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"Common Agricultural Policy Regional Impact Analysis"

Final Report

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Final consolidated report

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Executive Summary

Introduction

The main objective of the project was the development of an EU-wide economic modelling system able to analyse the regional impacts of the Common Agricultural Policy (CAP). This report presents the concept, implementation, and explorative results of the **C**ommon **A**gricultural **P**olicy **R**egional **I**mpact (CAPRI) modelling system.

In order to achieve its ambitious objective, the project relied to a great extent on the functionality of an European research network. Each of the five main partners was responsible for a specific cluster of Member States. They were successful in establishing research relationships with national sub-partners to collect the necessary data and to have access to expert information for the interpretation of model results. Besides the general time-consuming effort to build up the CAPRI data base, to perform ex-post analyses, and to interpret simulation results, each partner focused on specific tasks and complementary activities: regional labour projections (Ireland), alternative technologies (France), perennial crops (Spain), modelling of livestock and related environmental indicators (Italy), core model design and technical implementation (Germany). In addition to the EU-network, research teams from Norway and Switzerland joined the project and contributed considerably to the research process.

Results

The project successfully designed and completed the integrated development of a regionalised data base and a corresponding economic core model. With respect to regional agricultural production the design followed three principles to insure the feasibility of this complex project: (1) An *activity based approach* enabling a detailed description of agricultural production activities through output generation, input use, and levels; (2) *Compliance with accounting principles* guaranteeing consistency with respect to physical and monetary flows and a representation of the income generating process; (3) A *combined top-down/bottom-up approach* to manage consistency to the Economic Accounts for Agriculture (EAA) and to simultaneously make use of regional statistical, engineering, and expert information.

Based on these principles, the CAPRI data base has been compiled. It comprehensively covers agricultural production for about 200 NUTS 2 regions of the EU Member States (plus comparable regions in Norway and Switzerland) for the years 1990 to 1995. It differentiates between 60 outputs and 35 inputs according to the lists of products and inputs defined by the EAA. As production activities are linked to the main outputs, 50 crop and animal production activities are distinguished. The physical and value dimension of regional agricultural production is consistent to national market balances and EAA based on newly developed algorithms which make the best use of the available information. Commodity markets are represented at national level covering unit value prices and quantities of the market and farm balances. With respect to policy variables, CAP-measures (premiums, set-aside percentages, base areas, etc.) are included at regional level and trade instruments at EU-level. Finally, nutrient balances and emissions of climatically relevant gases linked to the regional production structure provide relevant environmental indicators.

The CAPRI data base provided the main source of information for an ex-post analysis of the CAP 92 reform impacts. This analysis - focussing on the cereals and oilseed sector as well as on the cattle sector - showed that the specific regional conditions of agricultural production as well as the regionally differentiated implementation of agricultural policies are significant determinants for actual policy impacts. Information on regionally differentiated impacts represent not only a value by themselves, but also provide fundamental insights for interpretation and projection of aggregate impacts at national level.

The principles mentioned above not only structured the compilation of the data base, they also set the frame for the economic core model which aims at a medium term projection of EU's agricultural sector under different policy scenarios. The developed CAPRI model has the unprecedented advantage to combine the representation of regional policies and production with political and economic conditions on agricultural commodity markets. The activity based approach allows the direct implementation of relevant CAP-policy measures and the technological definition of appropriate environmental indicators related to the agricultural production activities. The consistency with the EAA and market balances provide the link to the product markets at national and EU-level. The top down/bottom up approach goes beyond its purpose to define a consistent and plausible data base by providing the information and infrastructure for checking and interpreting regional model results.

In order to provide a computationally feasible system, the implemented core model is conceptually split-up into a supply and a market component. The supply module consists of individual non-linear, regional programming models based on a newly developed specification of Positive Mathematical Programming. The market module follows the tradition of multi-commodity models. Based on aggregated supply quantities from the regional models, the market model returns market clearing prices. An iterative process between the supply and market component ultimately achieves a comparative static equilibrium.

The model has been applied in a simulation exercise to compare the previous CAP with Agenda 2000 in the year 2005. This application proofs that the core model represents an operational tool to simultaneously model regional, national and EU-policy measures and analyse their impacts on the agricultural sectors of these aggregates. Again, the description of the results focuses on the cereal/oilseeds and the cattle sector. Exemplary results at aggregate and regional level as well as their interpretations in light of specific model characteristics and assumption are presented.

Apart from the integrated development of the data base and economic core model, the report provides complementary research results in their partner's areas of responsibility. These include the analysis of farm structure and regional labour input projections, case studies on alternative technologies and the use of crop growths models in the CAPRI context, the projection of perennial crop activity levels for the target year of the CAPRI simulations, the modelling of livestock and related environmental indicators, and the design and implementation of programming tools to steer the model and exploit data base and results.

Discussion/Conclusion

The results of the project underline the feasibility of the CAPRI approach. Nevertheless, the time constrained process of data collection and model building for an EU-wide regionalised information system left some areas for further research to improve the value of the information system for political decision makers. The following issues regarding merits, remaining problems, and useful future directions for the CAPRI information system are identified:

- The joint research activities of all partners, each responsible for a cluster of Member States, was not only a prerequisite for the successful compilation of the data base, it also contributes the necessary national expert knowledge available for ex-post and ex-ante analysis. The successful continuation of the CAPRI information system directly depends on the survival of the research network.

- The task of *data collection* was successfully completed in the sense that it provided a differentiated, regionalised, and EU-wide data base for an ex-post analysis of agricultural production and the necessary input for a corresponding agricultural sector model. However, gaps and errors in main data sources caused a time consuming collection of additional data based on national statistics and a considerable effort to ensure comparability and technical integration. For future data base updates, an incorporation of data from the Farm Accountancy Data Network (FADN) could be efficiently realised based on the developed programming tools to define regional production activities. This would potentially allow to regionally differentiate farm level prices and contribute to a more realistic picture of the regional profitability of various production activities.

- The *core modelling activities* performed during the project achieved their objectives. The concept of the agricultural sector model allows to simultaneously and consistently combine regional economic and political conditions with developments on EU- and world markets for agricultural commodities. The results of an explorative application to evaluate the impacts of Agenda 2000 shows that the system is operational and able to simulate the relevant policy measures of the CAP at the various regional levels. A new approach for the specification of Positive Mathematical Programming in the regional supply modules created significant interest in the scientific community and represents a promising path for further research to improve the methodology. The market model is able to represent the most important policy instruments such as sales quotas, tariffs, administrative prices combined with flexible levies as well as WTO restrictions on subsidised imports. Some markets, however, react quite sensible to assumed shifts in demand and supply in the "rest-of-the-world". A future co-operation with market experts, especially on international developments and more appropriate specifications of the price transmission between world and EU-markets for some commodities could improve the quality of the market simulation results.

- *Complementary modelling activities* and *case studies* provided projections of perennial crop activity levels in simulation runs, developed concepts for the formulation and application of alternative production technologies, and contributed income relevant forecasts of regional agricultural labour input. The specific relevance of perennial crops for income generation in Mediterranean regions would make the dynamic modelling of production decisions highly desirable, but this would require a considerable extension of the information base. The regional case studies on alternative technologies showed their usefulness for representing specific policy measures and related input substitution. An EU-wide, data and policy consistent definition of alternative technologies represents a challenging but possibly valuable future development.

- According to the project's objectives a set of appropriate *environmental indicators* related to the regional supply models was defined, validated and applied. The EU-wide implementations comprise nutrient balances and gas emissions relevant for global climatic change. An important advancement in the definition of nutrient balances is their calculation based on the regional animal production technology, i.e. they take into account regional feeding practices and fattening periods. Additional environmental indicators and methodological possibilities for refinement were successfully explored for sub-sets of regions. A relevant candidate for an EU-wide application would be an energy module, tested for Switzerland, which calculates the use of non-renewable energy use by agricultural production.

- Considerable time was invested to embed the data base and the modelling system in a *software* environment which allows an easy access to the system. Apart from the modelling code, user friendly tools for data collection, model steering, and exploitation of data base and results were developed. A completed documentation and further training sessions will render future data base updates more efficient and will allow all partners to fully exploit the potential of the information system.

Concluding generally, the CAPRI project has been successful in developing a regionalised agricultural information system for the EU. It is now in the position to establish an enduring usefulness for EU- and national policy makers to address the manifold expressed interest during the development phase. In order to insure a survival of the system, a regular update of the data base, partial methodological improvements as well as the validation of the model in the context of relevant political scenarios are necessary. It is quite clear that this can only be achieved (1) in the network approach which ensures the in-depth knowledge of regional aspects of agricultural production and the access to national data sources and (2) in a close dialogue with policy makers to efficiently use the system for policy design and evaluation.

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1 Introduction

The main objective of the project was the development of an EU-wide economic modelling system able to analyse the regional impacts of the Common Agricultural Policy (CAP). This report presents the concept, implementation, and explorative results of the **C**ommon **A**gricultural **P**olicy **R**egional **I**mpact (CAPRI) modelling system.

The research was centred around the integrated development of a regionalised data base and a corresponding economic core model. With respect to regional agricultural production the design followed three principles to insure the feasibility of this complex project: (1) An *activity based approach* enabling a detailed description of agricultural production activities through output generation, input use, and levels; (2) *Compliance with accounting principles* guaranteeing consistency with respect to physical and monetary flows and a representation of the income generating process; (3) A *combined top-down/bottom-up approach* to manage consistency to the Economic Accounts for Agriculture (EAA) and to simultaneously make use of regional statistical, engineering, and expert information.

These principles not only structure the compilation of the data base, they also set the frame for the economic core model which aims at a medium term projection of EU agricultural sector under different policy scenarios. The specific advantage - and unprecedented challenge - of this model is to combine the representation of regional policies and production with political and economic conditions on agricultural commodity markets. The activity based approach allows the direct implementation of relevant CAP-policy measures and the technological definition of appropriate environmental indicators related to the agricultural production activities. The consistency with the EAA and market balances provide the link to the product markets at national and EU-level. The top down/bottom up approach goes beyond it's purpose to define a consistent and plausible data base by providing the information and infrastructure for checking and interpreting regional model results.

This project design relies to a great extent on the functionality of an European research network. Each of the five main partners was responsible for a specific cluster of Member States. They were successful in establishing research relationships with national sub-partners to collect the necessary data and to have access to expert information for the interpretation of model results. Besides the general time-consuming effort to build up the CAPRI data base, to perform ex-post analyses, and to interpret simulation results, each partner focused on specific tasks and complementary activities: regional labour projections (Ireland), alternative technologies (France), perennial crops (Spain), modelling of livestock and related environmental indicators (Italy), core model design and technical implementation (Germany). In addition to the EU-network, research teams from Norway and Switzerland joined the project and contributed considerably to the research process.

This report presents a self contained description of research performed and results achieved during the project’s lifetime and comprises all of the partners activities. However, for a full and detailed documentation of all results the series of CAPRI-working papers published in the last three years as well as the electronic format of data base, model, and simulation results need to be consulted.[1]

The structure of the report is as follows: Chapter 2 introduces the methodology underlying the CAPRI modelling system. It presents the specific concept and implementation of the basic data system, the economic core model, environmental indicators, the exploitation module, and of the complementary modelling activities and case studies. Chapter 3 describes selected results with respect to an ex-post analysis of the 1992 CAP reform, the explorative application of the CAPRI model to evaluate Agenda 2000 impacts for the year 2005, and regional case studies. Finally, the project's achievements and remaining problems are discussed and conclusions drawn for future activities in chapter 4.

2 CAPRI - Modelling System (Material and Methods)

2.1 Basic Data System

2.1.1 Overall Concept

Analysing ex-post developments and building up a model for simulation purposes requires a solid and comprehensive data base. Accordingly, a major part of the CAPRI project was devoted to sample data and process them into the regionalised CAPRI data base whose main features are:

- *Regionalisation* of the European Union to 200 regional units (mostly according to NUTS II definition)
- *Production activity based break-down of agricultural production and input use*
- *Consistency* between sectoral and regional aggregates. Data match official EUROSTAT statistics including Economic Accounts of Agriculture (EAA)
- *Comprehensiveness:* complete coverage of product generation and input use according to the EAA, inclusion of activity levels, yields, input coefficients, prices, farm & market balances, economic performance, political instruments and environmental indicators

Table 1 gives an overview on the content of the CAPRI data base at different regional levels. Generally, all information available at lower regional levels is available at higher levels as well, by consistent aggregation. The following chapter describes in detail the methodology applied and data sources used to compile the data base. Currently, the data base covers the years 1990-1995 for all regions as well as a 3-year weighted average for 1994 which is used as the "base year" for simulation runs of the modeling system. However, for many regions and Member States, data on earlier years are available as well.

[1] All papers are available in the internet (http://www.agp.uni-bonn.de/agpo/rsrch/capri/capri_e.htm).

The break-down regarding production activities and inputs/outputs can be found in tables 2 and 3 at the end of the chapter.

Table 1: Overview on data base content

Regional level	**Coverage**	**Items**
EU **Norway** **Switzerland**	*Trade Policy instruments*	Ad-valorem and specific tariffs Administrative prices Export quotas
15 Member States **Norway** **Switzerland**	*Economic Accounts of Agriculture*	Valued output and input in current and constant prices
	Prices	Unit values consistent to EAA Consumer prices
	Farm balances	Sales, feed and seed use, losses, stock changes on farm, young animal flows
	Market balances	Import and export, feed and seed use, human consumption, processing, stock changes
50 Nuts I **200 Nuts II regions**	*Production related positions*	Cropped areas and herd sizes, yields, input coefficients, income indicators
	Policy instruments	Sales quotas, premiums, base areas, set-aside rate
	Environmental indicators	Nutrient balances, global warming potential

2.1.2 Methodology and data sources

Activity Based Accounting System (ABAS)

The key concept of the CAPRI data base is termed Activity Based Accounting System (ABAS). According to the concept, the agricultural production process for a each period, in case of CAPRI one calendar year, is broken down to individual production and use activities, both in physical and valued terms (see figure 1).

A *production activity*, for example cropping one ha of soft wheat, is characterised physically by input and output coefficients, and economically by income indicators as revenues, premiums, inputs costs and gross value added. CAPRI differentiates between 60 outputs and 35 inputs which cover agriculture according to the lists of products and inputs defined by the EAA. As production activities are linked to the main outputs, CAPRI differentiates about 50 crop and animal production activities, too (see table 2). Crop production activities are defined as main crop areas and hence completely cover the Utilisable Agricultural Area (UAA) of each region.

The output and input coefficients are defined consistently to sectoral output generation and input use. For given activity levels, all output coefficients which are generated by just one production activity, as cereals, oilseeds, milk, etc. can be easily derived by division of total production by the activity level. In cases like straw, produced by several activities, output coefficients are based on engineering knowledge and corrected in order to achieve consistency to sectoral production.

Use activities which define so called "farm balances" for each output and input describe the fate of the outputs and input "generation". Output produced may be sold, added to stocks, fed, used as seed etc. Inputs may be bought, taken out of stocks or stem from intra-sectoral transactions, for example young animals may be produced by another production activity.

In order to link the physical sphere with the EAA, *unit value prices* are introduced. They are residually defined by definitorial equations underlying the methodology of the EAA. Unit value prices are not observed prices at a certain time and place, but a consistent average over all quantities and qualities flowing into the calculation of the production value of the EAA. Problem arise, however, from the fact that the physical data entering the calculation are partly based on crop year definitions whereas the EAA values relate to calendar years.

Figure 1: A table in an Activity Based Accounting System

Physical Component			Price Component	Valued Component (Economic Accounts of Agricultural - EAA in gross and net concept)				
O-coefficients (x activity levels = output generation)	Farm balances for outputs (output use)	X	Output Prices	=	Gross Output	- Intermediate Output use	=	Net Output (EAA)
I-coefficients (x activity levels = input generation)	Farm balances for inputs (input use)	X	Input Prices	=	Gross Input	- Intermediate Input use	=	Net Input (EAA)
Income indicators per activity					Sectoral income indicators			Income (EAA)

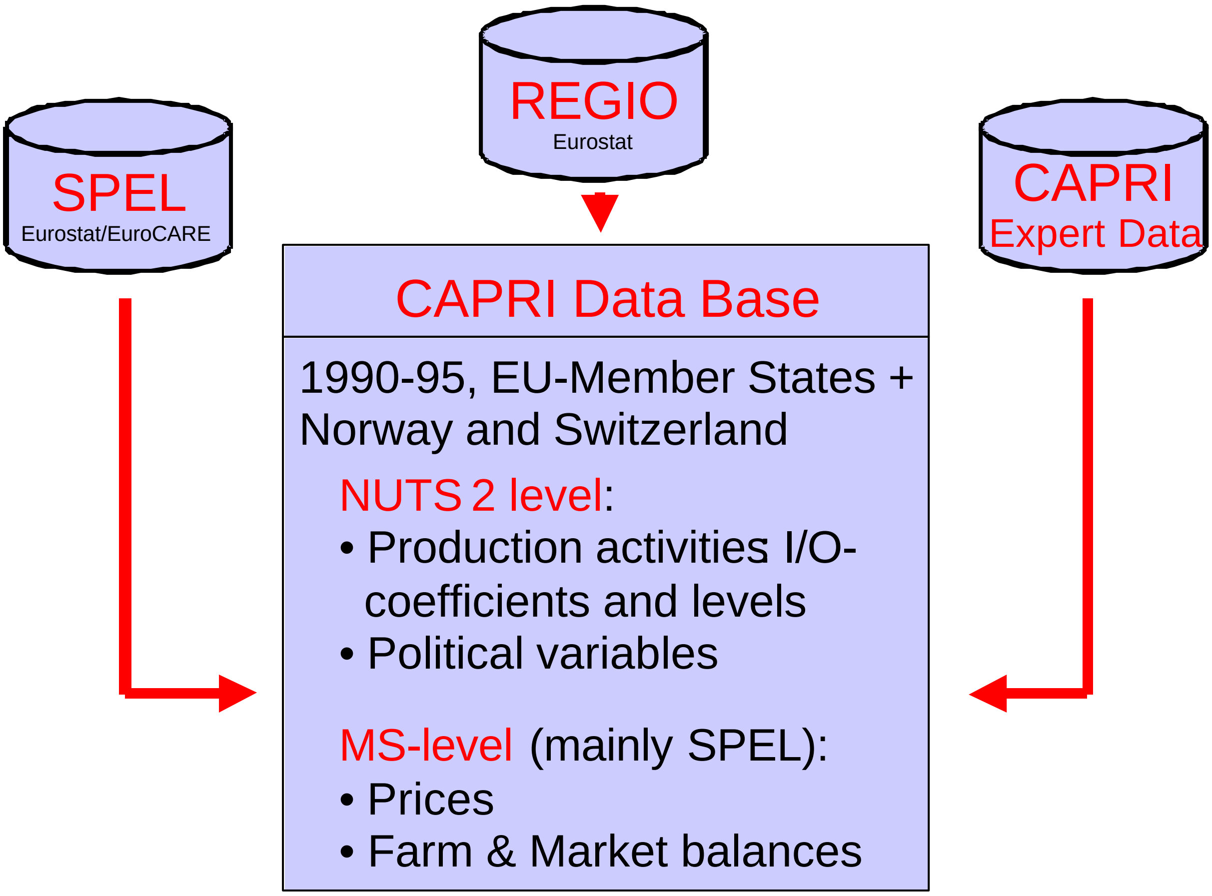
Data sources

On national scale, the project could to a greater extent rely on the SPEL-EU data base (WOLF 1995) from EUROSTAT covering longer time series on national data for all EU Member States according to the principles mentioned above (activity break-down of production and input use, consistency to EAA). The SPEL-EU data base itself is based on other EUROSTAT data bases, technological information and expert knowledge.

The uniform data sources (see figure 2) for all regions stem from EUROSTAT which provides in its REGIO domain (EUROSTAT 1995) information on areas and yields of major crops and quite detailed information on herd sizes. However, especially data on crop production suffer from incompleteness over time and a high aggregation level which is not adequate for the project's task. Completely missing is information on CAP measurements on regional level, e.g. set-aside obligations, premiums, historic yields, quotas as well as input and output coefficients and prices.

Hence, the regional data from EUROSTAT had to be complemented by other sources, a tremendous task as sources at national and even regional level had to be found, accessed, analysed and the data to be compiled to a uniform data base. The two key factor of success for this task were (1) the establishment of a network of researchers based on the cluster concept and (2) the clear methodological concept. Regarding the network approach, each of the main partners of the project was responsible for a cluster of Member States. In each cluster, appropriate sub-partners were contacted to access and check possible data sources and to send back adequate data. Standard data definitions and intensive communication between the co-ordinating team and each partner ensured compatibility of the data sampled. A typical example is the situation in United Kingdom, were regional data are dispersed across the country in various centres.

Figure 2: Data sources in the CAPRI data base system



Consistency between given national and regional data

The set of definitional equations and appropriate algorithms based on the ABAS concept allows to build up a complete and consistent data base at national level. As data sampled at regional level stem from a multitude of sources, consistency between national and regional level is not given automatically, but must be checked and ensured by appropriate algorithms. The process is based on three consecutive steps (BRITZ 1997):

1. Activity levels at regional level are aggregated to national level. Afterwards, a correction factor is derived by comparing the regional aggregate with the given national value. The correction factor is applied afterwards to all regional values.

2. Based on the consistent activity levels, regional production is derived based on potentially inconsistent output coefficients. As for activity levels, a correction factor ensures consistency.

3. Input coefficients are estimated and corrected to ensure consistency to national values. Since the process is methodologically more complex, the next chapter separately deals with it in more detail.

Additionally, Economic Accounts for Agriculture are usually not available at regional level. However, the ABAS concept allows to derive regional income indicators by aggregating over activities.

