply to crop production	**Reference run**	23.26	23.18	23.39	23.55	23.71
kg/ha	**Best practice**	23.26	33.27	37.69	43.14	48.69
Mineral fertiliser purchases	**Reference run**	68.68	71.5	72.66	74.29	75.88
kg/ha	**Best practice**	68.68	60.22	56.46	51.94	47.82
Total fertiliser supply to crops	**Reference run**	91.94	94.67	96.05	97.84	99.59
kg/ha	**Best practice**	91.94	93.49	94.14	95.08	96.51
Bio fixation + atmospheric origin	**Reference run**	15.99	16.13	16.18	16.24	16.29
kg/ha	**Best practice**	15.99	16.13	16.18	16.24	16.29
Gaseous losses as NH3	**Reference run**	21.34	21.54	21.79	22.03	22.26
kg/ha	**Best practice**	21.34	15.61	13.46	10.74	8.05
Net exports in harvested material	**Reference run**	81.5	87.31	89.41	92.17	94.98
kg/ha	**Best practice**	81.5	87.31	89.41	92.17	94.98
Nutrient surplus	**Reference run**	50.13	47.04	46.65	45.98	45.21
kg/ha	**Best practice**	50.13	41.71	38.77	34.91	31.36

Improved farming practices may be seen to have far stronger benefits for the environment than additional liberalisation of the livestock sector which benefits the environment, but only in an indirect way.

Table 5.4-6: Nitrogen balances in the "best practice" scenario compared to the reference run in EU 08

Region : EU 08 Product : Nitrogen		2001	2011	2015	2020	2025
Production by animals kg/ha	Reference run	40.97	40.73	40.82	40.8	40.75
	Best practice	40.97	40.73	40.82	40.8	40.75
Organic supply to crop production kg/ha	Reference run	11.31	10.95	10.87	10.73	10.58
	Best practice	11.31	16.5	18.66	21.32	23.96
Mineral fertiliser purchases kg/ha	Reference run	46.91	60.58	62.29	64.54	66.81
	Best practice	46.91	55.03	53.06	50.62	48.1
Total fertiliser supply to crops kg/ha	Reference run	58.21	71.53	73.15	75.27	77.39
	Best practice	58.21	71.53	71.72	71.94	72.06
Bio fixation + atmospheric origin kg/ha	Reference run	1.4	1.34	1.32	1.29	1.25
	Best practice	1.4	1.34	1.32	1.29	1.25
Gaseous losses as NH3 kg/ha	Reference run	12.71	13.02	13.09	13.12	13.15
	Best practice	12.71	9.55	8.2	6.5	4.8
Net exports in harvested material kg/ha	Reference run	60.57	63.8	65.14	66.88	68.62
	Best practice	60.57	63.8	65.14	66.88	68.62
Nutrient surplus kg/ha	Reference run	16	25.83	26.2	26.62	27.04
	Best practice	16	23.75	21.85	19.33	16.67

As explained above the situation in EU 08 countries may be expected to deteriorate in the next years given that mineral fertilizer purchases are likely to grow considerably. "Best practice" improvements, possibly fostered by environmental policies could help a lot to counteract this danger.

The final tables show that these improvements partly apply to other environmental indicator variables as well.

Table 5.4-7: Environmental indicators in the "best practice" scenario compared to the reference run in EU 23

Region : European Union Item : Environmental indicator per ha (kg/ha)		2001	2011	2015	2020	2025
Nitrogen	Reference run	42.64	42.4	42.14	41.66	41.12
	Best practice	42.64	37.77	35.04	31.44	28.05
Potassium	Reference run	31.44	29.54	29.12	28.52	28.01
	Best practice	31.44	19.92	16.27	12.26	8.81
Phosphate	Reference run	15.89	14.44	14.02	13.42	12.8
	Best practice	15.89	9.4	7.05	4.04	1.03
Ammonium	Reference run	19.45	19.68	19.87	20.04	20.21
	Best practice	19.45	14.28	12.3	9.8	7.32
Methane	Reference run	48.82	47.52	47.78	48	48.31
	Best practice	48.82	47.52	47.78	48	48.31
Nitrous oxide	Reference run	2.98	3.07	3.11	3.16	3.21
	Best practice	2.98	2.88	2.83	2.77	2.72