Input allocation

Whereas most output coefficients can be derived simply by dividing production by area or herd size, most inputs are used in many activities and basic statistics on national or regional average activity specific input coefficients are missing. There are two major sources to overcome the data gaps: (1) The Farm Accounting Data Network (FADN) and (2) engineering information.

Regarding (1), three major problems are related to the use of FADN data. First, the uniform data set available for all European Member States does not feature individual input coefficients, but just total input use at farm level. As most farms in the network have several activities and often a mixed farm program, econometric estimations are required in order to obtain the coefficients. Second, the policy to provide access to the data is still under review, and the project team was not able to get the data early enough to start the considerable work of checking and exploiting the FADN data. As a third point it should be mentioned that so far access to aggregated results was provided so far and not to the underlying single farm results, a major drawback to any econometric work with the data (for details: MOELLMANN 1997).

As a consequence, the input allocation in CAPRI could not be directly based on FADN data. Instead, engineering information was used. In the case of most inputs, data at national level in the SPEL-EU data base are based on Standard Gross Margin calculation, which in turn are linked to FADN. In order to regionalise these data, a linear limitational-relationship between expected yields and inputs are assumed, i.e. if expected yields in a region are 5 % higher than regional average, inputs costs are estimated to lay 5% above the national average as well. Expected yields are modelled by estimating linear trends on yields at national level.

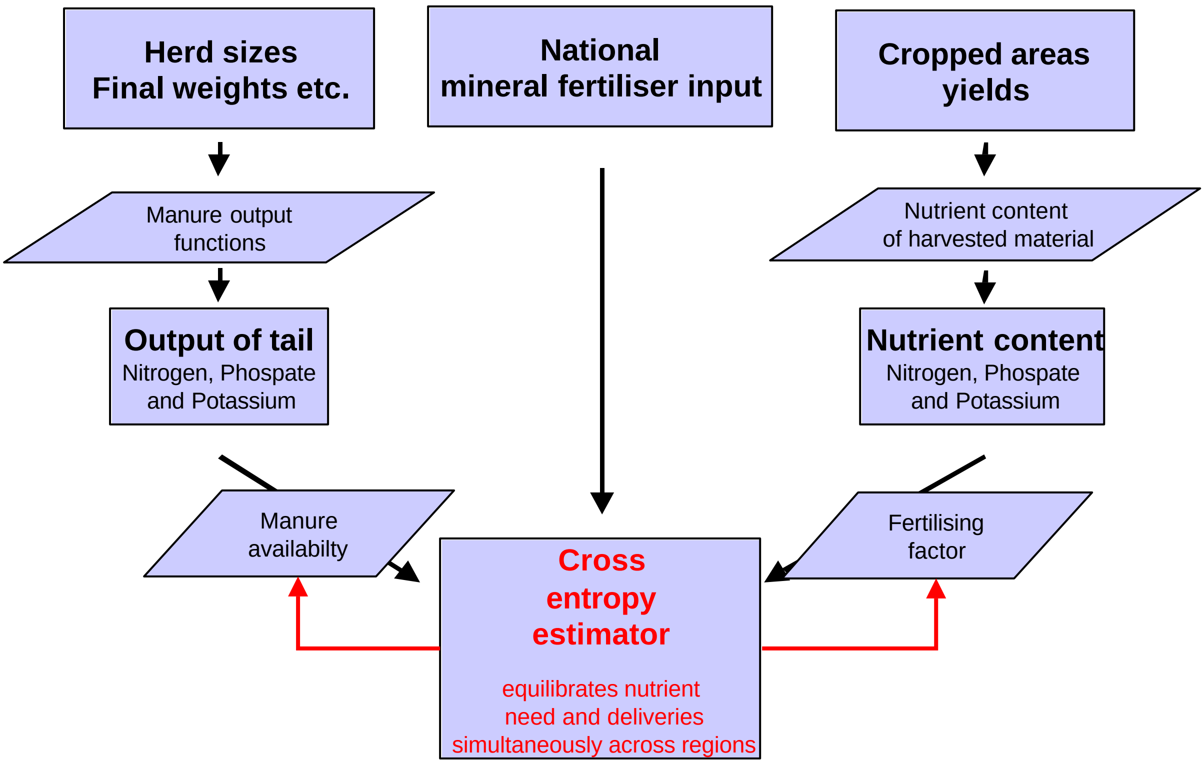
There are however two major exceptions from this general rule:

1. Mineral and organic fertiliser, and

2. Feedingstuff

For *fertilisers*, the problem consists in simultaneously distributing the known quantity of mineral fertilisers at sectoral level to the different crops and regions taking into account differences in yields between crops and regions and the availability of organic fertilisers from animals. Whereas the output of nutrient "at tail" for each animals can be estimated quite accurately, the further fate of the nutrient in the process of organic fertilising is unfortunately highly insecure, especially the often considerable loss of nitrogen during storage and spreading depends to a large extent on factors changing from farm to farm and day to day. Hence, the availability of organic nutrient must be estimated. In order to solve the problem, a non-linear estimation based on a Cross-Entropy criterion is used (see figure 3). The estimated variables are the nutrient need of the crops, the percentage availability of nutrients in manure, together with the quantities of mineral and organic fertiliser applied to each crop in each region. The supports used for the parameters to be estimated stem from engineering functions.

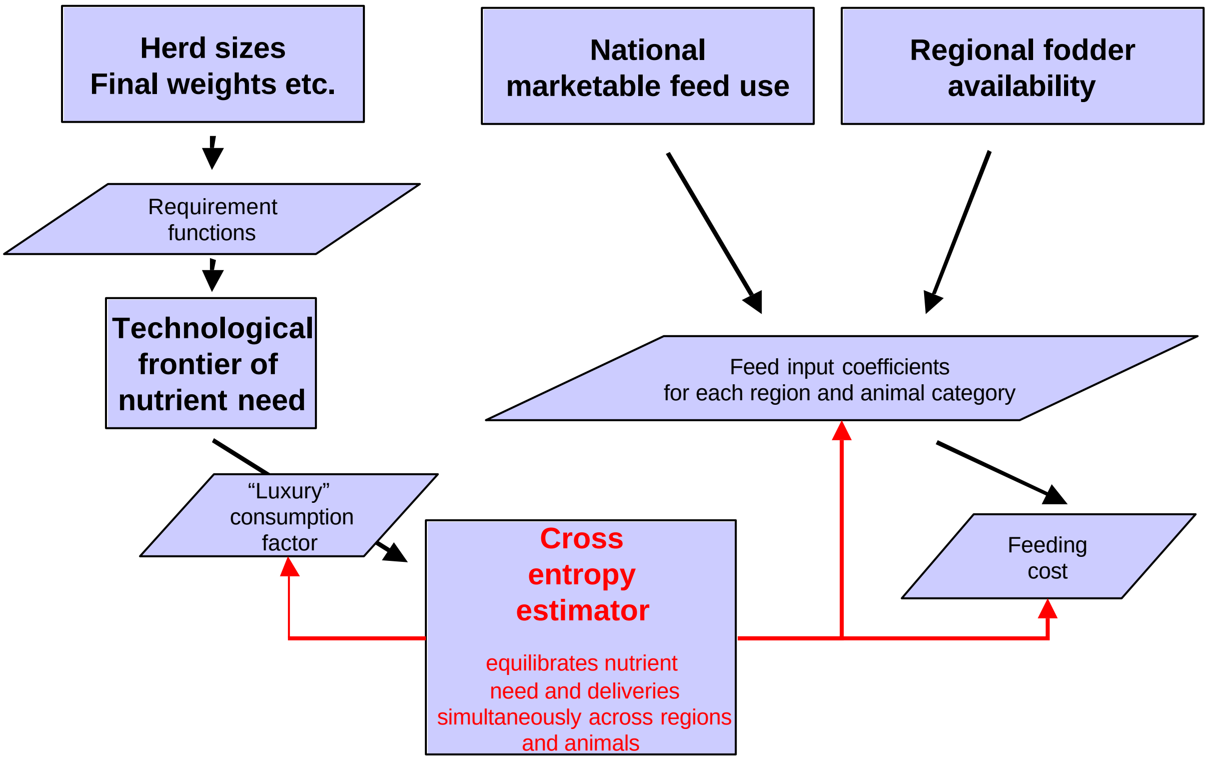
Figure 3: Cross entropy estimation of fertilising need and nutrient availability



In the case of *feedingstuff*, a set of requirement functions (NASUELLI, PALLADINO, SETTI, TAMPELLINI, ZANASI 1998) defines the need of each animal category depending on, for example, live weight, weight increase per day, milk yield. These requirement function are mostly derived under experimental conditions and define a technological frontier from which actual technology on farm level can be expected to deviate, not at least due to for example control and management costs usually not taken into account in experiments.

These requirements must be covered by feeding an appropriate mix of feedingstuff to each animal herd. As sectoral availability of feedingstuff is known ex-post, a complex non-linear optimisation program (see figure 4) distributes the available feedingstuff resources to the animals, simultaneously ensuring that the distribution leads to plausible feeding costs. If necessary, the requirement functions are shifted to account for differences between actual feeding practises of the farms and the technological frontier defined by the requirement functions (for details see: BRITZ & HECKELEI 1999).

Figure 4: Cross entropy estimation of feed distribution



The Italian team explored the methodological possibilities to disaggregate the distribution further on to individual components of marketable feedingstuff treated as aggregates in the CAPRI data base and model, e.g. "cereals". Consequently, more restrictions are needed to define the distribution, which are partly derived from the observed regional rotations:

- Regional feeding restrictions factors: forages / not forages ratios and ranges
- Single feed ingredients bulk capacity
- Forages regional availability (extensive - intensive region; tradability)
- Regional cereal vocation
- Maximum and minimum shares for single feedingstuff constraints (e.g. cakes to laying hens)

The application of the single-feedingstuff module requires far more manual adjustments as the bulk approach applied as the basis for the current simulations runs. Further on, its increased size has so far not allowed to combine it with a Cross-Entropy-Approach. Further evaluations are necessary in order to judge if the more detailed version may replace the current aggregated approach. Information about the use of single marketable feedingstuff could be especially interesting if used to describe regional price differences.

Herd module

In order to describe the relationships in between animal production activities, for example between piglet production and fattening pigs, and to define the effective number of animals bred (flow) at regional level, a so-called herd module has been developed (NASUELLI P., G. PALLADINO., M. SETTI M. & C. ZANASI 1999a). At national level, data on slaughtering, imports and exports of live animals and meat (CRONOS, COMEXT, INTRASTAT) as well as herd size statistics (stocks) (CRONOS, REGIO) allow quite well to describe livestock activity levels (e.g. numbers of milk cows, suckler cows, calves raised, calves fatted, heifers raised, heifers and beef fatted) and their inter-relationships.

In order to depict the regional differentiation, and given the fact that data availability at the regional level is low, further assumptions and relations are defined in the CAPRI herd module whose objectives are

(1) to construct a reliable data base about regional livestock activity levels and their I/O coefficients (e.g. piglets per sow, final weight, replacement rate, …) consistent with national statistics, a pre-condition

(2) to describe correctly nutrient requirements, feed intake and uptake, and emission output (details later on) of the regional herds, and

(3) to forecast the I/O-coefficients in simulation runs of the model where the herd sizes are endogenous results of the optimisation models.

The assumptions in the herd module are based on technological relationships as well as expert knowledge about regional differentiation, e.g. in weight increase per day and final weights. On these basis, the herd module places a special emphasis on the following aspects:

a) Description of the existing relationships between the different phases of the animal production process at regional level

b) Estimation of the live animals and meat interregional trade in the EU: flows among a region and each other EU country - taking into consideration the breeding period effectively occurred in the country (region) of origin and in the region (country) of destination - and (net) flows among one region and all other regions of the country;

c) Estimation of the total and effective number (flow concept) of animals yearly bred in each EU region.

Data on labour input

Data on agricultural work units (AWU's) across the regions has been compiled, based on Eurostat data (STEELE, GARVEY 2000). For most countries AWU's are calculated from a combination of periodic survey data on time worked on the farm, and annual census data on numbers of people working on the farm. Data availability at NUTS1 and NUTS2 level is rather restricted to three Eurostat surveys between 1987 and 1993, however, for many regions just one or two observations are available. Accordingly, the regionalisation is based on calculation of the average share of the region across the survey.

Naturally, in the context of a activity based approach, a disaggregation of total labour input to individual production activities would be desirable. Values have been found for the responsiveness of labour, in AWU's, to changes in various aggregated activities. The nature of this exercise means that these figures can be viewed as no more than indicators of specialisation within the relevant regions. Nevertheless, it is useful to have such indicators, particularly in cases where large percentage changes in activity levels are forecasted for a region.

The methodology was as follows: CAPRI activities were aggregated into 9 different categories - the production of cereals, olives and olive oil, fruit and vegetables (and nursery crops), other field crops (including other perennials), wine and grapes, dairy, other cattle (beef and cattle rearing), sheep and pigs. Relative EU 'coefficients' were found as follows: we used the Eurostat farm structure survey categories for farm types, and matched types as closely as possible to the constructed SPEL aggregations. Based on the researcher's 'rule of thumb' that at EU level on average 75% of all labour in each type of farm was devoted to the activity from which at least 66% of its income derived, we calculated the ratio of AWU's to the level of the farm type's main activity (in hectares or heads).

These EU 'coefficients' were spread across the countries using the cross entropy procedure. There was one restriction imposed on the cross entropy function: that the calculated national/regional coefficients 'fit' the relevant regional data on AWU's. Support points were set such that maximum entropy expected regional coefficient values would be simply a scalar multiple of the European coefficients for all activities. The use of the cross entropy function (as opposed to maximum entropy) in the actual optimisation procedure leads to an increased weighting on the coefficients of less common activities and a decreased weighting on more common activities in a region. In the context of calculating coefficients for alternative activities, this was considered the most reasonable approach.

The results calculated and presented in CAPRI working paper 00-01 are only to be taken as indicators, in the broadest sense. Regions with a particularly high elasticity of labour to activity level for certain activities need, from a policy perspective, to be treated with 'special care' in analysing income per capita changes if the CAPRI model forecasts significant shifts in the level of such activities in those regions. From the results it is possible to identify a few areas with relatively high elasticities. Thus, for example, the importance of beef in Ireland, dairying and pigs in the Netherlands, cereals in Finland, other field crops in Sweden, sheep in Greece. Changes in levels of dairying and beef would appear to have strong employment effects in BL300, DE200, DEA00, IT200, IT300, UK600, UK800, UKB00 (Northern Ireland). Changes in levels of olive oil and olives appear to have strong employment effects in EL200 and ES600. Changes in levels of fruit, vegetables, and nursery plants in ES500, IT400, IT800, ITA00, IT900. Changes in sheep levels appear to affect employment strongly in most parts of Greece, in Wales and Scotland and in ITB00. Many of the NUTS2 areas appear to be quite specialised, as one would expect, and in these areas changes in employment are likely (depending, of course, also on labour supply) , if there are significant changes in activity levels.

2.1.3 Data for complementary studies: estimation of alternative technologies

As explained above, input coefficients at regional level are generally based on a top-down approach where estimated average national input coefficients are modulated according to known regional yields. Additionally, three bottom up approaches for defining and specifying agricultural technologies were applied in a case study of the French region "Midi-Pyrénées", one of the twenty-two NUTS2 administrative regions of France, located in the south-west. and its agricultural area represents 9% of the national one). The case study not only tried to define average input and output coefficients at regional level, but concentrated on looking at the distribution of different technologies based on so-called "alternative technologies" (see chapter 2.5.3 and 3.3.1).

There are several reasons to choose the area "Midi-Pyrénées" for a case study of technologies in Grandes Cultures: many Grandes Cultures are cultivated; weather conditions are more variable than in north of France and farm sizes and structures are heterogeneous. In consequence, cropping practices, input intensities and yields show a high variability inside the region. various. Moreover, Midi-Pyrénées is a dynamic agricultural region, representative of French production and yields in Grandes Cultures.

The approaches used increasingly desegregated information. The first approach was based on a 1994 survey of the French Statistical Office called « Agricultural practices in 1994 » (MINISTÈRE DE L'AGRICULTURE, SCEES 1996) concerning main grandes cultures in France : soft wheat, durum wheat, barley, maize (grain and forage), rape, sunflower, pea (for pulses). Data were collected in 67 departments (nuts3) from 19 regions (nuts 2), representing major production regions. General objectives of this survey were:

- to describe agricultural techniques (at plot level) in order to characterise farmers practices;
- to monitor farmers strategies in a context of limitation of agricultural production;
- to detect farmers attitudes towards environment protection.

The survey choose representative regions for each crop, taking into account:

- the regional crop area compared to the national crop area;
- the regional crop area compared to the regional total area.

The survey is based on the data bank “Use of territory in 1994” (TERUTI) whose observation points correspond to agricultural plots. For each crop surveyed, plot samples have been drawn in a systematic and randomised way from the TERUTI data bank, representative for the regional plot size and yield. Farmers owning these plots were asked to fill a questionnaire about their cropping techniques. The resulting data items of this survey are plots, characterised by their area, levels of inputs, practices, and outputs. The area surveyed can then be distributed by range of input or output quantities.

Climatic condition in 1993-1994 were fortunately quite typical, however strong rain in winter and spring delayed some agricultural tasks. More critical is the fact that the data cover the first year of '92 CAP reform implementation, so that farmers acted in a partially new economic environment. Generally, a reduction in input can be observed in the first years of the reform which was later re-correct in later reform years again.

Data from this survey were used to specify parameters for different techniques for each of the Grandes Cultures for French regions.

In the second approach, information from Farm Accounting Offices at nuts3 level had been aggregated for 1994. In the third approach, alternative techniques were defined by agronomists and simulated using EPIC. The results are alternatively analysed and compared, in order to discuss the different objectives of technique definition in the model (see chapter 2.2.2 and 2.3.5)

For the second approach regional information was used: a survey of agricultural practices was done in 1994 by Regional Chamber of Agriculture in Midi-Pyrénées (CHAMBRE RÉGIONALE D'AGRICULTURE DE MIDI-PYRÉNÉES, CHAMBRE D'AGRICULTURE DE HAUTE-GARONNE ET DU TARN 1996*)*. Data has been collected in farms of two departments (nuts3) of the region.

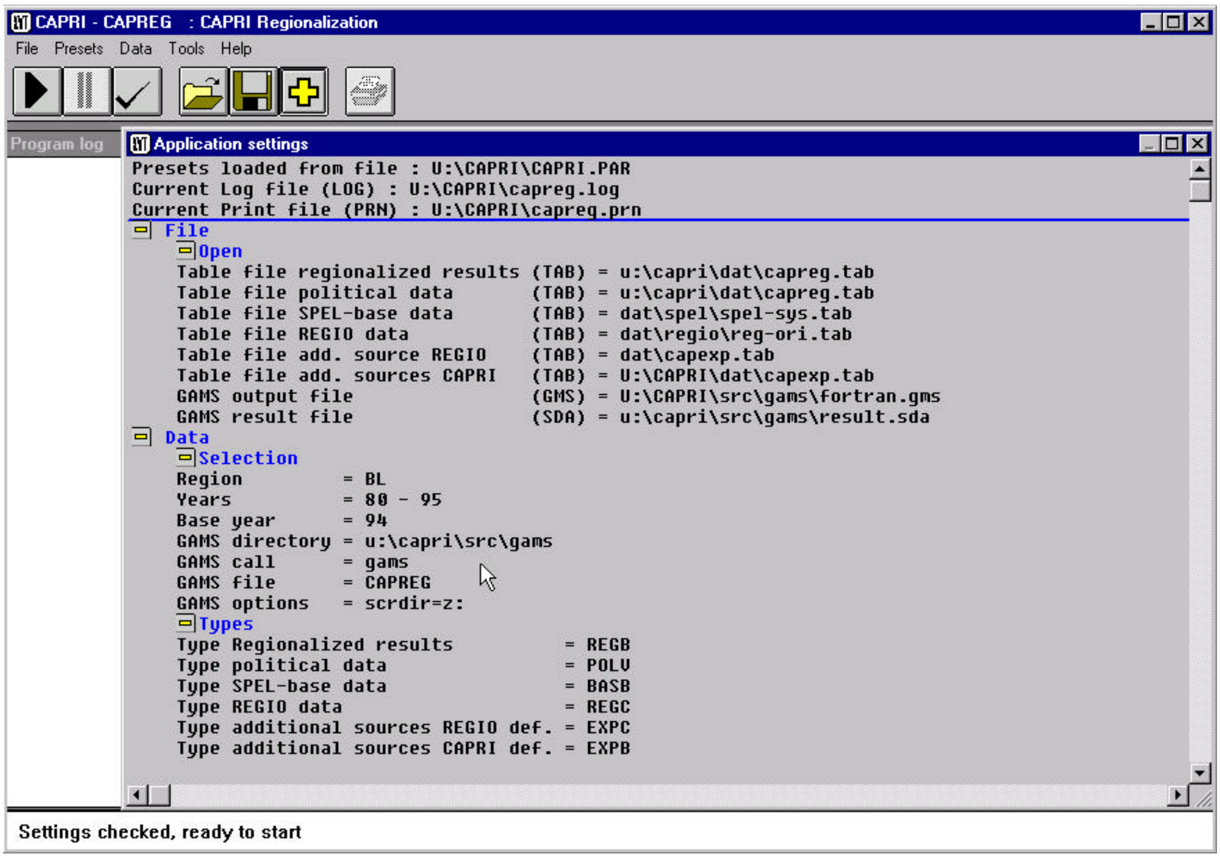
2.1.4 Technical Solution

As the data base covers 200 regions, several years, different data sources and eventually results from different scenarios and around 1.000 non-zero values per year, region and data type, the data needs to be stored in a appropriate data bank. The project uses a concept developed at the Institute of Agricultural Policy, University of Bonn, which is based on binary direct access files, coupled to library routines comprising data base drivers as well as a set of stand-alone utilities. The later comprise a multi-dimensional data viewer with export possibilities.

In order to have a transparent and efficient solution for the process of building up the data base, involving highly complex non-linear optimisation problems as described, the programming system GAMS (General Algebraic Modelling System) was used. GAMS is as a kind of "lingua franca" of economic modellers. It is widely spread, enables researchers to code the models and algorithms similar to scientific notations, can be linked to several solvers, is portable across platforms and still features moderate license fees for scientific institutions. However, GAMS does not support data bank access or Graphical User Interfaces so far, but is purely command line driven and reads and writes to flat files only.

In order to overcome the latter restrictions of GAMS, C/FORTRAN based programs have been developed to access the data bank, write input files for GAMS, start the GAMS programs and read back results into the CAPRI data base. The following figure 5 shows the user interface of CAPREG, the program designed to perform the regionalisation step which ensures consistency between regional and national data as well as calibrates the CAPRI model to base year data. Note that the user may interactively decide for which years and Member states to work.

Figure 5: Screen-Shot of CAPREG user interface



Access of data sources at national and regional level

In most cases, researchers in the different teams edited the data directly from statistical year books into spreadsheet. Appropriate, case-specific macros combined with some manual editing work converted the data in an uniform format and FORTRAN/C based routines loaded the data into the data base. The Bonn team was able to receive regionalised data for Germany in an uniformly defined comma-separated format, and could hence write a small application for format conversion.

Given the high level of heterogeneity characterising the agricultural production activities in the Italian and Greek regions and the analytical detail of the official statistics, the regional data collecting for the CAPRI purposes implied the necessity to input and to organise the time series data in a own DMBS (NASUELLI P., PALLADINO G., SETTI M. & C. ZANASI 1999b). Based on MS Access, appropriate routines (see figure 6) were developed to perform the following tasks: (1) automated update and access to original statistical data, (2) definition of aggregation and mapping rules to harmonise original data sources to CAPRI definition and (3) consistency checks and (4) exploitation including an export to file format which can be loaded automatically in the uniform CAPRI data base. The tool, at the current stage defined for the application to Italian and Greece regional and national statistics, can be easily extended to an application to other Member States as well and may ease the data updating for the whole CAPRI research network .

Figure 6: Overview on data collection and management tool

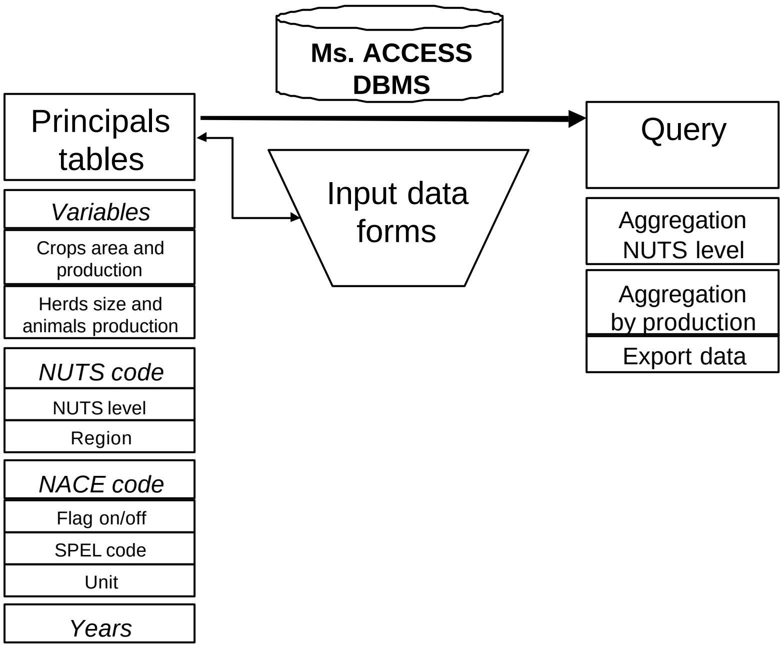


Table 2: Production activities in the data base

Group	Activity	Code
Cereals	Soft wheat Durum wheat Rye and Meslin Barley Oats Paddy rice Maize Other cereals	SWHE DWHE RYEM BARL OATS PARI MAIZ OCER
Oilseeds	Rape Sunflower Soya Olives for oil Other oilseeds	RAPE SUNF SOYA OLIV OOIL
Other annual crops	Pulses Potatoes Sugar beet Flax and hemp Tobacco Other industrial crops	PULS POTA SUGB FLAX TOBA OIND
Vegetables **Fruits** **Other perennials**	Tomatoes Other vegetables Apples, pear & peaches Citrus fruits Other fruits Table grapes Table olives	TOMA OVEG APPL CITR OFRU TAGR TABO

	Table wine Other wine Nurseries Flowers Other marketable crops	TWIN OWIN NURS FLOW OCRO
Fodder production	Fodder maize Fodder root crops Other fodder on arable land Extensive graze and grazing Intensive graze and grazing	FMAI FROO FARO GRAE GRAI
Fallow land and set-aside	Set-aside idling Non food production on set-aside Fallow land	SETA NONF FALL
Cattle	Dairy cows Sucker cows Male adult cattle fattening Heifers fattening Heifers raising Fattening of male calves Fattening of female calves Raising of male calves Raising of female calves	DCOW SCOW BEEF HEIF HEIR CAMF CAFF CAMR CAFR
Pigs, poultry and other animals	Pig fattening Pig breeding Poultry fattening Laying hens Sheep and goat fattening Sheep and goat for milk Other animals	PORF SOWS POUF HENS SHGF SHGM OANI

Table 3: Output, inputs, income indicators, political variables and processed products in the data base

Group	Item	Code
Outputs		
Cereals	Soft wheat Durum wheat Rye and Meslin Barley Oats Paddy rice Maize Other cereals	SWHE DWHE RYEM BARL OATS PARI MAIZ OCER
Oilseeds	Rape Sunflower Soya Olives for oil Other oilseeds	RAPE SUNF SOYA OLIV OOIL

Other annual crops	Pulses Potatoes Sugar beet Flax and hemp Tobacco Other industrial crops	PULS POTA SUGB FLAX TOBA OIND
Vegetables **Fruits** **Other perennials**	Tomatoes Other vegetables Apples, pear & peaches Citrus fruits Other fruits Table grapes Table olives Table wine Other wine Nurseries Flowers Other marketable crops	TOMA OVEG APPL CITR OFRU TAGR TABO TWIN OWIN NURS FLOW OCRO
Fodder	Gras Silage Hay dried Fodder root crops Straw Sugar beet for feeding	GRAS SILA HAYD FROO STRA SUGF
Marketable products **from animal product**	Milk from cows Beef Veal Pork meat Sheep and goat meat Sheep and goat milk Wool Poultry meat Other marketable animal products	MILK BEEF VEAL PORK SGMT SGMI WOOL POUM OANI
Intermediate products **from animal production**	Milk from cows for feeding Milk from sheep and goat cows for feeding Young cows Young bulls Young heifers Young male calves Young female calves Piglets Lambs Chicken Nitrogen from manure Phosphate from manure Potassium from manure	MILF SGMF YCOW YBUL YHEI YCAM YCAF YPIG YLAM YCHI MANN MANP MANK
Other Output from EAA	Contract work Statistical production adjustments	COWO PRAD
Inputs		
Mineral and organic fertiliser	Mineral nitrogen fertiliser Mineral phosphate fertiliser	NITF PHOF

Seed and plant protection	Mineral potassium fertiliser Mineral calcium fertiliser Organic nitrogen fertiliser Organic potassium fertiliser Organic phosphate fertiliser Seed Plant protection	POTF CAOF NITM PHOM POTM SEED PLAP
Feedingstuff	Feed cereals Feed rich protein Feed rich energy Feed milk and milk product Feed hay and straw Feed Gras & silage Feed other	FCER FPRO FENE FMIL FDRY FFSI FOTH
Young animal **Other animal specific inputs**	Young cow Young bull Young heifer Young male calf Young female calf Piglet Lamb Chicken Costs related to imports of animals Pharmaceutical inputs	ICOW IBUL IHEI ICAM ICAF IPIG ILAM ICHI IAIM IPHA
General inputs	Losses Repair and machinery variable Energy variable Water Other input variable Repair and machinery fix Energy fix Other input fix Statistical input adjustments Value added under compensation	LOSF REPV ENEV WATV INPV REPO ENEO INPO INAD VATU
Income indicators	Production value Total input costs Total variable input costs Total overheads Gross margin Gross value added at market prices CAP premium effectively paid Gross value added at market prices plus CAP premiums	PROV TOIN TOVA TOOV GRMA GVAM PRME MGVA
Activity level	Cropped area, slaughtered heads or herd size	LEVL
Political variables **Relating to activities**	Base area or herd Historic yield Premium per ton historic yield Set-aside rate Premium declared below base area/herd	BASL HSTY PRET SETR PRMD
Processed products	Rice milled Molasse Starch Sugar	RICE MOLA STAR SUGA

	Rape seed oil	RAPO
	Sunflower seed oil	SUNO
	Soya oil	SOYO
	Olive oil	OLIO
	Other oil	OTHO
	Rape seed cake	RAPC
	Sunflower seed cake	SUNC
	Soya cake	SOYC
	Olive cakes	OLIC
	Other cakes	OTHC
	Butter	BUTT
	Skimmed milk powder	SMIP
	Cheese	CHES
	Other milk products	OMPR

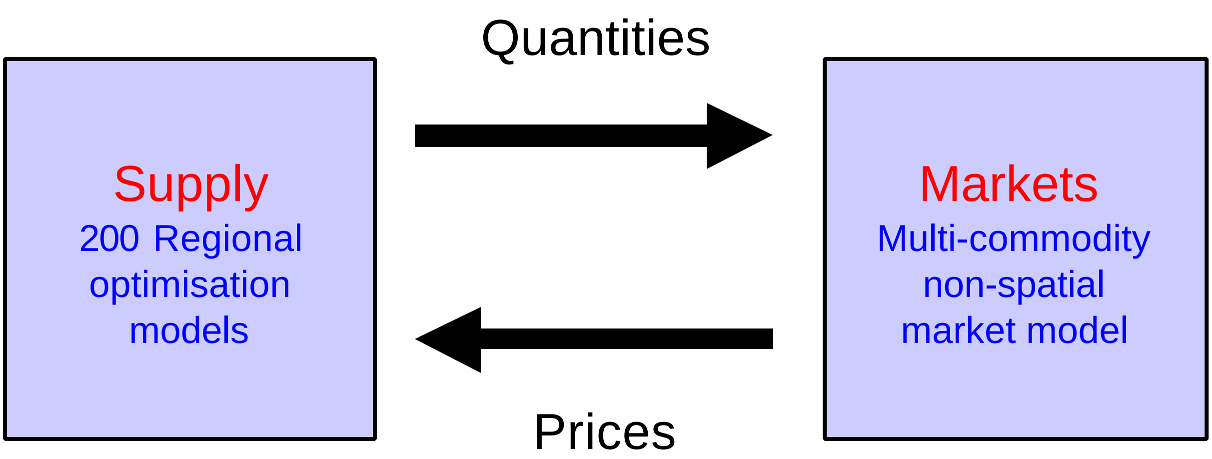
2.2 Economic Core Model

2.2.1 Overall Concept

From a methodological point of view, the main challenge was the development of a modelling system which could combine deep regionalisation with complete coverage of the EU-agricultural sector. This set-up was necessary in order to simultaneously analyse the effect of commodity market and policy developments on agriculture in the individual regions as well as the feedback from the regions to EU and world markets.

Since market and activity specific policy instruments require a rather disaggregated model in terms of products, a simultaneous system which would optimise producer and consumer surplus for 200 regions and some 50 products was computationally infeasible. Consequently, the model system was conceptually split-up into a supply and a market component (see figure 7). The supply module consists of individual programming models for about 200 NUTS 2 regions. The market module follows the tradition of multi-commodity models. Based on aggregated supply quantities from the regional models, the market model returns market clearing prices. An iterative process between the supply and market component ultimately achieves a comparative static equilibrium.

Figure 7: General Model Layout



The original concept was guided by the experience from other EU-wide systems (e.g. Weber 1995) and had foreseen the development of a recursive-dynamic approach (BRITZ & HECKELEI 1997). However, sensitivity experiments based on coupling national supply models with a first version of the market module revealed a sharp impact of small changes in the parameters of the price expectation module. A high sensitivity to parameters by itself would not be critical if a sound empirical basis existed to estimate and validate them. However, the only prices easily available covering all Member States and products are unit values calculated from the EAA and farm balances. They are not suitable to define price expectations of producers as they refer to all traded quantities and take quality differences into account. The dense time schedule of the project did not allow to sample an alternative time series data of appropriate prices to estimate based on it a price expectation module and to validate its impact on a recursive-dynamic system.

Besides reduced complexity, a further advantage relates to the fact that the base year to which the model is calibrated and started from in simulation runs represents an average over several years, avoiding problems compared to the use of just one calendar year. First, problems arising from a mix of crop and calendar year data in the data base are relaxed. Second, average prices and yields over a longer period can be interpreted as representing average expectations. Third, it is possible to calibrate simultaneously to activity levels (herd sizes, areas) and farm balances (feed use, seed, use, sales) if the latter are consistent with expected yields. Further issues regarding the modelling of primary factor impacts, time constraints, and immediate political relevance lead to the conclusion to develop a comparative-static system. For details of the discussion see HECKELEI, BRITZ & LÖHE (1998).

2.2.2 Supply Module

General Layout

Two generally different approaches dominate the modelling of agricultural supply response to economic incentives: (1) Programming models and (2) econometrically estimated behavioural equations. Programming models are generally characterised by optimising some economic objective function subject to the explicit specification of agricultural production technology. They are well-suited for a high degree of activity differentiation, allow to directly represent the most relevant farm policy measurements (e.g. premiums, set-aside obligations), and ensure simulation results consistent with general resource constraints. State-of-the-art econometric supply systems feature parameters estimated from and fitted to observed behaviour consistent with economic (optimisation) theory. However, significant estimation problems occur if a deep disaggregation in terms of products needs to be combined with technological and policy restrictions as, for example, the current set-aside regime. In order to render the estimation feasible rather restrictive specifications have to be chosen. As many other modellers engaged in agricultural policy analysis, we consider the advantages of programming models convincing and opted for this approach. However, the application of a new specification of Positive Mathematical Programming based on observed behaviour dilutes the strict distinction between econometric and programming models in our context.

Calibration

The normative character of an aggregate programming model which explicitly optimises an objective function subject to a set of technological and political constraints typically leads to a significant difference between the optimal ex-post result and observed producer decisions, even though the model's parameters may be carefully set to represent the actual technology, policy and economic incentives. This deviation partly relates to the aggregation problem and remaining data deficiencies such as the measurement of labour, capital and management input. Furthermore, the usually applied assumption of profit maximisation may be challenged if one considers the relevance of risk averse behaviour or preferences for certain production branches, especially looking at the typical farm-household complex of European farms. It is sometimes argued that the deviations between model allocation and reality can be neglected if relative differences between simulation runs are analysed instead of absolute numbers. However, policy analysis systematically requires absolute results and without further analysis of the model misspecification, an impact on relative simulation results cannot be excluded.

The method called "Positive Mathematical Programming" (PMP) - known since the late eighties but introduced to a wider community of agricultural economists by HOWITT (1995) - allows to perfectly calibrate a programming model to observed data and solves - at first glance - the problems mentioned above. The basic idea of PMP is to exploit dual values of calibration constraints which force the solution of the programming model to the observed allocation. These dual values can be interpreted as the difference between the "real" marginal economic incentives driving the relevant variables to observed levels and the ones currently specified in the model by the interplay between objective function and the constraints. If one appropriately maps these differences to a new non-linear objective function, the model will perfectly reproduce the base year situation without calibration constraints or any other modification of the model.

Compared to linear programming (LP), the introduction of a non-linear objective function allows solutions with more variables than binding constraints - an important characteristic for aggregate supply models where the number of justified constraints is rather small but the number of realised production activities large. Furthermore, it results in a smoother, more realistic response behaviour of the model to changes in exogenous parameters. This advantage and the calibration property lead to a wide spread use of PMP in recent modelling exercises. Given data availability and the specific tasks of the CAPRI project to analyse the economic, social and environmental impact of the CAP for 200 European regions, the features of a PMP based programming model were also considered advantageous compared to an econometric approach. Hence, the supply side of CAPRI consists of individual regional programming models based on PMP.

Allocation steering

The conditions for perfect calibration are clearly defined and adopted by all PMP applications, but they allow for an infinite number of different parameter specifications, all perfectly calibrating the model to observed activity levels, but implying distinct differences with respect to the allocational response in simulations (see: HECKELEI 1997 for a discussion). Most applications of PMP so far used one of the following two approaches to define the parameters of the objective function: (1) a so-called standard approach or (2) a specification based on exogenous elasticities. In the CAPRI model the second approach was used to define the parameters for animal production activities. Since elasticities were not available for crop production activities, the team explored the possibilities of approach (1) in this case.

A literature research showed that documented applications of the "standard approach" did not seriously attack the problem of potentially arbitrary simulation results. Hence, possible reasons for the deviations between the uncalibrated model and reality - as discussed above - were analysed in order to find an empirical basis for defining the parameters of the objective function. Neglecting risk averse behaviour relating to systematic yield and price fluctuations could have been one of the main factors. We could attack this problem with a more formal analysis since a) the effect on producer behaviour is discussed extensively in the literature, b) data could be constructed using national time series and c) the methodology for integrating risk averse behaviour into sectoral programming are established. However, the incorporation of risk averse behaviour into the regional programming models did not move the optimal level of endogenous variables any closer to observed behaviour or - put differently - the risk specification did not explain the dual values of the calibration constraints in the original model (for details see HECKELEI & BRITZ 1998).

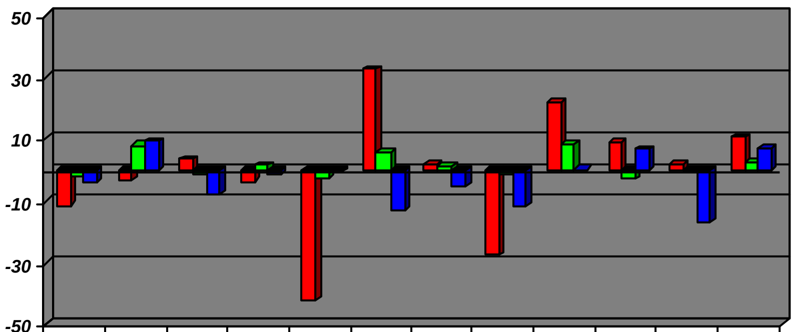
Fortunately, at the same time, PARIS & HOWITT published the idea to use Maximum Entropy (ME) techniques to estimate the parameters of a PMP model (PARIS & HOWITT 1998). As mentioned above, programming models typically feature a deeper disaggregation in terms of products compared to econometrics models. The econometric estimation of CAPRI's PMP parameters was deemed impossible before this article due to (1) a degree of freedom problem and (2) the size of the estimation problem. Maximum (and Cross) Entropy techniques, however, allow to estimate underdetermined ("ill-posed") problems where the number of parameters exceeds the number of observations. Hence, the technique is well suited to estimate the PMP parameters for a deeply disaggregated system with limited data. The article clearly showed the potential of the approach but suffered from two important disadvantages: First, the method was just applied to a single observation, implying that the data did not contain any information on changes of economic incentives when allocation moves away from the observation point. Second, the specific way the article attacked the problem to estimate parameters which guarantee a correct curvature of the resulting objective function again resulted in an arbitrary specification of the parameters.

However, the idea to use ME was nevertheless a fundamental breakthrough, because it generally allows to use more than one observation on dual values thereby paving the path to a better empirical base for the PMP specification. Data on observed crop allocations in the context of the CAPRI model were available from 1990-1995 on a regional basis. Parameters could hence be estimated based on time series, cross sectional samples or both. A pure time series analysis with just five data points per region was not promising. As a consequence, the estimation was based on cross-sectional analysis, introducing parameter restrictions across regions, keeping in mind a possible extension to a combined time and cross-section analysis at a later stage.

The parameter restrictions across regions are based on rather simple assumptions: (1) the *relative change* in profitability when moving from one crop rotation to another is similar between regions and (2) other differences in the relative change of profitability relate to natural conditions which can be measured by the economic performance of the overall rotation. Accordingly, observed differences in marginal costs between regions are "explained" by differences in rotations and average revenues per ha in the regions. The application in the context of CAPRI is the first documented application of a ME estimation of PMP parameters with more than one observation. Additionally, a solution for the dazzling curvature problem was found, a pre-condition to make the estimation operational. The resulting regional models were validated by an ex-post validation exercise:

The following figure 8 shows aggregated results of an ex-post simulation across the '92 CAP reform. The regional supply models are calibrated to a three year average "1990", afterwards PMP parameters are defined for the so-called standard approach (red bars) and estimated by Maximum Entropy techniques using the newly developed methodology (green bars). The overall absolute deviation of the ME approach is just 3 % and far better than the standard approach. The blue bars show no-change forecasts which, however, take into account the effect of the obligatory set-aside regime.

Figure 8: Ex-post validation of the new ME based estimation of PMP parameters for France, simulation across the '92 CAP reform



	Wheat	Barley	Maize	Cereals	Sun-flowers	Rape	Oil seeds	Pulses	Pota-toes	Arable Fodder	Fallow Set aside	Total
Standard	-11	-3	3	-4	-42	33	2	-28	22	9	2	11
ME	-2	8	-2	1	-3	6	1	-1	8	-3	0	3
No change	-4	9	-8	-2	-1	-13	-5	-12	0	7	-17	7

The regional forecasting accuracy of the ME-approach was also superior to the standard PMP application (For details of the approach and the validation see HECKELEI & BRITZ 1999).

Consequently, the resulting programming models employed in CAPRI are a "hybrid" approach as they combine features of both classical programming models and econometric approaches. The following section gives a short overview on their general layout.