An important caveat on our best practice scenario should be kept in mind: The improvements in management practice are simply assumed to happen, without considering their cost. It will either reduce agricultural income if these improvements are enforced by tighter environmental regulation or there will be additional support from public budgets. However it has been show that these changes would also have sizeable returns in terms of improved environmental quality.

6 Appendix: Technical details on the CAPSIM simulations

6.1 Objective function of CAPSIM

It has been explained in the main report that the external projections have been organised as a set of “supports” with associated a-priori probabilities. The work plan and a prototype version which has been developed in the first phase of this outlook relied on the standard cross entropy objective as explained in Golan, Judge, Miller 1996,

Equation 30 $$Obj = \sum_{s} pr^{j}_{r,i,s,t} \cdot log(pr^{j}_{r,i,s,t} / qr^{j}_{r,i,s,t}) \ ,$$

where r indicate regions, i products, j items, s supports and t time. However, this approach requires for each variable to be estimated, say the area of soft wheat in a region, two auxiliary equations, namely the variable expectation based on the supports (Equation 29) and the adding up constraint for the probabilities included therein. Furthermore each external support introduces an associated probability as an auxiliary variable, 3 per variable of interest if we have only one inner support and the two outer supports (max, min value). This demand for auxiliary equations and auxiliary variables became a serious obstacle to technical feasibility such that a new objective function was devised which could handle the a-priori information in a computationally more efficient form.

The new objective function is a posterior density deriving from the Bayesian approach to handle a-priori information. The supports and associated a-priori probabilities are used to compute the mean and standard deviation oft the a-priori information. This mean and standard deviation may be used in a normal density function:

Equation 31 $$pd = \prod_{r,i,j,t} \frac{1}{\sqrt{2\pi\sigma^{j}_{r,i,t}}^{2}} e^{\left(\frac{X^{j}_{r,i,t} - \overline{X}^{j}_{r,i,t}}{\sigma^{j}_{r,i,t}} \right)^{2}}$$

where we have assumed a diagonal covariance with standard deviations,

Equation 32 $$\sigma^{j}_{r,i,t} = \sqrt{\sum_{s} qr^{j}_{r,i,s,t} \left(Sup^{j}_{r,i,s,t} - \overline{X}^{j}_{r,i,t} \right)^{2}} \ ,$$

and a-priori expected values of the variables,

Equation 33 $$\overline{X}^{j}_{r,i,t} = \sum_{s} qr^{j}_{r,i,s,t} Sup^{j}_{r,i,s,t} \ ,$$

summarising the information included in the originally discrete distribution of the supports. Taking the log of the posterior density (as is also common in ML estimation) finally leads to the convenient[21] objective:

Equation 34 $$obj = \sum_{r,i,j,t} \left(\frac{X_{r,i,t}^{j} - \overline{X}_{r,i,t}^{j}}{\sigma_{r,i,t}^{j}} \right)^2$$

The implicit normal distribution does not capture skewness in the original distribution of the supports but the main reason for skewness, namely a lower bound of zero for many variables, may also be handled with a hard lower bound for the corresponding variables. In a test simulation with the prototype version of CAPSIM it turned out that the cross entropy and posterior density objectives do not differ a lot in the final results. This was to be expected based on the comparison of least squares and maximum entropy in Preckel, AJAE 2001, pp. 366-377.

The previous equation presume that thee is a positive variance which is ensured if we add two "outer" supports characterising a very high and very low value of the variable which receive only a small probability weight. These probabilities have been calculated to standardise the implied punishment for a deviation from the mean support amounting to 50% of the conceivable range.