Structure of regional supply models

As mentioned above, each region is represented by its own regional supply model whose structure is shown in figure 9. The objective function maximises the aggregated gross value added at market prices including CAP premiums for the region plus a quadratic function based on PMP. The quadratic functions ensures perfect calibration to observed activity levels (areas, herd sizes), production and feed use in the base year and a plausible simulation behaviour.

The choice of the optimal production mix is restricted by a relative small number of constraints: availability of arable and permanent gras land, selling quotas for milk and sugarbeet, set-aside obligations and upper bounds for voluntary set-aside according to CAP regulations. Feed costs are minimised endogenously by determining the optimal mix of a limited number of aggregated feedingstuff (cereals, protein rich, energy rich, milk product based, other) and non-tradable feed (gras, silage, hay, raw milk, sugar beet) under requirement constraints (energy, protein, fibre etc.). Further on, minimum and maximum shares of the feedingstuff ensure a technologically plausible mix .Nutrient needs of crops can be covered either by mineral or organic fertilisers, the latter restricted to the amount produced by the regional herds. Constraints ensure that a crop specific percentage of the nutrient need is covered by mineral fertiliser. Apart from the feedingstuffs which are assumed to be not tradable, the model does not differentiate between quantities from different origins.

Figure 9: Structure of a regional programming model

	Production Activities	Feed-Use Activities	Net-Trade Activities	Constraints
Objective Function	Cost + Premiums + PMP	PMP Feed	Prices	
Products Feed Requ . Nutrients	– – + + –	+ – 	+ 	= 0 < 0 = surplus
Arable Land & Gras land	+ +			< ha < ha
Set-aside & Quotas	+/– + +			< 0 < quota

Young animal markets

Branches in animal production are linked by the exchange of animals, for example, specialised farms produce and sell piglets to farms fattening pigs. In the common market, these trade flows cross regional and national boundaries and call for an explicit modelling of the different branches as well as for a market clearing mechanism across all regions. Without such a mechanism, the resulting herd mix could be implausible if demand and supply of young animals are unbalanced. In order to achieve market clearance, either all regions must be solved simultaneously or an adequate price finding algorithm must be employed. Since a simultaneous solution is technically not feasible, an algorithm based on PMP was developed. After solving all regional models with given prices for young animals, the PMP terms of each Member State model are specified such that the national model calibrates almost perfectly to the aggregated results from the regional models. The national models are then solved simultaneously with endogenous prices for young animals under market clearing constraints. The resulting prices are subsequently mapped to the regional models which are solved again. The process is repeated until sufficient convergence is achieved.

Alternative technologies

An important part of the '92 CAP reform was designed to support environmentally sound agricultural production systems and gave Member States and regions the possibility to co-finance related programs under the regulation 2078/92. An analysis by the CAPRI network (SANCHO M,. & J.M. GARCÍA ALVAREZ-COQUE 1997, LÖHE & BRITZ 1997) as well as research conducted by another team of European researchers (DEBLITZ & PLANKL 1998) on the implementation of the directive in the different Member States and regions showed a large variety of quite specific programs. Although an EU wide approach to actually model the different regional programs was out of the scope for the current project, it seemed obvious that a model design accommodating different production technologies would be highly advantageous for future specific analyses of these programs. Consequently, a module for *alternative technologies* was developed.

The module allows to define different farming systems in relation to the observed average system in a region by setting, if necessary, individual input and output coefficients for each production activity. Three applications of the module were done or are currently performed:

1. The Swiss team defined alternative technologies which relate to specific Swiss policy programs to support environmentally friendly farming system (see section 2.5.2)

2. The French team used questionnaire data on the economic performance of farmers in different French regions to test the module (see section 2.5.3)

3. In close co-operation with the Bonn team, a group at the Federal Research Centre in Braunschweig, Germany, is currently applying CAPRI to simulations regarding an increase of ecological farming systems in the EU Member States (OFFERMANN (2000) in the context of the FAIR project FAIR3-CT96-1794).

Perennial submodule

The supply of perennial crops cannot be modelled with a static profit maximisation approach as in the case of annual crops. Therefore, it was necessary to create a perennial submodule which is able to perform forecasts for perennial crops' supply variables in a stylised and straightforward way that is exogenous to the rest of the CAPRI core model (as indicated in EL KAMEL & GARCIA ALVAREZ-COQUE 1997). Therefore, activity levels for perennial crops are calculated as a "net investment“, instead of a separate accounting of plantings and removals. As far as yields and output are concerned, the econometric estimation can be obtained without a structural formulation that explains the output variations, since actual output of perennial crops are taken as exogenous in the CAPRI price simulations. Area planted was selected as the variable that best approximates investment decisions (medium-term perennial supply) and was used as the basic variable representing supply of perennial crops. The reasons that justify this choice are several: Firstly, planted area is believed to be a good approximation of the productive potential at the medium-term, assuming that the yield average is maintained constant. Secondly, the randomness of the yields due to the climatic conditions, diseases and other factors, introduces noise in the estimation of actual supply response. Finally, the farmers’ reaction to economic incentives is reflected in decisions affecting the planted area.

Based on the time series constructed for activity levels (planted areas) in the EU regions with strongest specialisation in perennial crops, autoregressive equations were estimated to forecast the perennial crop supply. The time series covered the period 1974-1996. The total area of each perennial activity is determined through the following equation:

$$Ln\, S_t \;=\; a + b\, Ln\, S_{t-1} + c\, Ln\, S_{t-2} + d\, Ln\, S_{t-3} + e\, t + \frac{m_t}{1-rL}$$

where S_t is the planted area in year “t”, a, b, c, d and e and p are parameters to estimate, μ_t is a random term and L is a lag operator. After preliminary tests based on the indicated equation, consistency of land allocation within crops and regions was considered a crucial point for the forecasting work in perennials. In order to ensure consistency of area estimates, an extension of the *Theil's multinomial logit model* was used for the determination of land allocation and crop production (see EL KAMEL ET AL. 1999). The purpose of this model is to obtain consistent estimated values for the shares of the different crops in the total arable area so as to determine how cultivating land is allocated among the different activities. Due to the lack of sufficient regional time series data this model was applied to national data (extracted from SPEL database) in order to obtain the estimated shares of the different crops within each of three aggregate activities of the perennial crop sector (vineyard, olive trees, fruits).

It is clear that the obtained results can only be used as a reference run for simulation purposes. However, one could accept that most area developments in perennial crops could be considered as exogenously determined, or at least not strongly affected by short term price changes as it might happen in continental cultures and livestock activities. On the other hand, assuming that the regional structure of the national planted area in each specific crop keeps stable is an important limitation of our modelling. However, with the big number of regions considered and the short periods covered by the available time series, this assumption was considered sufficient to provide reference forecasts of the area levels for 2005. The intention of the present research on perennials was just to estimate "reference" forecasts that will indicate the regional allocation in the next years provided that current trends keep going.

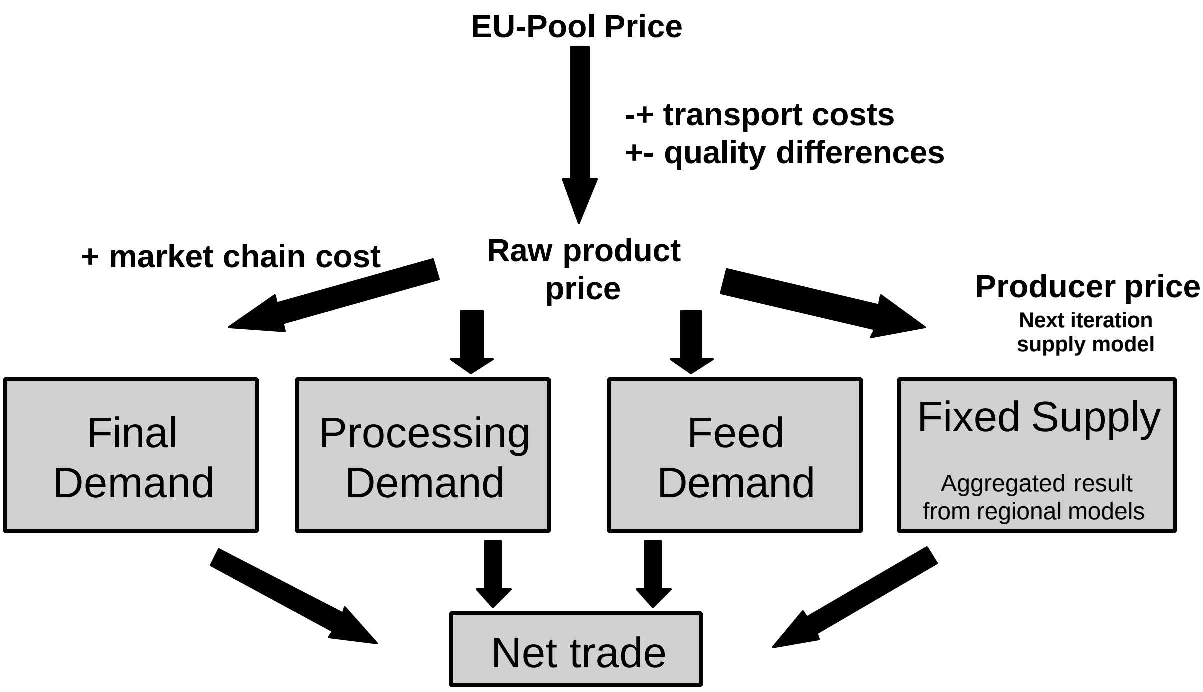
2.2.3 Market Module

Because the main task of CAPRI relates to the regional analysis of the CAP, methodological solutions for the market module were based on the well explored concept of multi-commodity models (BRITZ 1998). This type of market model has a long-standing tradition in agricultural sector analysis since the days of SWOPSIM. Behavioural equations for supply and demand equilibrate regional and international markets, driven by regional producer and consumer prices which are linked via price transmission functions to a uniform world market price. These models assume homogeneity between products from different origins and to different destinations and just represent the net trade of each region as the difference between regional demand and supply. Given time and data constraints, the parameters of the behavioural demand equations are not estimated, but instead calibrated under theoretical restrictions to elasticities taken from literature (WITZKE & BRITZ 1998).

The model is regionalised at EU Member State level, Switzerland and Rest of the World. Data, behavioural parameters and exogenous shifts for the Rest of the World aggregate stem to a large extent from WATSIM, a world wide modelling system for trade in agricultural products (VON LAMPE 1998). Supply for all other regions is fixed to the results of the regional supply models. Final demand and shares of single products in aggregated feed categories follow double-log functions with constant elasticities. Price transmission functions include tariffs as well as marketing and processing costs. Processing of oil seeds is modelled explicitly assuming fixed extraction rates for cakes and oils from crushing. In the case of processed milk products (skimmed milk powder, butter and other), constraints equilibrate fat and protein content of processed quantities of raw milk and with the processed products. The price of raw milk and processed milk products is derived from uniform fat and protein prices weighted with their contents.

Apart from the inclusion of tariffs in the price transmission functions between the world market price and regional prices, further important trade policy instruments such as constraints on subsidised exports and flexible levies combined with internal price floors are modelled endogenously. This leads to non-differentiable constraints of the market clearing algorithm. In order to ensure feasibility the market model is solved stepwise by setting appropriate starting values and introducing the non-differentiable constraints one after another.

Figure 10: Price transmission and components of supply and demand of a Member State Module



2.2.4 Coupling of Supply and Market Module

As supply quantities in the market module are fixed to aggregated results of the regional models, the prices from solving the market module need not represent market clearing prices. Producers may choose another optimal production mix for these prices. Hence, prices must be mapped back to the regional models and resulting quantities back to the market model until further changes in quantities and prices are sufficiently small, i.e. convergence is achieved.

The process in itself is similar to the procedure used in a recursive-dynamic coupling of supply and market module and questions may arise whether convergence can be achieved with a limited number of iterations. This could be insured by using weighted average prices over past iterations instead of prices from the last one.

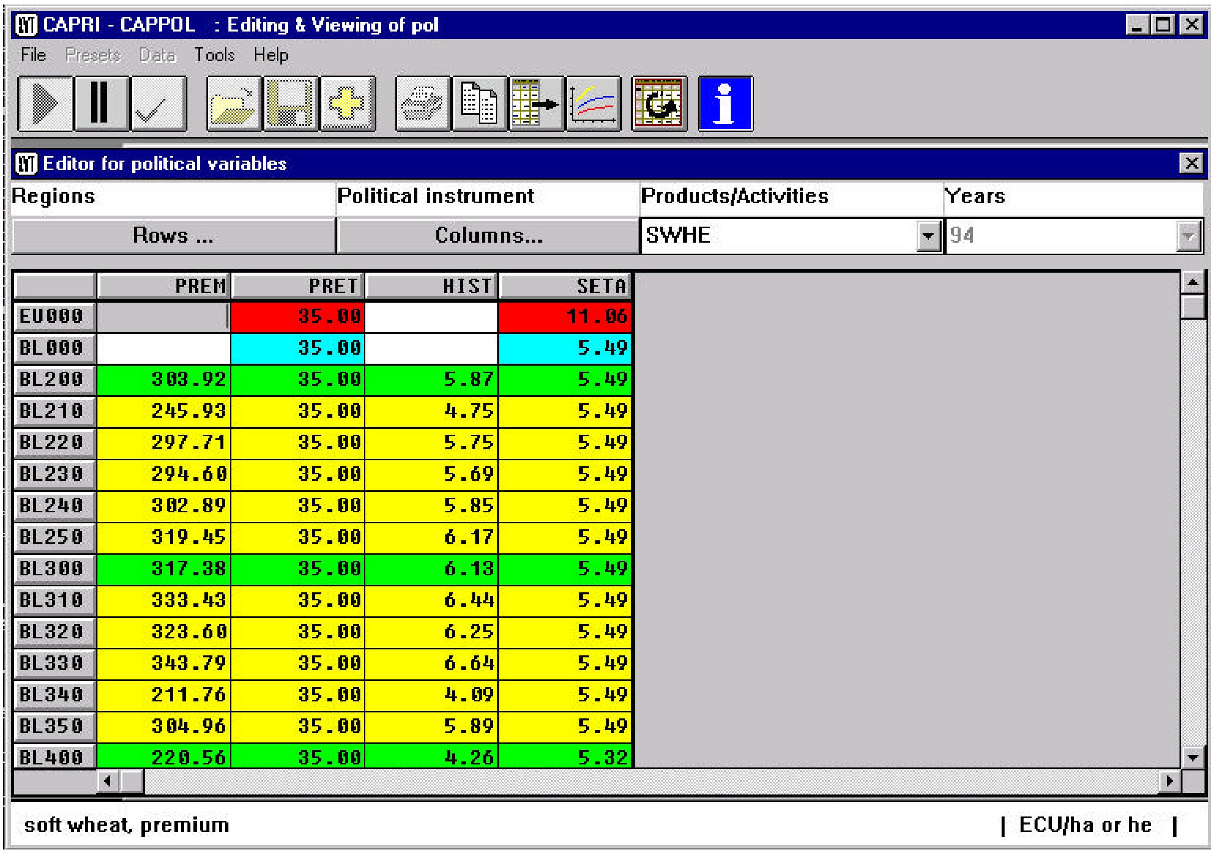
2.2.5 Technical Solution

A co-operative effort to develop a regionalised agricultural sector model requires a technical solution which allows each team to contribute to the development of data base and model by high transparency and the use of uniform tools. Transparency was to a large extent achieved by a clear concept of the CAPRI data base, whose entries are concisely defined. Stringent coding provides a solid base for the definition of relations between these entries and the model equations or algorithms. Furthermore, the use of the modelling language GAMS ensured that programs were generally accessible to partners, partly because members of the network were already familiar with the language, partly because its resembles scientific notation. Additionally, the project follows a modular design, where clear tasks and interfaces between them had been defined before the coding begun. Consequently, teams could develop parts of the system independently from each other as long as the interface definitions were clear and kept unchanged. Last but not least, considerable effort was invested in documentation of the programs and training of the network members, especially regarding the concept of the data base and its definitions.

In order to steer the model, for example to define which simulation to run, two major stand-alone routines were developed: (1) CAPPOL, designed to edit the political variables for different scenarios, and (2) CAPMOD, designed to execute simulation runs with the system. These routines are written in C/FORTRAN and linked to software libraries developed by the Institute of Agricultural Policy, University of Bonn. These libraries, together with the existing GUI and DBMS, are already successfully implemented in other agricultural policy information systems, and were a pre-condition for a successful and efficient technical solution for CAPRI. Naturally, the development and maintenance both of the libraries and the CAPRI specific programs requires experienced software engineers.

CAPPOL is designed as an interactive editor to set policy variables for a simulation run. For each production activity and region, set-aside rates, base areas or herd sizes and premiums may be defined. At European level, tariffs, intervention prices and export restriction may be entered. Data at lower regional level are automatically set to values from higher aggregates as long as no specific regional data is entered, a colour code shows at which NUTS level a certain value has been entered (red for EU, cyan for national, green for NUTS I and yellow for NUTS II level). Each set of policy instruments is identified by its own short name in the data base. As an example, the screen shot in figure 11 shows data for soft wheat production (PREM: premiums in Euro per ha, PRET: premiums in Euro per ton, HIST: historic yield in ton/ha, SETA: effective set-aside obligation in % taking into account the share of production under the small producer scheme).

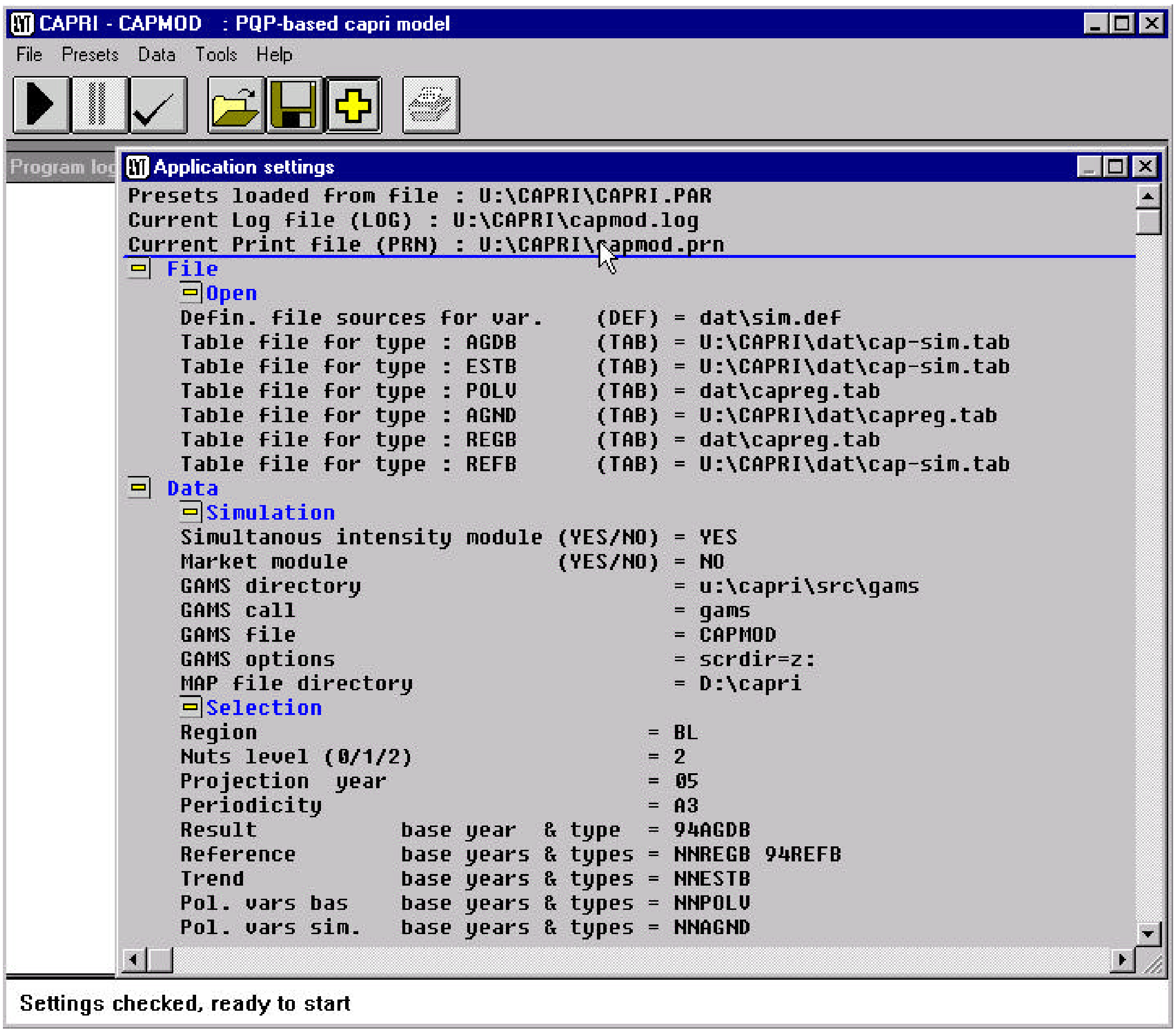
Figure 11: Screen-Shot of CAPPOL user interface



CAPMOD serves as a frame around the GAMS coded programs and writes the run specific data and information to a GAMS input file. Since the regional definitions, base years, etc., may vary between model runs, the GAMS code must be written in a quite general and flexible manner. A key feature to allow for this flexibility is the GAMS concept of set driven algebraic statements. Results from model runs are stored back in the CAPRI data base, using the same definitions as ex-post. This feature is of extreme importance for the exploitation of results, because single elements of the data base can be compared between years and scenarios without any additional data treatment. The following screen shot (figure 12) shows the user interface of CAPMOD. Especially note, that the Member State and Nuts level as well as the simulation year can be selected by the user, and that the market part can be switched off to perform a simulation with exogenous prices.