Finally it turned out also useful to introduce additional weights in the objective for the importance of the variable in question, because some variables are more important, say soft wheat area in France, than others, say the sheep and goat herd in Finland. "Importance" may be measured both with the (quantity) share in EU totals as well as with shares in the (monetary) national totals which have been combined with equal weights. Furthermore, due to their crucial importance for the plausibility of results, the weight for EU net trade has been set to 10 times the minimum weight and the weight for EU prices has been set to 20 times the minimum weight.

Equation 35 $$obj = \sum_{r,i,j,t} obwgt_{r,i,t}^{j} \cdot \left(\frac{X_{r,i,t}^{j} - \overline{X}_{r,i,t}^{j}}{\sigma_{r,i,t}^{j}} \right)^2$$

An additional flexibility in the objective function is incorporated in the a-priori probabilities for the different sources. Currently all inner supports have equal probability for all variables, except for the trend support, which receives only half of the standard probability. However in particular cases, for example regarding projections on the rye market, the probability weight for DG Agri has been increased, assuming that international sources or (CAP ignorant) trends are less informed than DG Agri is on this isssue.

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[21] It has to be stressed that all considerations relevant for solution behaviour are critical in this study. Whereas the standard version of CAPSIM (solving for a given year with predetermined parameters) had about 8500 equations and a bit more variables, the current EEA version has about 29000 equations and 32000 variables. This turned out to increase the solution time considerably (about 6 hours are currently required). As a consequence the specification of starting values matters a lot and considerable effort had to be devoted to optimise their choice. The current procedure is to prepare the solution of the desired full EU model with a loop of single Member State models, fixing EU prices at their a-priori expectation.

6.2 From expert projections to CAPSIM supports

The available expert data have been characterised in Chapter 2 of the main report. In this section we will explain the how this information has been converted to a set of change indices as reproduced in Chapter 2. Expert sources potentially offer information on the following items:

1. Activity levels (mainly for crops),
2. Yields (mainly for crops),
3. Production,
4. Demand components (total, human consumption, feed, processing),
5. Trade (net trade, imports, exports),
6. Prices (EU prices, world market prices).

In general, the change indices relative to the CAPSIM base year 1999/2001 have been calculated as follows

Equation 36 $$Ind^{j}_{r,i,s,t} = \left(X^{j}_{r,i,s,t} \,/\, X^{j}_{r,i,s,t_s} \right) \cdot \left(X^{j}_{r,i,CAPSIM,base} \,/\, X^{j}_{r,i,CAPSIM,t_s} \right)$$

where $Ind^{j}_{r,i,s,t}$ is the change index for region r, item j, product i, year t according to source s, $X^{j}_{r,i,s,t}$ is the level of the corresponding variable in year t, X^{j}_{r,i,s,t_s} is the level of the corresponding variable in the base year t_s of source s, $X^{j}_{r,i,CAPSIM,base}$ is the level of the corresponding variable in the CAPSIM base year (99/01) according to the CAPSIM database, and $X^{j}_{r,i,CAPSIM,t_s}$ is the level of the corresponding variable in the base year of source s according to the CAPSIM database. The second factor could be omitted for FAPRI and FAO data because we could choose the base year in the source data identical to those in our database ($t_s = base$).

In many cases the CAPSIM database is more differentiated in terms of products than in the expert sources. The latter may include, for example, a projection for “coarse grains” but not for individual cereals. In this and other cases we have applied the same change factor to each member of the group. In a similar fashion we have applied the change factors for EU15 or EU 08 to each Member State of the respective group, where necessary. This procedure introduces additional assumptions beyond those from the expert sources such that our supports are only *derived from* them.

It might be considered preferable to avoid additional assumptions and to introduce supports only for those aggregates which are directly available from the expert sources. This would certainly increase transparency in the processing of supports, but it has two disadvantages. The first and more important one is that very disparate developments are almost sure to be projected for EU Member States with EU supports only. In this case the solver will find it optimal to attain an EU target growth rate through high growth in a few Member States with little or even negative growth in others. While this may happen occasionally in the real world we would be surprised to observe such diversity frequently in the results without good explanations. Note that diversity is not precluded in our current approach as the common growth assumption defines only the target values while actual simulation results may be quite heterogeneous nonetheless. The second reason is that additional equations would be necessary to aggregate the variables to that level which corresponds closely to the corresponding source. In the case of coarse grains, for example, we would require 3 coarse grains aggregates because DG Agri, IFPRI and FAO use different groupings. Also for the EU level we would require additional aggregates which have not been introduced so far. Additional equations have been avoided so far, because they would increase the complexity of the model and possibly also the solution time.

There are a few details to be added which are specific to each of the 6 groups of items above.

1. Expert information on activity levels is available in most sources only for important crops (or crop groups). To preserve some uniformity in the treatment of expert sources (which facilitates comparisons in the results) the sketchy information on activity levels of animals has been disregarded completely.
2. Yield projections are also available for crops from different expert sources. They have been used as additional supports for future years whereas the observed ex post years (for 1994) have been imposed strictly
3. Production forecasts are given for most products but they have only been used for animal products. The reason is that the crop sector is sufficiently described with activity levels and yields such that supports on production would mainly increase the number of terms in the objective function.
4. Expert information on demand has been introduced for the mayor components: feed use, human consumption and processing. Where only a larger aggregate has been available (typical case: human consumption + feed use for oilseeds) we applied the change factor for the aggregate to each of the components. Minor components of demand are either linked to production in CAPSIM (seed use, waste) or they are forecasted according to trends (industrial use)
5. Net trade is more variable over time and across sources (see Chapter 2) because it summarises the possibly reinforcing changes on the supply and demand side. A change index according to Equation 36 would significantly depend on the initial net trade situation which differs in each of the sources. Therefore we derived the change index for source s from the changes on the supply and demand side with weights according to the CAPSIM database. This is the change index which would have resulted without data discrepancies:

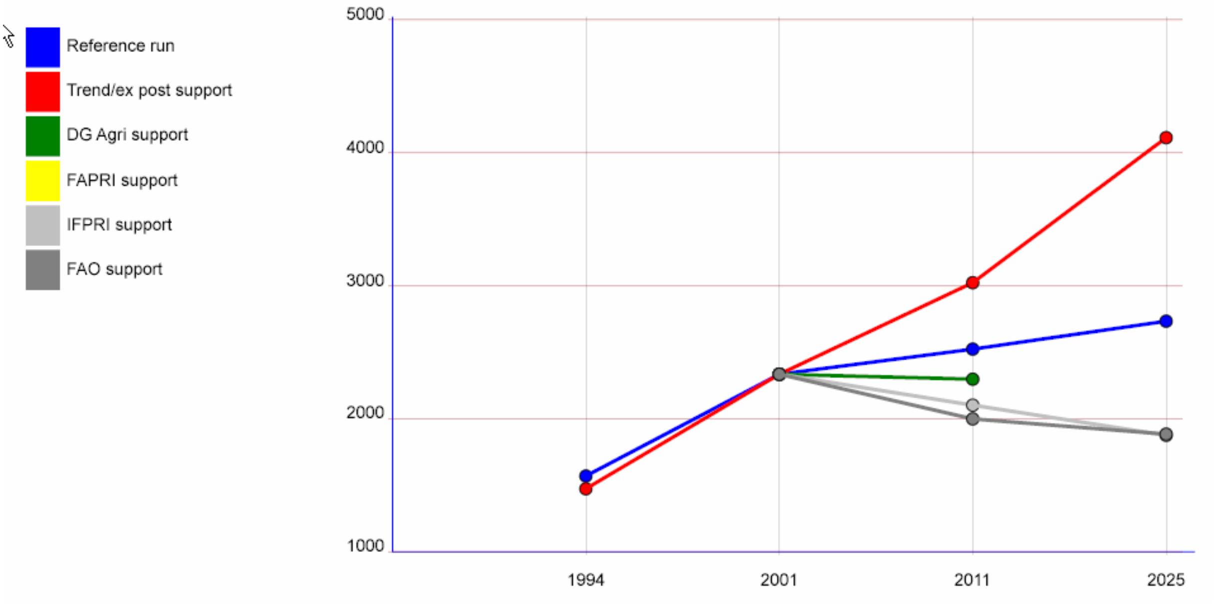
Equation 37 $$Ind_{r,i,s,t}^{NTRD} = \left(\frac{X_{r,i,s,t}^{PRD}}{X_{r,i,s,t_s}^{PRD}} \cdot \frac{X_{r,i,CAPSIM,t_s}^{PRD}}{X_{r,i,CAPSIM,t_s}^{NTRD}} - \frac{X_{r,i,s,t}^{DEM}}{X_{r,i,s,t_s}^{DEM}} \cdot \frac{X_{r,i,CAPSIM,t_s}^{DEM}}{X_{r,i,CAPSIM,t_s}^{NTRD}} \right) \cdot \frac{X_{r,i,CAPSIM,base}^{NTRD}}{X_{r,i,CAPSIM,t_s}^{NTRD}}$$