It should be mentioned that the overall modelling system results in a complex network of modules, algorithms, and working steps which is certainly hard to digest. Naturally, some improvements in transparency could surely be achieved if the necessary time is invested to review the system after it had been more or less under permanent development during the project's time span. Nevertheless, there is a common understanding between the team members that certain parts of the system can be maintained by software engineers and system design experts only, and that further training and documentation is necessary to allow every partner in the network to employ and possibly change the system to his need.

Figure 12: Screen-Shot of CAPMOD user interface



2.3 Environmental Indicators

2.3.1 Overall Concept

According to the project's goal to analyse the multi-functional aspects of agricultural production in the EU at regional level, a set of environmental indicators was defined, validated and applied. Useful indicators at this stage of the CAPRI information system are defined by (1) a direct link to the agricultural production system, (2) meaningful interpretation at CAPRI's current regional level of differentiation, i.e. the NUTS II level, and (3) being operational with respect to data availability. These definitions exclude indicators which describe states of environmental problems at local level or with respect to ecological systems defined by specific regional boundaries (e.g. water catching, landscape). CAPRI, however, offers the unique chance to apply appropriate indicators in a consistent and uniform manner across Europe relating to the regional agricultural production system. Based on these considerations the project implemented nutrient balances and gas emissions relevant for global climatic change for all regions in the system. Furthermore, several additional indicators and methodological possibilities were explored for sub-sets of regions.

2.3.2 Nutrient Balances

Nutrient balances are a widely-used and generally accepted concept to measure the potential danger to water resources and long-term devaluation of the soil. The general idea of these nutrient balances is straightforward: based on an appropriate system boundary definition, all sources and sinks are defined, and the difference between them interpreted as total nutrient excess in the system (for details see MEUDT & BRITZ 1997).

Starting with rather simple approaches already successfully applied in other studies, the CAPRI team has improved the concept to derive nutrient balances in two major ways:

(1) *"Crop zone approach"*: the balances refer to all inputs of nutrients to and all exports from the zone above and below ground used by crops. This typically accounts for organic and mineral fertilisers on the load side and export of harvested material on the sink side. The difference might either be lost as gas or dissolved in water and leached below the crop zone, where it either accumulates or leaches further down to ground water reservoirs.

Nutrient requirements of crops are covered by fertiliser application which amount is determined according to expected yields. In an earlier approach, input coefficients for mineral and organic fertiliser were based on the national input coefficient from the SPEL/EU data base modified by expected regional yields. Output coefficients for animals at tail were fixed per head with the exception of milk cows where they depended on milk yield. A later approach used in the context of the simulation runs improved this into three directions: (1) nutrient requirements were estimated based on engineering information on nutrient content per ton of harvested material, (2) nutrient output at tail from animal production was modulated for almost all activities depending on regional specific factors such as average live weight and length of the fattening process, (3) a Cross Entropy program was employed to simultaneously estimate the ex-post distribution of mineral fertilisers across regions and the nutrient availability from organic fertiliser for crops.

(2) "Farm gate approach": The system boundary is moved to the regional farm taking into account the import of nutrients by buying feedingstuff and the export of nutrients by selling animals and animal products. Consequently, output coefficients per animal endogenously depend on the feeding technology. This approach is now described in more detail:

Farm gate approach

The “livestock – environmental module” aims to assess the EU regional environmental impact - nutrients and greenhouse gases - of animal production activities (for details, see NASUELLI et al. 1998 and NASUELLI et al. 2000).

The module defines a set of regional engineering functions able to estimate the (*variable*) retention of elements of environmental relevance in the animal body and further outputs (milk, wool, young animals, ...). For each animal category, a nutrient balance between intake from feeding and retention is then implemented for the emissions of nitrogen, phosphorus, potassium, macro-minerals (Ca, Mg, ..), ammonia, and methane. Compared to other approaches, three special features should be stressed:

(1) The livestock – environmental module takes into consideration regional differences for each animal category based on data availability.

(2) Economic performance and environmental repercussions of regional animal productions technologies can be analytically evaluated, because they are based on functions able to describe the nutrients path from feed use to animal emission and take into account regional feeding and breeding practises. This formulation also allows to distinguish between different (extensive and intensive) technologies and corresponding policy measures.

(3) The module offers an additional feedback to validate both the estimated regional analytical feed rations and the nutrient content of the feed material used.

With particular reference to the estimation of the regional nitrogen emission from livestock[2], two different approaches have been followed: For some animal categories (e.g. dairy cows) the nitrogen production has been directly derived from the regional feed consumption of protein (and then nitrogen), and from the regional physiological and technical characteristics of the animals (live weight, yield, ...). In other cases (e.g. cattle), the definition of the nitrogen emission is obtained through the estimation of the retention of proteins into the animal’s body (empty body concept) in the different regions; this amount is to be subtracted from the regional protein intake.

In this last case, it has been necessary to differentiate the adult animals from the young animals. In fact, in the first case (dairy cows) it is sufficient to count the protein retained by the related products (milk, wool, …). Yet, for environmental purposes, parts of the protein uptake during the possible gestation period must not to be included in the emissions, and therefore subtracted from the protein intake. This accounts for the proteins retained by the growing animal’s body taking into consideration the decreasing assimilation capacity as well.

2.3.3 Greenhouse Gas Emissions

In the last decade scientific knowledge of human influence on climate change has deepened. The man-made increase of global temperature, the so called anthropogenic greenhouse effect, was one focus of this research. Global temperature changes are mainly caused by emission of specific gases, namely carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), steam and chlorofluorocarbons (CFCs). Besides CFCs, all these gases are emitted by ecosystems as well. However, since the industrial revolution in the beginning of the 19th century, the anthropogenic emission of greenhouse gases, especially carbon dioxide, increased drastically.

An important part of greenhouse gas emissions stems from Agriculture. This is especially true in the case of methane and nitrous oxide, agriculture contributes also to 80-90% of ammonia emissions which are an indirect cause of Climate Change. In the European context, emissions are mainly caused by animal production (for details, see MEUDT 1999)

[2] The manure output of nitrogen is reduced by 30% to take into consideration the wastage volatilisation during the storage phase (180 days).

The heat absorption differ between the gases but also with respect to different time horizons (0, 20, 100 and 500 years), depending on the half-life of the gases. In order to compare the effects of different greenhouse gases emitted by agriculture, CO_2-equivalents, so called "global warming potentials" (GWP), are calculated for the direct greenhouse gases methane CH_4 and nitrous oxide N_2O (Table 4). Ammonia is not taken into account, because it has no direct influence on the greenhouse effect.

Table 4: Global warming potentials of agricultural greenhouse gases

Gas	GWP*)			
Time Horizon (Years)	0	20	100	500
CO_2	1	1	1	1
CH_4	58	35	11	4
N_2O	206	260	270	170

*) CO_2 equivalents related to same mass of the gas
Source: BMU (1994): p. 142.

Table 4 clearly shows the importance of the two greenhouse gases methane and nitrous oxide measured by their GWP and underlines that pure quantity measurements are misleading. An explorative study for Germany based on the RAUMIS-model showed also that agricultural emissions of CO_2 do not matter whereas CH_4 and N_2O account for a relevant share of total GWP. CAPRI as a medium-term simulation model covers a time horizon of 10 years. Hence, in order to evaluate the greenhouse effect in CAPRI, GWPs of the time horizon "zero" are used.

The GWP-indicator in CAPRI shows the GWP/ha main crop area and covers two sources of emissions:

- CO_2 , CH_4 and N_2O from mineral fertiliser
- CH_4 from animal production

In order to calculate the GWP, coefficients from RAUMIS are used, which are defined on an average production activity basis for Germany. These coefficients are the gas output per ton fertiliser and the methane-output of each animal activity per stable place and year. The coefficients are combined with regional data: In the case of mineral fertiliser the gas output per ton is multiplied with the regional total use of mineral fertiliser which indirectly depends on the specific nutrient output from animal production in each region (see above). In the case of emissions from animal production, the regional fattening or rearing period is taken into account. By considering such regional aspects the CAPRI approach improves upon the RAUMIS predecessor.

2.3.4 Non-renewable Energy Use

Since the famous report of the "Club of Rome", there is growing awareness of limited global energy resources. More recently, the CO_2 accumulation in the atmosphere partially originating from the use of non-renewable energy sources such as oil and gas is also considered an important reason for global climatic change. Therefore, a key indicator for the environmental performance of agricultural production systems in the decades ahead could be their effectiveness in using non-renewable energy resources. Especially, the goal of reduced environmental impact by extensive production system may be in conflict with an efficient use of energy resources. Also, a careful evaluation of agricultural activities producing renewable energy is necessary, as they require the use of non-renewable resources as well.

The production activity approach with physical input and output coefficients underlying CAPRI is generally well suited to define the use of non-renewable energy. It allows, for example, to compare the use of energy per ton produced between conventional and environmentally friendly production alternatives. The approach applied in the context of CAPRI (FISCHER 1999) differentiates between *direct* energy input, for example related to gas consumption of tractors or oil consumption to heat agricultural buildings, and *indirect* energy input related to the production of agricultural inputs such as fertilisers or investment goods. A pre-condition to apply the approach is quite detailed, comprehensive and validated information on the use of all inputs in the different production branches. Given extraordinary good data availability, the Swiss CAPRI team was able to develop an operational approach and apply it on at regional level to different production systems in Switzerland. This gives an idea for potential future EU-wide applications in this respect. However, an extension to other countries exceeded the scope of the current project.

Following is a more detailed description of the approach done by means of the Swiss agricultural system SILAS (MACK 1998), a sector model similar to the CAPRI approach with respect to the relevant aspects:

Energy consumption calculation methods

For the evaluation of energy consumption, several alternative methods were examined. For this project, the concept of cumulated energy use was chosen. Cumulated energy consumption indicates the total of primary energetic input (KEA), which is related to the production, utilisation and disposal of a good (Federation of German Engineers, VDI 1995).

The KEA of a source of energy or a material contains its energy content (with fuels: the heat value, with uranium: the disintegration energy) as well as the energy spent for supply. The units of measurement of energy expenditure are kilowatt-hours (kWh) or mega-joules (MJ).

System definitions

The definition of the agricultural sector is done according to the concept of a national farm, according to the Economic Account for Agriculture (EAA). Rural households and the processing industry are not taken into consideration. Not included in the assessment of system limitations are:

- *Human labour.* The assessment of human labour in developed countries is a marginal input from the point of view of energy.
- *Energy content of soil, air and water.* Because sustainable management was assumed, these substances were not taken into consideration.
- *Use of renewable energy sources.*

Calculation of energy consumption of plant and animal production activities

Numerous statistics, the majority of which were worked out by the FAT, served as a data base (GAILLARD et al. 1997, AMMAN 1996, NÄF 1996). The technology module for the Swiss model SILAS allows for a precise determination of energy use per activity. The production procedures with the weights of the assigned machines and the tractor performances already included culture-specific fuel and lubricant consumption. Moreover, machine construction requirements and mineral fertiliser application were determined. Basically, energy input can be divided into direct energy inputs and indirect energy input (Table 5)

Table 5: Assessment of energy input for plant and animal production activities

	Crop farming	**Animal production**
Direct energy Input	Fuel Lubricant Oil heating	Fuel Lubricant Electricity Gas heating (chicken)
Indirect energy Input	Machines Fertilisers Pesticides Machine sheds	Machines Sheds Fodder import Fodder processed

Energy input of plant and animal production activities

As an example, Figure 13 shows that the cumulated energy input for potato production is twice as high as the input for the production of winter wheat. The cultivation of fallow land, however, required only one fourth of energy input necessary to produce soft wheat.

Energy use of certain animal species are compared (at the level of live stock units, LU) in Figure 14. This illustration shows that the energy expenditure for dairy cows is the highest. Chickens also have a high energy input per LU. The heating of stables in wintertime plays an important role.

Figure 13: Cumulated energy consumption (KEA) of selected plant production activities per ha

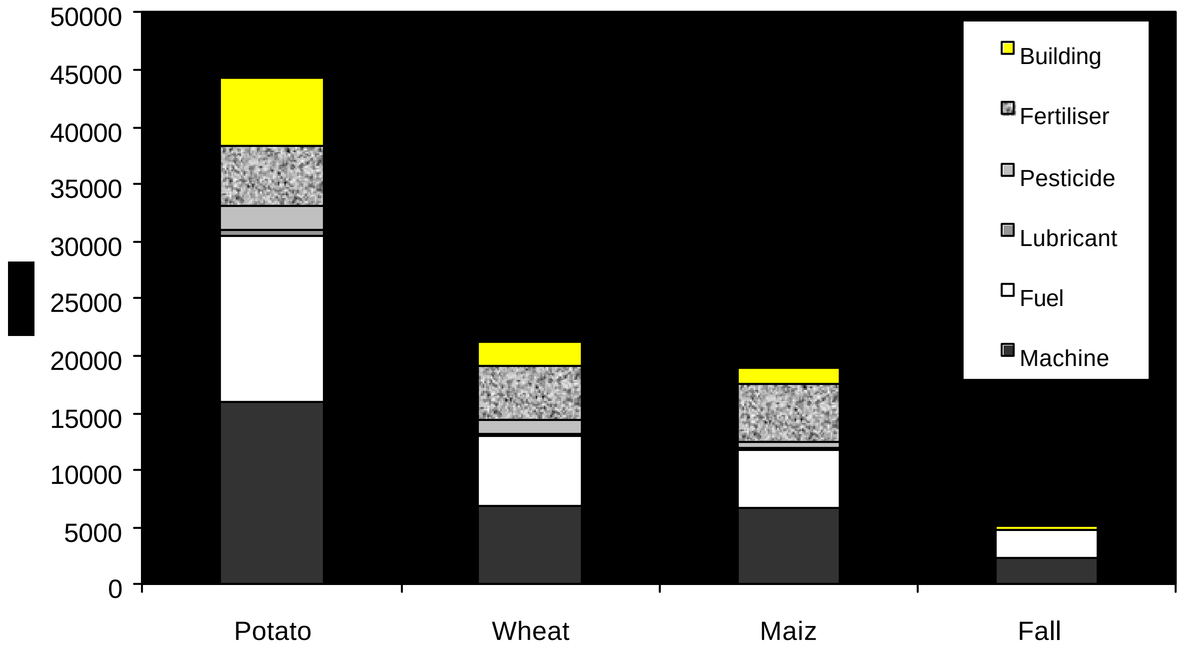
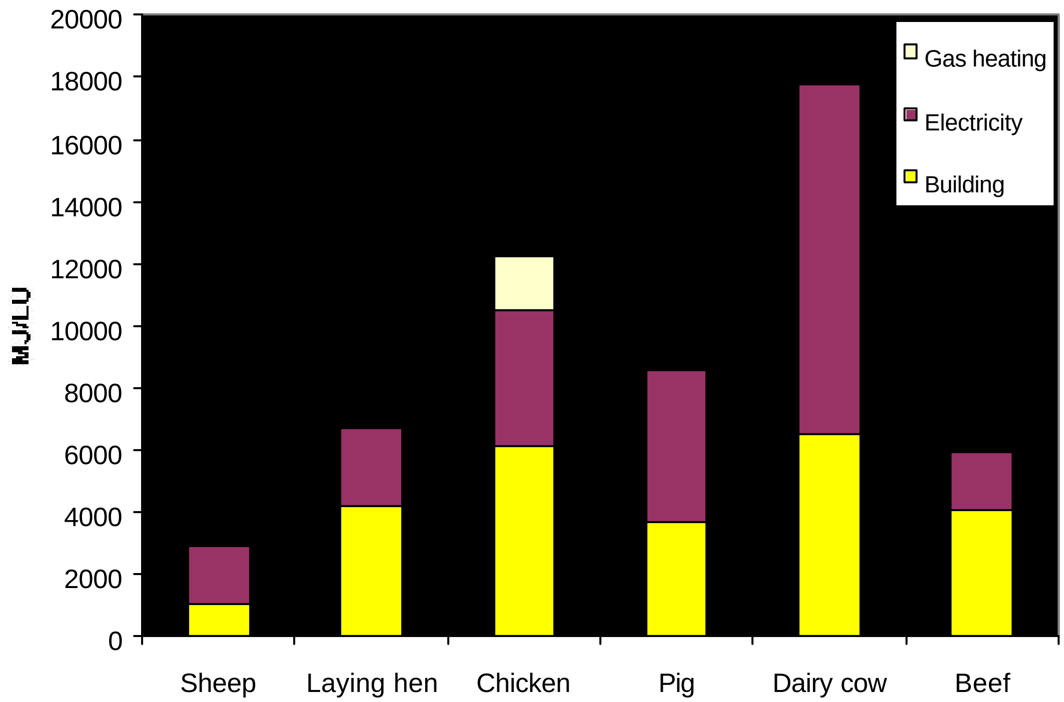


Figure 14: Cumulated energy consumption of selected animal species per livestock unit



Development of energy consumption in the agricultural sector

The model system SILAS shows that, thanks to the agricultural reform in Switzerland, energy input will decrease by approx. 6.5% by the year 2003 (Table 6). This is a consequence of the strong extensification in agriculture. The transition to more extensive management will lead to a reduction in the use of machines. In turn, this will cause fuel and lubricant consumption in the sector as well as the demand in machine shelters to drop. Through an extensification the input on mineral fertiliser and plant production will also decrease. This is a trend that began some years ago. The decrease of animal stock will lead to less space requirement and consequently, to less building expenditures. The electricity consumption will drop due to a slight reduction in animal stock. Three energy inputs are increasing:

- Due to a rise (estimate) in the number of vegetable surfaces, the surface under glass and consequently, the amount of oil used to heat greenhouses will increase.

- In plant production, there will be a decrease in the production of high-quality rough fodder. Thus, the use of concentrated feed will increase. Imports of concentrated fodder will increase.

- Due to a rise in domestic demand, poultry stock will increase until the year 2003. Naturally, this will lead to a slight increase in the corresponding energy input.

Table 6: Estimate of cumulated energy consumption in the agricultural sector from 1996 to 2003 in Terra-Joule.

	Energy consumption				
	1996	**2000**	**2001**	**2002**	**2003**
Diesel fuel	5 315	5 085	4 904	4 806	4 699
Lubricant	106	102	98	96	94
Gasoline	973	863	855	830	815
Fuel total	6 394	6 050	5 857	5 732	5 608
Plant protection	298	252	236	228	218
Machines	8 237	7 872	7 598	7 492	7 349
Shed for machines	2 219	2 097	2 022	1 993	1 968
Shed for animals	9 760	9 824	9 733	9 528	9 378
Mineral fertiliser	3 681	3 057	2 729	2 641	2 516
Electricity	13 288	13 289	13 131	12 865	12 640
Fuel oil	4 100	4 303	4 355	4 408	4 461
Gas heating	14	16	16	17	17
Processed fodder	773	530	487	432	363
Fodder import	710	1 509	1 615	1 698	1 778
Total	**49 474**	**48 799**	**47 779**	**47 034**	**46 296**

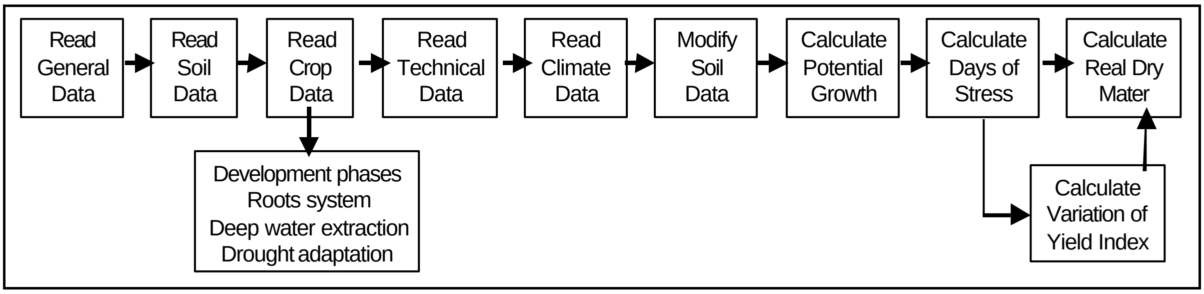
The Swiss government endeavours to reduce CO_2 emissions by 8 %. In addition to this, compliance with the environmental declarations of Kyoto will become compulsory. By means of extensification, a significant reduction of CO_2 emissions could be achieved. It is feasible that the target to reduce the emission of CO_2 particles in agriculture will have been achieved by the year 2003.

2.3.5 Crop Growth Models

Environmental indicators can also be based on the result of bio-physical models which allow for a much more detailed description of production technology and its interaction with soil and climatic conditions. In the context of CAPRI a case study was executed and results obtained from the crop growth model EPIC-Phase (Erosion Production Impact Calculator) for three levels of input intensity. Two French agricultural regions were initially chosen for this test: the Lauragais in region Midi-Pyrénées (south-west) and the Beauce in region Centre (MONOT, FLICHMAN 1997 and DONALDSON, FLICHMAN, WEBSTER 1995). This case study was originally designed to test economical and technical feasibility of extensive cropping practices under specific CAP measures, and to estimate related nitrate pollution reduction.

EPIC-Phase is a model designed by agronomists which simulates day-to-day plant development using crop and environmental parameters. It differentiates between plant development phases where water stress has specific impacts (CABELGUENNE, JONES, MARTY, DYKE, WILLIAMS 1990). Plant growth is defined by equations that have been obtained from and verified by field experiments. In opposite to nutrient balances, EPIC estimates nitrate leaching, taking into account not only the balance between fertiliser input and crop intake but also effects of weather variability, irrigation and soil work practices. The principle of the EPIC calculation procedure is represented in figure 6:

Figure 15: Simplified organigram of EPIC-Phase model



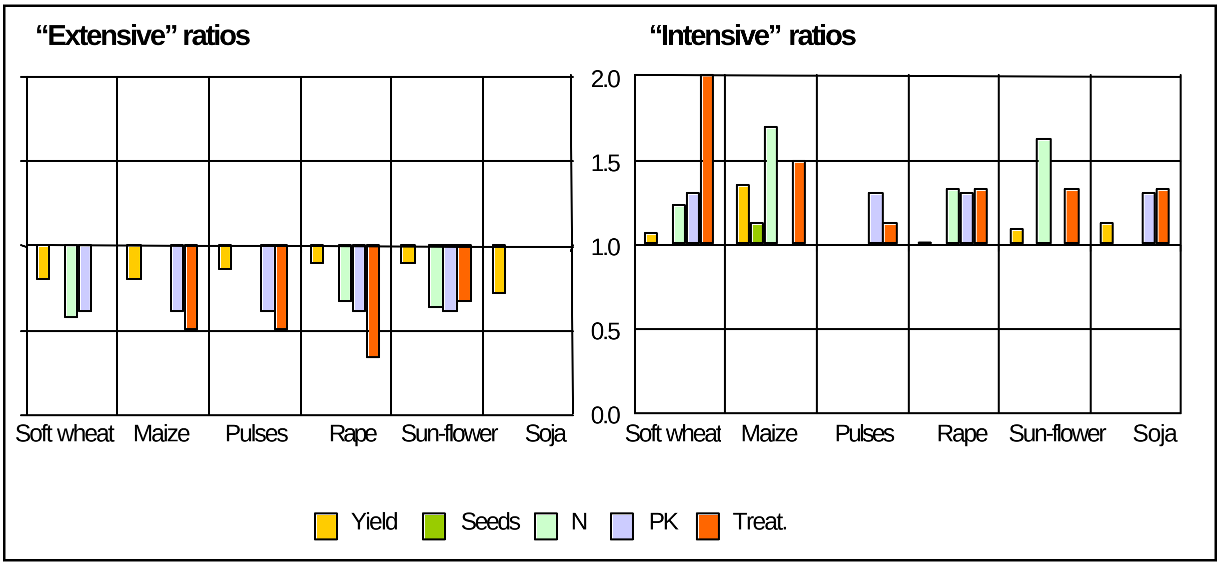
"General Data" represent information influencing crop growth which are not specified in the other data categories. In "Soil Data", the soil is divided in a maximum of 10 layers, each defined by 18 parameters influencing nutrient absorption, stock and water movements. In "Crop Data", each crop is defined by around 35 agronomic parameters that are more or less crop specific and that determine crop growth and harvest quality in response to weather, soil conditions and cropping technique. In "Technical Data", each agricultural operation as for example ploughing or spreading is defined by a maximum of 8 parameters concerning machinery and chemicals characteristics. Finally in "Climate Data", climate is either defined day-by-day using real daily data records or daily data "constructed" randomly from average information. These climate data concern enlightenment, temperature, rainwater and wind.

EPIC simulates various indicators of plant development from planting to harvest, and evolution of nutrients and water in soil layers in a daily basis. Diseases are roughly modelled with indices of infection risk. The model has been calibrated and validated for some Grandes Cultures in water stress conditions for the south of France. In the calibration phase, certain crop parameters are carefully adjusted “ex post”, to fit with experimental results. The model is then validated for these crops and can be used for further simulations.

Three types of techniques were simulated: “Extensive”, “Current” and “Intensive” techniques, defined by their level of inputs. The “Current” technique is supposed to be representative of actual practices of the majority of farmers. “Extensive” and “Intensive” correspond to lower, respectively higher quantities of inputs. Simulations were run for parameters of a local deep soil, assumed to be more responsive to high input levels. The three techniques were defined by the INRA in the region Lauragais in Midi-Pyrénées. In the similar study for Beauce, techniques were defined by the French Technical Institute for Cereals. Two sets of EPIC simulations are discussed in here which generate alternative yields and nitrate leaching for soft wheat, maize, pulse, rape, sunflower and soya.

Figure 16 represents the exogenously set changes of input quantities of the alternative techniques (“Extensive” or “Intensive”) and the resulting estimated yield response compared to the current technique. The estimated yield is an average over representative years of regional climate.

Figure 16: “Intensive”, “Extensive” compared with “Current” techniques (EPIC simulations)

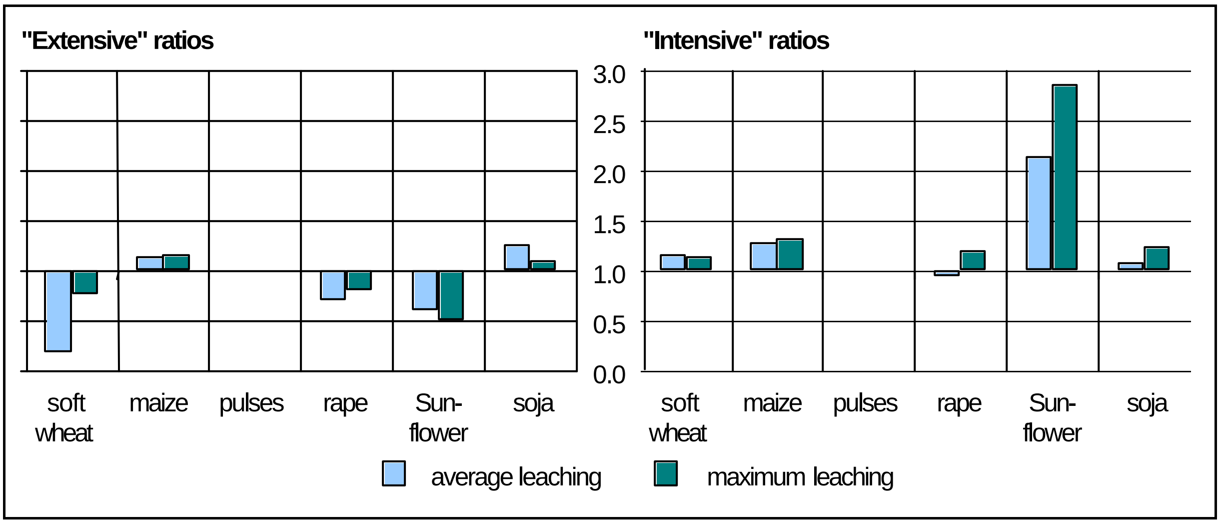


Input and output are quantitatively defined (except number of treatments), so that results can be compared to the first method (national survey). But remember that EPIC simulations use techniques defined by agronomists, and not actual practices of farmers.

Concerning cereals, input level differences between “Extensive” and “Current” techniques are higher than in the first survey. Indeed, lower yields are also due to worse soils or less efficient farm structures. Here, EPIC just simulates input effects and not soil variability, so that simulated yield variations are lower than observed ones. The case is similar for a comparison between “Intensive” and “Current” techniques. “Extensive” soya has a lower yield because “Current” technique is irrigated. Input decreases are generally more than proportional to output decreases. It shows that deep soil with high fertility can be cultivated with less input than currently and still maintain a good yield. This observation is confirmed by "Intensive" alternative results, where increases in inputs induce a less than proportional increases in yields.

EPIC takes into account that nitrate leaching is highly dependent on weather variability, soil conditions and agricultural practices. Accordingly, two indicators of nitrate pollution were used: "Average leaching" calculated on several years representative of regional climatic variability and the simulated "Maximum leaching". Figure 17 shows the ratios between average and maximum leaching simulated for the two alternative and the "Current" techniques. These ratios indicate not only variations in average pollution related to technical changes but also punctual risks of high pollution, highly variable with local climatic and soil conditions or irrigation.

Figure 17: Comparison between average (resp. maximum) nitrate leaching related to alternatives and "Current" technique (EPIC simulation)



The high pollution effect in intensive irrigated sunflowers relates to the low yield and nutrient absorption responsiveness of that crop to increased fertilising levels. Extensive maize was defined with nitrate input similar to current technique, the increased nitrate leaching is based on decreased yields as other input become limiting factors. Concerning soya, the suppression of irrigation provokes an important decrease in yield, so that water limits nitrate absorption in this case and induces a higher leaching. Generally, the effect on input variations is higher on maximum leaching compared to the average.

To complete this simulation, the influence of policy measures on farmer's behaviour and input management is analysed based on nitrate balances before and after the implementation of the 1992 CAP reform. Figure 18 shows nitrate balances in 1988, 1995 and 1997, in kg per ha of total usable agricultural area. This is a simple balance calculated per NUTS II region using

- herd size and manure production per animal;
- mineral nitrate quantities applied on crops
- crop specific intake, yield and area

One observes that levels of nitrate imports and exports are lower in Midi-Pyrénées compared to the French average and that the CAP reform induced a decrease in mineral nitrate fertilising. But this decrease is observed on total agricultural area and partly due to the "set-aside effect". When looking at nitrate applied on the residual area (excluding set-aside), we observed first a decrease in 1995 and then an increase in 1997 compared to 1988 levels (Figure 19). Apparently, farmers reduced their nitrate input directly after the reform, but moved towards intensification again in 1997.

Figure 18: Nitrate balance evolution in kg/ ha of Usable Agricultural Area (UAA)

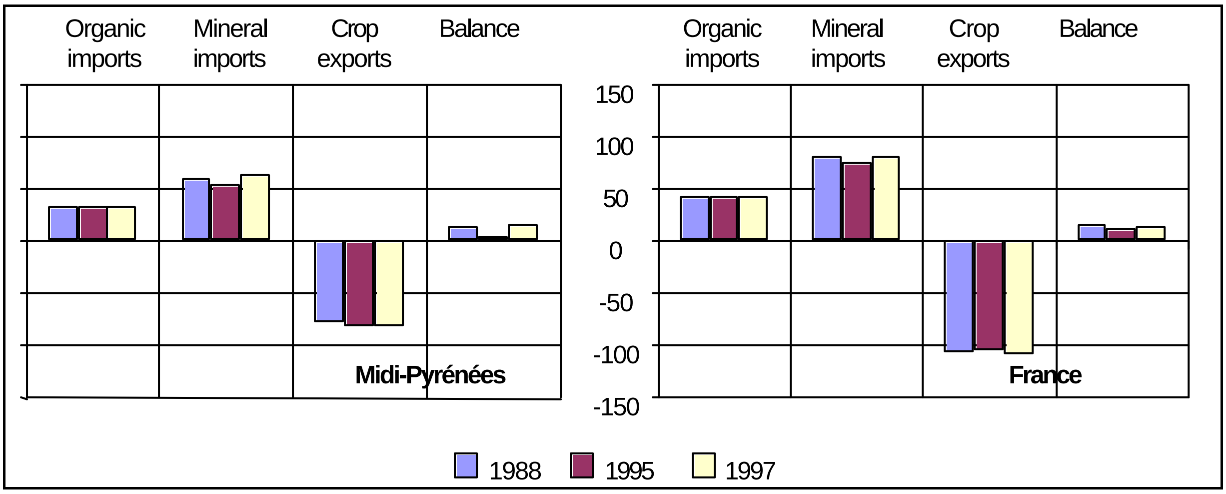
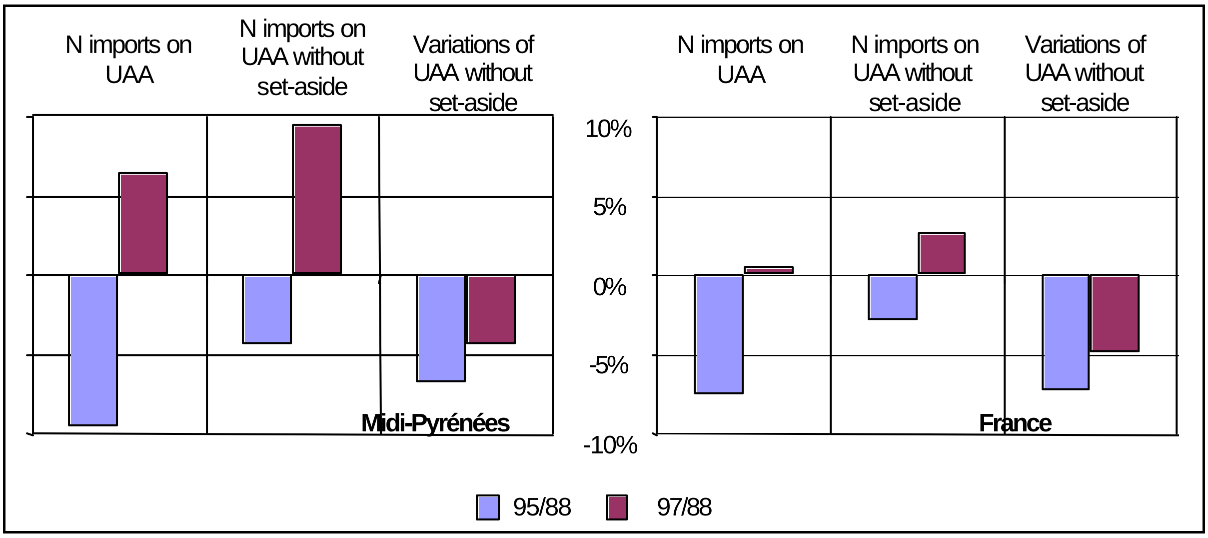


Figure 19: Variations (base 1988) of mineral N-fertiliser on UAA, with or without set-aside



Apart from the direct use of crop growth models as EPIC in the context of environmental indicators, another possible applications is to simulate new techniques in regions where they are not yet applied by farmers, or not even experimentally evaluated. By coupling EPIC results with economic farm models, one could test farmer's potential interest for this new technique, or one could search for the premium necessary to make this alternative attractive for this type of farm. In a PMP calibrated farm or sector model the evaluation of new techniques is problematic, since the calibration procedure relies on observed behaviour which does not exist for these technologies.

Furthermore, one could use EPIC to simulate average regional yield of an average technique on an agronomic basis, explicitly accounting for the distribution of cropping conditions in the region. One would need data on the distribution of soils, climate and techniques, in order to simulate the distribution of related technologies across the area. Then, PMP parameters could be calculated based on observed regional distribution of technologies by farm type. Resulting parameters could represent “non agronomic” constraints, like structural or social constraints to adopt a certain technology for the specific farm type. Following, the evolution of PMP parameters in an economical context could be analysed.

Even if the application of crop growth models offers interesting avenues, two major drawbacks in the context of aggregated models are the tremendous data need on soil, climate and individual techniques and the work load connected to calibrate the models to observed yields. Another problem relates to the fact that crop growth models simulate rotations and not single crops, which increases the data need to cover the often highly diversified production program in the model's regions. Further on, environmental results as nitrate leaching are typically so far not calibrated, as data e.g. on observed nitrate leaching are scarce and quite costly to produce.

2.3.6 Evaluation of Additional Indicators

Two additional indicators were evaluated in the context of data availability and other specifics aspects of the project:

- Bio-diversity indicator, and
- Input of plant protection products

In the case of the *bio-diversity indicator*, experience was gained in the context of the RAUMIS project (VON KAMPEN 1991), an agricultural sector model for Germany which distinguishes about 400 regions. Two factors lead to the conclusion that such an approach is not suitable for a system such as CAPRI: (1) bio-diversity depends to a large extent on spot specific conditions, for example the size of field margins or the spread of landscape elements such as hedges, which differ already drastically at local level. European data bases on such features are currently non-existing, and an aggregation to NUTS II level would not be meaningful. (2) The impact of agricultural policy on these factors is quite complex and cannot be captured with a modelling system as CAPRI alone. The direct impact of simulated rotational changes on bio-diversity is of minor importance, at least for any currently realistic scenarios.

At first glance, *input of plant protection products* looks like a more promising candidate. Again, there is experience from the RAUMIS system (DEHIO 1993). According to European legislation, yearly time series on total domestic use of aggregates as herbicides, fungicides etc. are reported at Member State level (SCHMIDT, HOLZMANNN & ALISCH 1999). Assuming prices for the different categories, a combination of these physical data with data from EAA and estimates of input coefficients for each crop activity allows to estimate the input in each region, both ex-post and ex-ante, based on ex-post consistency at national level. An application of Cross Entropy techniques to Germany, where expectated values for the input coefficients were based on questionnaire data of

ZSCHALER, RUBACH, ENZIAN & WITTCHEN (1995), however showed large differences between reported domestic use and aggregation across regions and activities. The deviations exceeded by far results obtained from applying similar approaches to fertiliser use. Furthermore, and perhaps still more important, the statistics relate to sold product weights of aggregated categories, independent from the possible environmental harm related to individual chemicals. Additionally, the reported weights depend on the form the products are marketed, for example as powder or dissolved. According to an oral information from the Biological Research Institute for Agriculture and Forestry, responsible for the compilation of the statistics in Germany, (1) technical progress leads to a high variability regarding the active ingredients over time and (2) there is no direct link between the potential damage and product weight. Consequently, the application of an indicator on this statistical base was deemed unsuitable.

2.4 Exploitation Module

2.4.1 Overall Concept

Single data items stored in the CAPRI data base, regardless whether they represent ex-post observation or ex-ante results, have a very limited value in themselves. Their "user value" depends on how quickly and how flexible *information* can be generated by the process termed "exploitation". Exploitation comprises the possibilities to access, aggregate, and visualise data items, to relate them among one another, and to obtain interpretations. The design of appropriate exploitation tools and strategies is, therefore, a key factor for the success of an information system such as CAPRI.

Given the large number of data items and dimensions (regions, years, products, items, scenarios etc.) in the CAPRI data base, this task is quite demanding. It is further complicated by the necessity to serve different user groups, for example model builders debugging programs, agricultural economists performing ex-post analyses of regional developments, officials looking at aggregated model results, and eventually at a later stage, politicians analysing policy options based on simulation runs. Consequently, only an adequate mix of different instruments and standardised exploitation routines can fulfil the task.

Following, the two main instruments for data access, visualisation, and export used in CAPRI, the multi-dimensional Data viewer *DAOUT* and the *CAPRI-mapping tool* are presented. Subsequently, standardised exploitation routines are described.

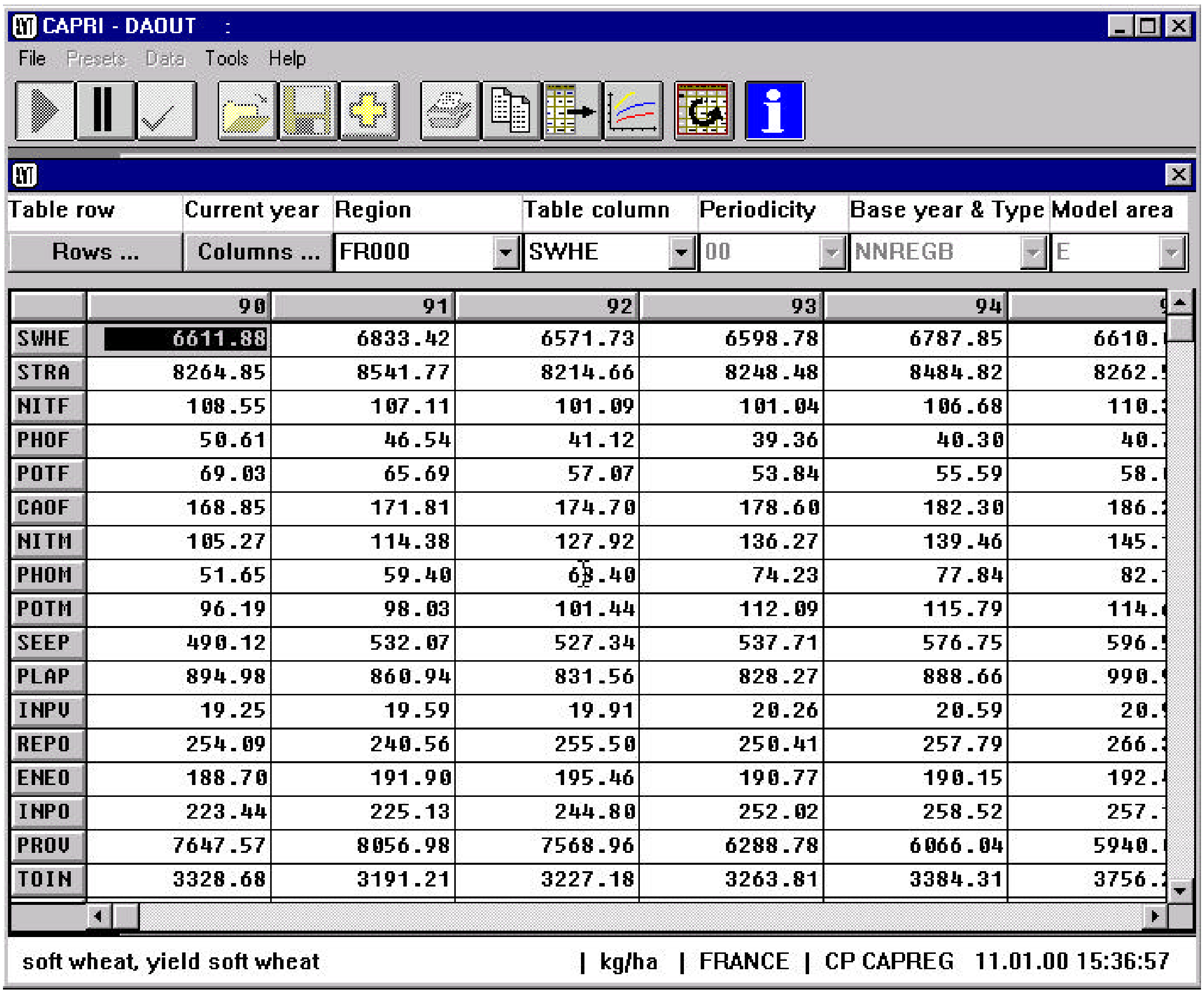
2.4.2 Multi-dimensional Viewer: DAOUT

The maintenance and development of the CAPRI system asked for an instrument which allows quick access to all possible data items in the CAPRI data base and to view them in the most flexible way.