6. Price information, in particular on world market prices in US $, currently relies exclusively on FAPRI and IFPRI projections. The exchange rate assumption has been specified as in the DG Agri projections (1.1 $/€) from 2011 onwards (modified in the sensitivity analysis discussed above). The supports for EU prices have been derived from the international prices, taking into account a possibly reduced border protection as in the case of rice.

6.3 Illustrating the methodology with selected results

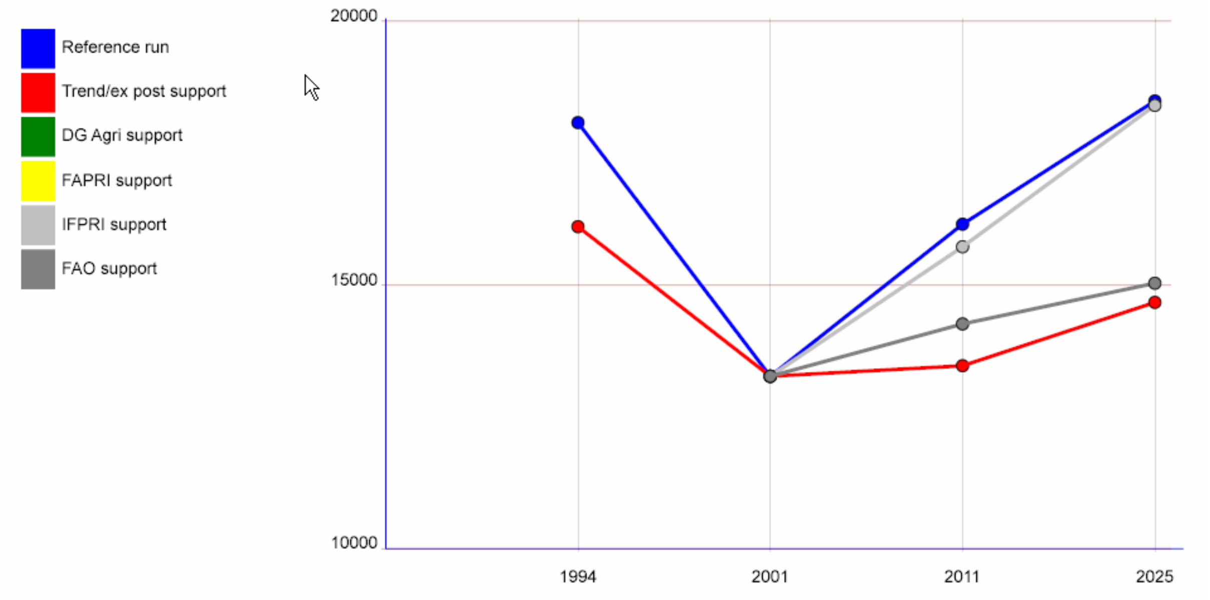
The fact that the constants are forced on a “monotonic” and “tempered” trend line prevents CAPSIM from attaining arbitrary set of supports even though they might be technically consistent. An example is provided by the other cereals area in the EU which was increasing in the ex post period but should decrease according to most expert sources.

Figure 6.3-1: Simulation results and supports for other cereals in the EU [1000 ha]



The mean of the supports is likely to imply a nonmonotonic development of the constant term here which is precluded by assumption thus that the restriction may have deteriorated the “fit”. Overall it is expected that the restrictions add more in terms of plausibility and transparency than they cost in terms of fit. A detailed analysis has to occur on the level of individual Member States. Furthermore CAPSIM may track non monotonic developments if they are explained by price movements which is illustrated in the next example of fed use of potatoes .

Figure 6.3-2: Simulation results and supports for feed use of potatoes in EU 23 [1000 t]



The next examples show an awful "fit" on the expert predictions for net trade of soft wheat. In this case the forecasts are much closer to the trend supports that corresponding to their 50% weight in the objective function, presumably because the nutrient balances were imposed in a similar fashion both in the trends and in CAPSIM which might cause the similarity to become closer than expected. The following example of barley shows however, that this does not holt in all cases and that CAPSIM is usually following following the expert forecasts quite closely even on "difficult variables such as net trade.

Figure 6.3-3: Simulation results and supports for net trade of soft wheat in EU 23 [1000 t]

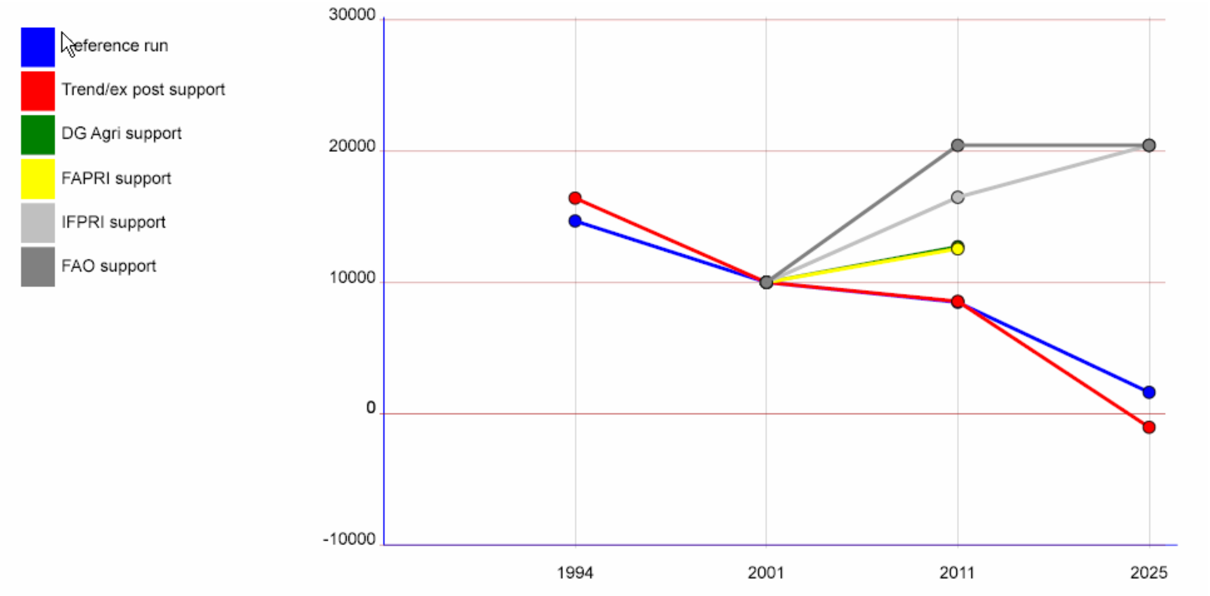


Figure 6.3-4: Simulation results and supports for net trade of barley in EU 23 [1000 t]