A dazzling problem when designing such a viewer is the fact that a computer screen or a piece of paper is restricted to two dimensions whereas the CAPRI data base features many more, for example regions, years, production activities, input/output coefficients. The well known but unsatisfactory answer to the problem is *stacking*, i.e. to present results as a sequence of pages with two-dimensional tables. In spreadsheet software, data would be organised in rows, columns, and sheets of a work book. However, many programs require a considerable number of working steps to re-organise the mapping between original data dimensions and the view port. For example, data in a spreadsheet work book could be organised so that each sheet relates to a specific region and production activity, the rows in each sheet to input/output coefficients and its columns to years. If the need arises to compare, for example, the fertiliser input of a specific activity between regions, a series of error-prone copy and transform steps is required in order to show the data as needed. With a DBMS such as MS ACCESS, the process is perhaps less cumbersome because one just needs to define a new query and re-load the data, but these instruments are not widely known.

Fortunately, CAPRI was not the first project facing the problem and the programming team at the Institute of Agricultural Policy had a ready-to-use tool named DAOUT available which is designed to handle the task. Its main feature is a powerful and simple dialogue that maps the original data dimensions such as years, regions etc. "on the fly" to columns, rows, and tables of the view port. This allows, for example, to change from a comparison of output coefficients across regions to a comparison across time in a few seconds. Furthermore, a button allows immediate switching between a spreadsheet view and a graph of selected data items. The graphing routine additionally provides summary statistics of the underlying data.

Figure 20: Screen shot of user interface of DAOUT



	90	91	92	93	94	9
SWHE	6611.88	6833.42	6571.73	6598.78	6787.85	6610.
STRA	8264.85	8541.77	8214.66	8248.48	8484.82	8262.
NITF	108.55	107.11	101.09	101.04	106.68	110.
PHOF	50.61	46.54	41.12	39.36	40.30	40.
POTF	69.03	65.69	57.07	53.84	55.59	58.
CAOF	168.85	171.81	174.70	178.60	182.30	186.
NITM	105.27	114.38	127.92	136.27	139.46	145.
PHOM	51.65	59.40	68.40	74.23	77.84	82.
POTM	96.19	98.03	101.44	112.09	115.79	114.
SEEP	490.12	532.07	527.34	537.71	576.75	596.
PLAP	894.98	860.94	831.56	828.27	888.66	990.
INPV	19.25	19.59	19.91	20.26	20.59	20.
REPO	254.09	240.56	255.50	250.41	257.79	266.
ENEO	188.70	191.90	195.46	190.77	190.15	192.
INPO	223.44	225.13	244.80	252.02	258.52	257.
PROV	7647.57	8056.98	7568.96	6288.78	6066.04	5940.
TOIN	3328.68	3191.21	3227.18	3263.81	3384.31	3756.

Another important feature of DAOUT is the data export flexibility. Data can be exported in the way they are currently arranged in the viewer to different file formats: CSV (for import into spreadsheets or DBMS), GAMS table format, HTML internet format in order to present data on an internet page, and a simple table format which, for example, can be imported into word documents. Additionally, data from the current front table, restricted to a certain selection if desired, can be exported to the clipboard.

2.4.3 Mapping Tools

A specific challenge in order to analyse and exploit the results of CAPRI relates to the deep regionalisation into 200 NUTS 2 regions. Maps are much more suited for this task than tables or graphs. Manifold technical solutions to produce maps exist and some of them are used in the context of the project:

1. *Geographical Information Systems* (GIS). The co-ordinating team in Bonn used the product MAPINFO (MAPINFO CORPORATION 1998) to adjust the resolution and regional aggregation level of the co-ordinate set bought from EUROSTAT, to integrate co-ordinates for Norway and Switzerland and to export the resulting co-ordinates set to other applications such as MS Excel. GIS software is relatively expensive and still not widely used as a tool in agricultural sector modelling. The CAPRI project manages only statistical data relating to a uniform set of administrative units. Therefore, GIS features going beyond pure mapping of polygon related data are currently not of interest to the CAPRI network. Hence, GIS are not the best-suited mapping tool for the project. Instead, cheaper and more easy-to-use instruments were necessary.

2. *Built-in mapping tools of MicroSoft Excel® (MircoSoft Map® 8.0 by Mapinfo).* In opposite to a GIS, the mapping tool of EXCEL, included free-of-charge, was a more promising candidate for the visualisation of spatial data in the project. Almost all kind of users with an interest in the project have access to EXCEL and are familiar with it. Hence, a co-ordinate set technically suited for the EXCEL mapping tool was distributed to the network together with an spreadsheet showing how to use the tool. However, before any data can be mapped, they first need to be retrieved from the CAPRI data base and loaded manually into a spreadsheet, an important draw-back if a larger number of items shall be visualised.

3. *Third party add-ins.* For example, the *MicroSoft Access®* add-in was used by the Italian team to present results on environmental indicators during the final meeting. These powerful tools are not royalty free, and the range of researchers familiar with both the DBMS such as Microsoft Access and these mapping tools is quite limited.

As all solutions mentioned above show certain disadvantages, a fourth solution was developed where fast and easy-to-use access to CAPRI results for a broad range of users was the main issue. A JAVA applet was chosen as the technical solution due to the following features:

1. *License free and platform independent:* in order to run the applet, the user only needs an internet browser. Both data and co-ordinates are stored in portable comma separated files (CSV format). Input files can be created, if necessary, by a broad range of applications, including spreadsheets and DBMS. In the case of CAPRI, the GAMS program used for simulation automatically creates aggregates and selects interesting data for visualisation and analysis and stores them in appropriate files.

2. *Menu driven, easy-to-use interfac*e which especially allows to switch quickly between different data items. As the tool switches - transparently for the user - between different input files, input data can be distributed over an appropriate number of input files in order to optimise the data traffic flow between the client front-end and the server hosting the data.

3. *Simultaneous overview*: regional data are both mapped and presented as a GINI diagram showing their distribution, national and EU data are presented as table and bar chart, see below for an example.

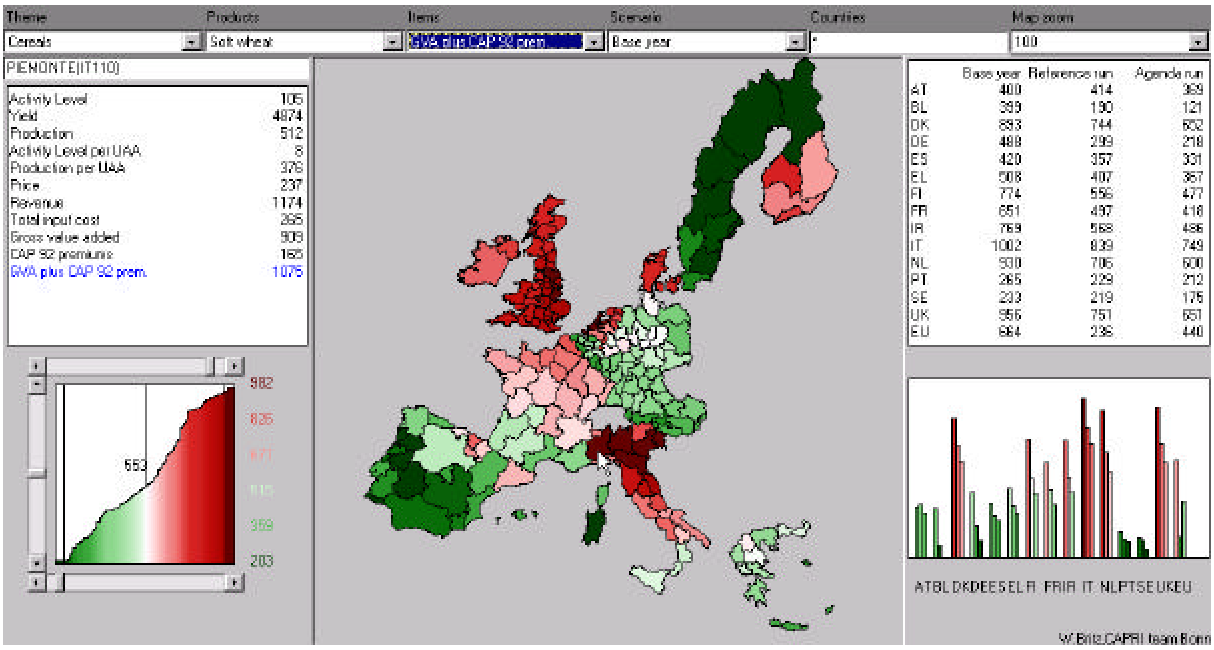
4. *Regional informer*: by moving the mouse over a region, a selection of important data relating to the selected data item are presented for the current region.

5. *Automatic calculation* of relative differences between base year and one or several simulation runs.

6. *Integration into HTML* allows to use the tool in the context of a hypertext information system, for example linked to a methodological documentation.

Figure 21 shows a screen-shot of the tool at work. The upper part contains the scroll down boxes which allow to select specific data items. The map of the NUTS II regions is located in the centre. The user may zoom into the map or restrict it to certain countries or regions. On the upper left side, the regional informer reports data relating to region with the mouse focus, here Piemonte, a northern Italian region is selected. Below the regional informer, a GINI diagram presents the distribution of the current data item over all the regions and allows to relate the colours in the map to numeric values. The scrollbar around the GINI diagram allow to set the upper and lower limit of the data range as well as the data value shown in white. On the right side of the screen, weighted national and EU averages for the base year and two simulation runs are presented as a table and a bar chart.

Figure 21: Screen shot of the CAPRI mapping tool



2.4.4 Standardised Exploitation Routines

In many cases, specific user group exploitation requires an appropriate selection and aggregation. If the informational need of different user group is known, and similar queries are frequently repeated, the working steps of data selection, retrieval, aggregation and preparation of tables, graphs or maps etc. should be mechanised. Naturally, as the CAPRI information system just enters the operational phase, no too much is known about possible future users and their needs. The current available standardised exploitation tools are therefore based on earlier experiences with similar systems or relate to the informational need of the CAPRI team members.

So far, the mapping tool was used as the main channel for such standard exploitations. The data selection and aggregation is pre-defined in a GAMS based module automatically called when a simulation run is performed. Regarding the regional dimension, the current standard exploitation covers the aggregation of NUTS II data to weighted national and EU wide values. Products and activities are both grouped and aggregated, for each activity and activity group, its level, yield, price, revenue, costs and premiums can be selected. Additionally, the exploitation covers the elements of the nutrient balances and green house gas emissions. Not at least, regional agricultural income indicators such as revenues, costs and gross value added, broken down to production branches, are covered.

Since users are often not familiar with the CAPRI data base they may run into problems with the four character abbreviations used to code the data items in the data base and programs. Therefore, these internal codes are translated wherever necessary to long texts in the standard exploitation routines.

2.4.5 Written Analysis

The most extensive (and expensive) form of exploiting data and results is done by written analyses. They allow to incorporate information from outside the system, to structure the information according to the analysts assessment, and to provide interpretations without requiring the reader to understand the details of the underlying complex information system. They imply, however, a reduced flexibility for the user compared to "self-driven" exploitation tools describes above. The CAPRI team prepared written analyses in two ways: (1) an ex-post analysis of the '92 reform, and (2) an analysis of simulation results to show that the system is operational.

The ex-post analysis relating to the regional cluster of each partner was presented at the 4th CAPRI workshop in Galway, Ireland, and later on edited and published as a CAPRI working paper (CAPRI TEAM 1999). Selected results of the simulation runs were presented and analysed during the final CAPRI meeting in Bonn, December 1999. They main findings are presented later on in this report.

2.5 Complementary Modelling activities and case studies

2.5.1 Trends on Labour Input

Although the effect of labour input is currently covered by the PMP calibration techniques and not by restrictions or explicit cost formulation, the further development of agricultural labour input (measured in Agricultural

Working Units, AWU) plays a major role in analysing the available income of farm households (STEELE, GARVEY 2000). Ex-post, one observes a decline in all Member States, which has been steepest (from 1988 to 1998) in Germany, Austria and Portugal, at approximately 5% per annum. However, the historic decline has nearly stopped in the Netherlands (an average decline of .6% per annum) and varies between 1.5% and 4% for the other EU countries. These developments are the sum of separate declines in non-family and family labour. The rates of decline of family labour AWU's were faster than those in non-family AWU's (from 1979 to 1995) in the following countries: Belgium, Holland, Greece, Spain, France, Luxembourg, the Netherlands, Austria, Finland and Sweden.

These national trends in total AWU's have been employed by the Galway team to project developments to the year 2005, the reference run date for the CAPRI model. Due to insufficient data at regional level, regional trends are based on relative development at national level. The method used to calculate the trend values was to regress the log of national AWU on time, using observations from 1988 to 1998, and subsequently to extrapolating the series to 2005 based on these estimates. The decline between 1994 and 2005 (the relevant period for model simulations) is forecasted to be higher than 30% for Germany, Austria, Finland, Portugal, Italy, France, Greece and Luxembourg. AWU's in Holland and the UK are forecasted to decline the least during this period.

2.5.2 Application of CAPRI to Switzerland

Because of discussions concerning Switzerland's possible future accession to the European Union, there is a basic interest in gathering information on the effects this could have on the Swiss agricultural sector.

Model specifications

The simulation analysis is based on the results of the supply model, without taking into account market feedbacks. This procedure is applied because the impact of Switzerland's accession to the EU on EU-market prices is considered to be minimal.

The different political and the agricultural settings in Switzerland and in the EU Member States (production structure, geographical conditions) have made specific model adaptations necessary. Modifications of the CAPRI model comprised:

- Formulation and implementation of specific Swiss political variables
- Establishment of a technology module for the differentiated definition of individual production alternatives (alternative technologies), in order to represent important measures of farm policy in Switzerland
- Integration of additional programming modules for the representation of special political conditions.

Political variables: In principle, Swiss national farm policy is similar to the one in the EU. The Swiss system of subsidies, however, is more directed towards environmental objectives. Therefore, the political variables (basically, the direct payments) had to be collected and allocated to the production activities. Furthermore, the political variables of the base year 1994 differ from those of the target year 2005, because of the Swiss agricultural reform in process, i.e. the complete restructuring of large portions of the Swiss direct payments system in 2005.

Technology module: In addition to differences in historical development, Swiss production structure is marked by its farm policy and the considerable variation of geographic conditions. This led to the adoption of farming methods that are more varied than those practised in the EU. Therefore, the technology module permits deviations from traditional procedures practised within the scope of the model, thereby taking into account the following characteristics:

- Definition of fallow and grassland specific farming alternatives as well as alternatives regarding the possibility of exclusive organic plant cultivation.
- The entire surface of fallow land in Switzerland was divided into green fallow and mixed fallow land as well as into extensively managed meadows on set-aside arable land. Payments differ according to category. Moreover, in organic farming, it is also possible to apply extensification alternatives.
- With regard to alternative farming methods (organic agriculture), input coefficients were homogeneously modified for all plant cultivation activities. Consequently, a drop in yield of 25% or the fertilisation restriction "no fertilisation with nitrate" were taken into consideration in the calculation of payments for organic farming, as opposed to traditional farming.

Additional programming modules: The regulations laid down by agricultural policy which could not be determined as political variables within the scope of the corresponding module (CAPPOL), were added to the basic program structure in form of an additional module. In most of the cases, these are additional farming policy restrictions within the context of additional payment claims. In particular:

- Payment claims for roughage consuming animals, which depend on a certain stocking density. These restrictions differ in intensity, according to species and farming region.
- The following animals entitle farmers to receive payments: sheep (milk and mutton sheep), goats (milk and mutton goats), and cattle (dairy cows, calves, mother cows, and bulls) - up to an average of 2 LU / ha of grassland.
- The restrictions with regard to LU stocking density decrease to 0.6 LU / ha of grassland in the highest mountain regions. In certain regions, very strict compliance with them is enforced.

Definition of scenarios

Different scenarios were defined in order to assess the potential effects of Switzerland's accession to the EU. A reference situation in the year 2005 was compared to Switzerland's integration into the EU. The reference situation of Switzerland's "no EU-accession" is characterised by the following assumptions:

- An agricultural reform is undergoing in Switzerland. Therefore, the political variables of the base year 1994 will change until 2005.
- With regard to certain alternatives (technology module), in view of their technical implementation, simplifying assumptions had to be made. Taking into consideration alternative types of farming in particular, the alternative "organic farming" had to be defined for cultivation as such, without taking into account individual plant cultivation activities in a differentiated manner.

- Exogenous price assumptions for the years 1994 and 2005 were taken from the national sector model SILAS. However, as for the production activities taken into account in the CAPRI model (which did not make use of information from the SILAS model), an average price reduction of 25% in the year 2005, as compared to the year 1994, was assumed.

The simulation scenario "Full membership" was based on the following assumptions:

- The year 2005 simulation scenario comprises general EU settings in compliance with the reform program "Agenda 2000".
- It was assumed that prices in Switzerland would be the same as those in the EU.
- Switzerland has adopted the entire EU system of subsidies.
- As we limited our work to a pure supply analysis, it was assumed that EU-commodity prices would not be affected by the accession of Switzerland.

2.5.3 Specification of Alternative Technologies – A case Study for a French Region

The definition of alternative techniques in a sector model is a way to represent farm diversity, and may allow a more realistic allocational behaviour of the model by relaxing the assumption of fixed regional yields. Additionally, sets of input and output coefficients for environmentally friendly production systems can be used to explore the effect of related policy programs.

Generally, representative data on the distribution of input and output coefficients in a region are scarce. The underlying farm specific technical choice is a complex process taking into account factors as on-farm factor availability and quality, local market condition and policy programs. Whereas a full census is costly and eventually quite restricted in its data coverage as not all farms are able to report the allocation of inputs to different production activities, samples struggle with selecting representative farms. The presented case study evaluate different information sources to define alternative techniques and the effect on the model's allocational behaviour:

- a French national questionnaire on input and output coefficients in major French production regions
- a quite detailed, partially spot related regional questionnaire, and
- simulation results from the crop growth model EPIC.

The case study relates to Grandes Cultures in the region Midi-Pyrénées (south-west of France), chosen because (1) it contributes to national production of a large range of grandes cultures, (2) features a diversified farm structure and (3) its production program is similar to the national average. In addition, agronomists of INRA[3] validated an agronomic model (EPIC) for several crops in Midi-Pyrénées, allowing to simulate yields and nitrate leaching for different alternatives (this aspect is presented in section 2.3.5).

Using national statistics

A survey has been done in 1994 about grandes cultures cropping techniques in major producing regions. It was the first year of CAP reform implementation, so that the economical environment was quite uncertain for farmers. In order to secure their margin, farmers tended to reduce variable costs by adjusting input quantities to crop needs. This survey was used to specify a CAPRI technology module for French regions. Specification of alternative technology parameters are described below.

The survey « Agricultural practices in 1994 » (MINISTÈRE DE L'AGRICULTURE, SCEES 1996) concerns main grandes cultures in France : soft wheat, durum wheat, barley, maize (grain and forage), rape, sunflower, pea (for pulses). Data were collected in 67 departments (NUTS 3) from 19 regions (NUTS 2). General objectives of this survey were:

- to describe agricultural techniques (at plot level) in order to characterise farmers practices;
- to see farmers strategies in the context of limitation of agricultural production;
- to detect farmers attitudes towards environmental protection.

The survey chose representative regions for each crop, taking into account:

- the regional crop area compared to the national crop area;
- the regional crop area compared to the regional total area.

The survey is based on the data bank "Use of territory in 1994" (TERUTI), where observation points correspond to agricultural plots. For each crop surveyed, plots have been chosen in a systematic and randomised way. Each regional sample of plots is constructed to be representative of the region's size, crop levels and yields. Farmers who owns these plots were asked to fill out a questionnaire on their cropping techniques. Climatic conditions in 1993-1994 were fortunately quite typical, however, strong rain in winter and spring delayed some agricultural tasks. More critical is the fact that the data cover the first year of '92 CAP reform implementation, so that farmers acted in a partially new economic environment. Generally, a reduction in inputs can be observed in the first years of the reform which was re-corrected in subsequent years.

The resulting data items of this survey are plots, characterised by their area, level of inputs, practices, and outputs. The area surveyed can then be distributed by range of input or output quantities.

On the base of this survey, three different technologies are defined representing the areas connected to 20% lowest, 60 % medium and 20 % highest yields. Data relate to the input use of seeds ($P_{S,i}$), mineral nitrate ($P_{N,j}$), mineral phosphate ($P_{P,j}$), mineral potassium ($P_{K,j}$), number of plant protection treatments ($P_{T,j}$) as well as the yield coefficients. Input and output coefficients for the medium technique were defined as to ensure consistency

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to the regional average observed. The resulting ratios show variations between the low and high yield alternative technologies compared to the average. The results are described in section 3.3.1.

Data from this survey were used to specify parameters for different technologies for each of the Grandes Cultures for French regions.

Using regional information

For the second approach regional information was used: a survey of agricultural practices was done in 1994 by the Regional Chamber of Agriculture in Midi-Pyrénées (CHAMBRE RÉGIONALE D'AGRICULTURE DE MIDI-PYRÉNÉES, CHAMBRE D'AGRICULTURE DE HAUTE-GARONNE ET DU TARN 1996). Data has been collected for farms of two departments (NUTS 3) of this region.

The survey's objective was to define factors determining economic and technical farm results. These data are useful to complement the preceding approach with the economic dimension of farmers technical choice. Indeed, economic parameters are of great importance for the evolution of technologies. However, since the two surveys are not homogenous, this second analysis is not included in CAPRI core model. The results are described in section 3.3.1 as well.

3 RESULTS

The CAPRI project provides the unique possibility to analyse the agricultural sector of the European Union at regional level based on a consistent and comprehensive data base and by the mean of an EU-wide medium term simulation model. In this chapter, an ex-post analyses of the CAP reform of 1992 and the results of a CAPRI model simulation comparing the previous CAP with Agenda 2000 are described. The latter proofs that the CAPRI core model represents an operational tool to simultaneously model regional, national and EU-policy measures and analyse their impacts on the agricultural sectors of these aggregates. The chapter is concluded by results of various complementary modelling exercises and case studies introduced and motivated above. It should be noted here, that - apart from the CAPRI core model results - the contents of this chapter are summaries or selected presentations of results from more extensive CAPRI working papers. They serve to illustrate the analytical potential of the CAPRI data base and model.

3.1 Data Base Analysis

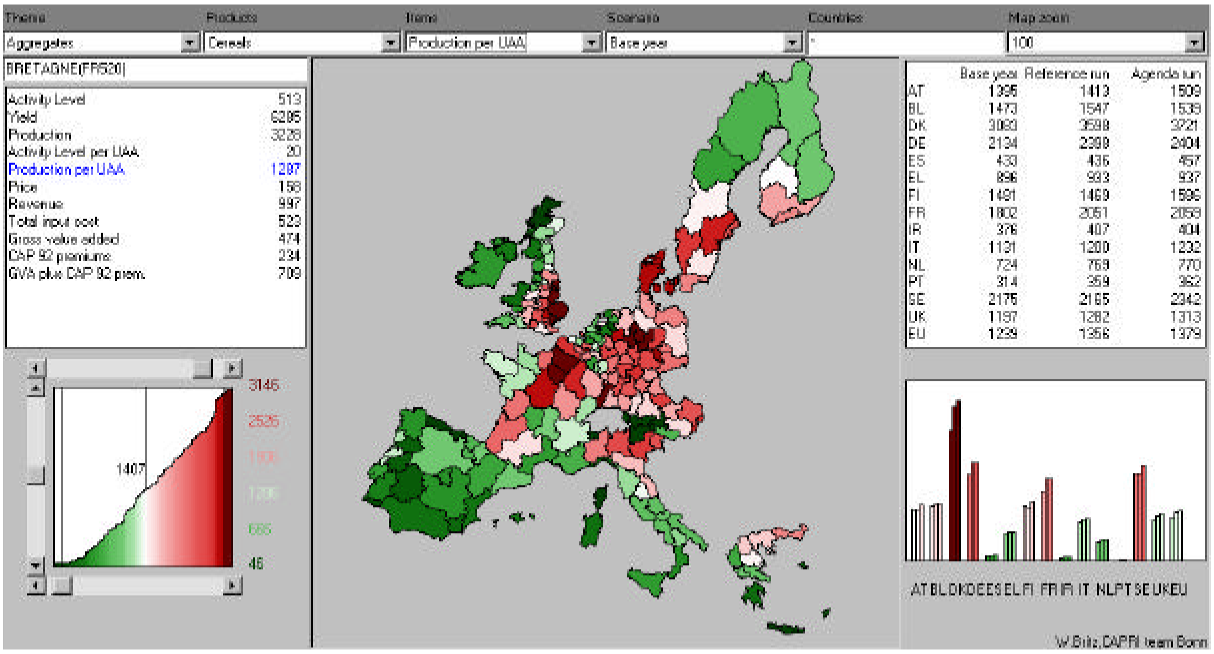
3.1.1 Production Structure in the EU

In order to analyse the regional impacts of market oriented policy instruments, indicators are necessary to show which regions are affected most. Especially production shares are well suited for this purpose. In opposite to national values, a regional disaggregation at NUTS II allows for a more in-depth analysis within the more important producing countries. For example, the analysis can show whether production volumes are evenly distributed or are rather concentrated in a few regions. Also, in Member States with small production values for a certain product, regions with a relatively important production volume may be identified.

The CAP-reform 1992 as well as Agenda 2000 focus on cereals, oilseeds and beef. Therefore, the following descriptive overview looks at production and activity levels per ha utilised agricultural area in the NUTS II regions of the EU to identify important producing regions of these products.

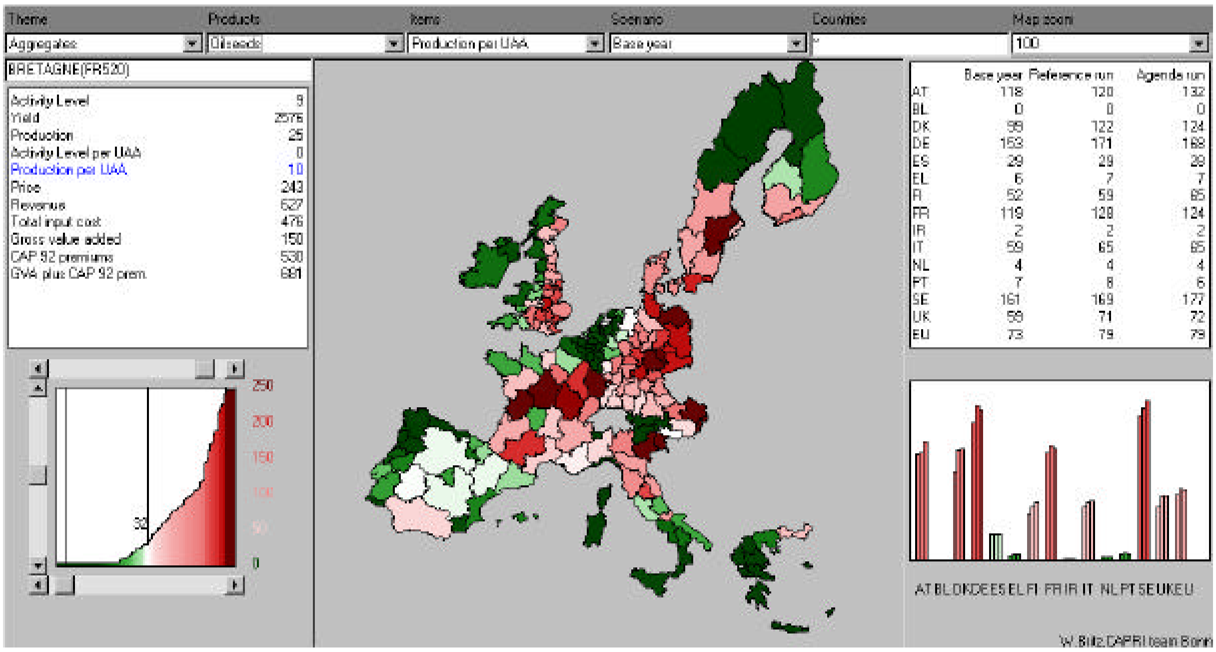
Figure 22 presents cereal production in kg per ha utilised agricultural area. Generally, high values are linked to high shares of cereals in the rotation and/or high yields. With regard to the main producing countries, one can observe that the bulk of French cereal production originates in the north-west corner of the country. Germany – after France the most important cereal producer in the EU – however, is characterised by a relatively homogeneous production structure with a production cluster in the south-east of Lower Saxony. In the case of Italy, higher production per ha is observed in the north. The United Kingdom presents higher levels for cereal production per ha in the south-east counties of England, whilst the rest of the country, as well as Ireland, observes a relatively low concentration of cereal production. Spain and Portugal also observe relatively low but homogeneous distribution of cereal production. With respect to other Member States, Denmark, the southern halves of Finland and Sweden and the north-east corner of Greece present high values, whilst the Netherlands, Belgium and the remaining parts of the other countries observe relatively low production shares. One of the immediate results from this analysis relates to the fact that changes in cereal prices or premiums will have a sharp affect mainly on Germany and Denmark and some high productive regions in France, England and Northern Italy. Regional impacts, for example in France as the European Unions largest cereal producer, will vary considerably.

Figure 22: Production of cereals per utilised agricultural area in kg/ha in the base year



The territorial distribution of oilseeds (shown in Figure 23), on the other hand, presents a far more inhomogeneous distribution of production. In a greater number of regions no oilseeds at all are cultivated. The highest values of oilseed production per ha are recognised in east Germany, in most of the northern French regions, northern Italy, east Austria and in east England. High values are also observed in Denmark and southern parts of Sweden and Finland. Lowest values are found in the Netherlands, Belgium, Portugal, Ireland and in the south of Italy and Greece. Many important oilseed production regions coincide with high production shares of cereals. Consequently, a high substitution between these two production branches is likely, and parallel policy changes in both sectors will favour or disfavour a quite distinct set of regions.

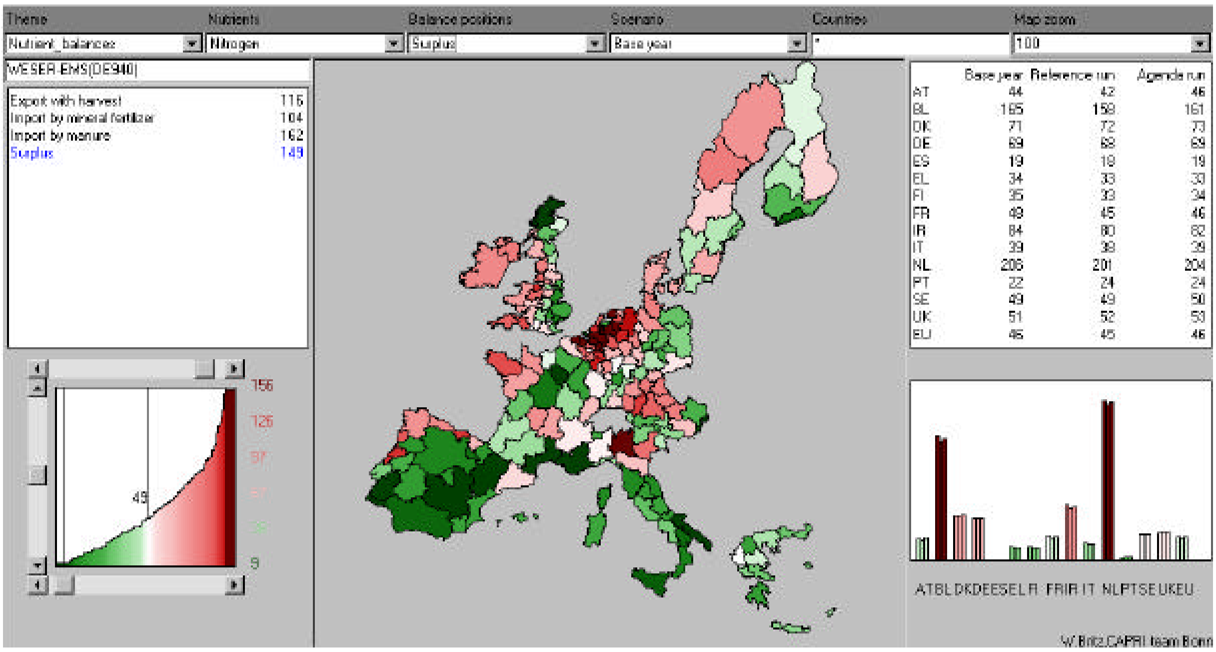
Figure 23: Production of oilseeds per utilised agricultural area in kg/ha in the base year



Based on the collected data, environmental indicators can be calculated according to the methodology presented in section 2.3. As an example, the nitrogen surplus per ha is presented in Figure 24. Regional high values of nitrogen surplus are observed in the Netherlands, Belgium, north-west France (mainly Brittany), north-west and south-east Germany, west England and Wales, Denmark, north Italy and in the Atlantic-coastal regions in Spain and Portugal. Comparing the surplus with the regional nitrogen output from animal production makes it obvious that the stocking density is the key determining factor whereas intensive crop production is of minor importance in this context. Consequently, political measures directed towards reducing the environmental impact of manure output from animal production may be a more promising avenue to reduce groundwater contamination with nitrogen compared to an extensification of crop production. However, the analysis of specific threats and the definition of appropriate policy measures depend on local conditions and go beyond the analytical potential of the CAPRI data base.

Because of the direct connection between nitrogen surplus and animal production, figure 24 resembles the map of stocking densities in the EU. High stocking densities in pork fattening and pig breeding are observed in Belgium, the Netherlands, north-west Germany, Denmark, and Catalonia in Spain. Centres of poultry and egg production are generally located in the same regions, but more concentrated in the Netherlands and additionally in north Italy and Brittany. In contrast, cattle production is more evenly distributed. High stocking densities can be observed in Belgium, the Netherlands, north-west Germany, Bavaria, Denmark, Ireland, west England, north Italy and in the north-west corner of Spain. Instead of cattle production some Mediterranean and southern regions, namely Mediterranean France, central and parts of Mediterranean Spain, and southern Greece are specialised in ewes and goats keeping. But this is a more "extensive" production system so that the stocking density is much lower than in regions with intensive cattle or pork production.

Figure 24: Nitrogen surplus in kg/ha in the base year



The examples discussed above show that simply visualising the regional distribution of agricultural activities across Europe can already hint at the general regional impact of sub-sector related policy instruments. The next section presents a summary of an ex-post analysis of the 92 CAP reform's impact on regional production structure in the EU (CARPI-Team 1999).

3.1.2 Impacts of the CAP Reform 1992

The main instruments of the 92 reform in the cereal and oilseed sector were a reduction of intervention prices, the introduction of area premiums (as compensation) and set aside obligations. In this sectors, clear effects can be observed already in the first years of the reform. Adjustments of policy instruments in the cattle sector have a delayed impact due to the longer production process and could not be assessed with a pure ex-post analysis.

The reform lead to a clear reduction of cereal areas in the European Union caused by the set-aside policy, whereas the oilseed area stayed relatively constant. At regional level different developments took place: oilseed area was increased relative to cereals area in east-Germany, United Kingdom, Ireland and in the southern regions of the EU. The opposite effect was observed in West-Germany, Denmark, the Netherlands, North-Italy and in some French regions. What are the reasons for the regional differences? Analyses showed, that the change of revenues/ha can not fully explain the producer reactions, other factors are also important. Regional changes in the production structure of cereals and oilseeds depend very much on the small producer share, the soil quality, the relation of cereal and oilseed premiums and on some regionally specific conditions:

- The reunification of Germany lead to drastic changes of crop rotations in the eastern part. Especially the level of oilseeds increased. Therefore, these developments cannot be compared with other regions.

- In Spain climatic conditions have a considerable impact. Due to a drought period from 1993 to 1996 there was a strong substitution of cereals by oilseeds in farmer's seeding decisions.
- The rape area in France and Germany is strongly influenced by the possible cultivation of non-food oilseeds on set aside area. In 1995, 40% of French rape area is grown on set aside for industrial use, especially in the most productive regions (Bassin Parisien, Grand Ouest).
- The production of soy beans (concentrated in north-east Italy) decreased, because the cultivated area for soy beans is irrigated and in the last years farmers preferred maize production because of higher income levels.
- Maize area generally increased due to favourable prices and even more in regions with a specific premium.

How important regionally specific conditions or policies are, can be clearly seen in the case of some (at first glance) general developments/agreements as, for example, the change of area premiums. The basic amounts of premiums per tonne of historical yield are in fact the same in all regions, but special regional adjustments have a great impact on the regional area response. The CAPRI team is aware of these specialities and integrated them into the model for the ex-ante analyses (e.g. adjustment of historic yields in Spain in 1998, supplementary area payments for durum wheat in specific regions, additional suckler cow premiums in some member states, ...).

3.2 CAPRI Model Results

An explorative application of the CAPRI modelling system (described in section 2) proved that the system is operational and shows the potential of the information system for ex-ante analysis. It is designed to model impacts of an Agenda 2000 scenario (simulation run) compared to a continuation of the status quo policy for the European agricultural sector (reference run) for the year 2005.

The subsequent description of model results focuses at first on the product group cereals and oilseeds and then on the beef and dairy sector, as the main target sectors of Agenda 2000. For each sector EU-level results as well as regional impacts are presented. In a supplementary illustration, projections of Mediterranean crops are described.

3.2.1 Cereals and Oilseeds Sector

The political instruments of both scenarios for cereals and oilseeds are presented in the following table. Note that premiums in table 7 represent averages weighted by observed (base year) and projected (reference and Agenda scenario) regional activity levels so that the resulting values are partly endogenous. Additionally, differences between base year and reference scenario are also caused by the third step of the 92 CAP reform which was not fully implemented in 1994.

Additionally other assumptions mainly relating to exogenous shifts from the base to the target year had to be made:

- Increased yields, inputs adjusted accordingly, but with input saving technical progress of 0.5 % by year

  + 1.33 % yield increase per year for cereals (EU average, regionalised at national level)

+ 1.45 % yield increase per year for oilseeds (EU average, regionalised at national level)

- All cereals and oilseeds receive premiums. It is assumed that all oilseeds are cultivated under the main scheme

- Small producer share kept constant at base year levels

Table 7: Political variables for Cereals and Oilseeds

	Base year 1994	Reference 2005 (% against base year)	Agenda 2005 (% against reference)
Cereals			
Intervention price	143.5	123.0	104.6
change		(-14%)	(-15%)
Average premium per ha	211.6	274.4	319.9
change		(30%)	(17%)
Oilseeds			
Average premium per ha	449.8	443.9	275.3
change		(-1%)	(-38%)
Set aside			
Set aside rate (in %)	14.0	17.5	10.0
Average premium per ha	289.0	315.0	303.4
change		(9%)	(-4%)

Impacts on EU level

Tables 8 and 9 present detailed model results for cropping activities with respect to levels and production, respectively. The main developments from the *base year 1994 to the reference scenario 2005* include a decrease of the cultivated cereal area by 6.7% to 32.6 million ha, mainly due to the increased set-aside rate from 14.0 to 17,5%. However, with technical progress driving up yields by about 1,3 % per year, the production is estimated to increase by 9.3% to about 192 million tons. As domestic demand decreased slightly, net exports and/or intervention sales need to expand (see Table 10). Simulated intervention prices for cereals in the reference run exceed world market prices, as in many studies. As a consequence, export subsidies are required and exports are limited by WTO restrictions. If an increase intervention stocks shall be avoided, either lower intervention prices or higher set-side rate are necessary.

Comparing *Agenda 2000 results to the reference run*, reduced set aside rates increase cereal production by 3.5% to 195.8 million tons. Lower prices cause extended domestic use, but do not affect EU's status as a cereal net exporter. In opposite to the reference scenario, world market prices for wheat are simulated to lay above intervention price level, allowing wheat exports without subsidies and WTO restrictions. However, the simulated difference between world market prices and the intervention price is rather small. With respect to barley, the intervention price is still above world market price implying continuing problems since exports would require subsidies and will be limited by WTO restrictions. Intervention sales are also necessary for rye and oats whereas maize can be exported without subsidies, so consequently exports rise up drastically from *reference run* to *Agenda 2000*.

Table 8: Crop production in Europe, Activity levels (in 1000 hectares)

	Base year 1994	Reference 2005	Agenda 2005	Change Reference to Base year	Change Agenda to Reference
Cereals (excl. rice)	35012	32663	33796	-6.7%	3.5%
Wheat	16018	14990	15230	-6.4%	1.6%
Soft wheat	13022	12191	12323	-6.4%	1.1%
Durum wheat	2996	2799	2907	-6.6%	3.9%
Coarse grains	18994	17673	18566	-7.0%	5.1%
Rye	1308	1195	1288	-8.6%	7.8%
Barley	11072	10352	10916	-6.5%	5.4%
Oats	2138	1881	2042	-12.0%	8.6%
Maize	3840	3637	3706	-5.3%	1.9%
Other cereals	637	607	614	-4.6%	1.1%
Pulses	1680	1676	1699	-0.2%	1.4%
Oilseeds	5273	5141	4848	-2.5%	-5.7%
Rapeseed	2258	2359	2165	4.5%	-8.2%
Sunflower seed	2740	2512	2415	-8.3%	-3.9%
Soya beans	274	270	269	-1.6%	-0.4%
Fodder, high yield	7086	6990	7263	-1.4%	3.9%
Fodder, low yield	7086	7288	7549	2.8%	3.6%
Non Food on set aside	618	935	777	51.3%	-16.9%
Fallow land	7502	7423	7681	-1.1%	3.5%
Set aside	4131	5468	4063	32.4%	-25.7%

Table 9: Crop production in Europe, Physical production (in 1000 tons)

	Base year 1994	Reference 2005	Agenda 2005	Change Reference to Base year	Change Agenda to Reference
Cereals (excl. rice)	175558	191844	195824	9.3%	2.1%
Wheat	85368	94384	95253	10.6%	0.9%
Soft wheat	77993	86326	86963	10.7%	0.7%
Durum wheat	7375	8058	8290	9.3%	2.9%
Coarse grains	90190	97460	100572	8.1%	3.2%
Rye	5242	5399	5644	3.0%	4.5%
Barley	44691	48487	50202	8.5%	3.5%
Oats	7203	7070	7555	-1.9%	6.9%
Maize	30063	33357	33992	11.0%	1.9%
Other cereals	2991	3147	3179	5.2%	1.0%
Pulses	5463	6159	6221	12.8%	1.0%
Oilseeds	10256	11917	11089	16.2%	-6.9%
Rapeseed	6004	7484	6828	24.7%	-8.8%
Sunflower seed	3366	3413	3246	1.4%	-4.9%
Soya beans	886	1020	1015	15.1%	-0.5%

The development of cereal domestic demand is mainly driven by the feed use. Feed use will decrease from the base year to 2005 (see Table 10), because the effect of an increased number of suckler cows, fattening pigs and laying hens is over-compensated by reduced levels of remaining animals and increased feed efficiency. There will be hardly any change in the amount of cereals used for human consumption up to 2005. In *Agenda 2000* the feed use will rise up slightly, due to the increased cattle herd.

In parallel to cereals, production of oilseeds is simulated to expand in the reference compared to the base year, mainly due to an estimated yield increase of 1.5% per annum. Part of the yield increase in the oilseeds aggregates relates to expansion of oilseeds in the northern parts of the Union, where rape seed dominates, featuring higher yields as sunflower seeds. The Agenda 2000 package decreases oilseed premium quite drastically to the level of cereal premiums. The loss of profitability results in an estimated 6 % reduction in oilseeds areas against reference run results. Compared to the drastic premium cut, the simulation response of the model may look at first glance too low. However, the following two aspects should be taken into account:

The obligatory set aside rate for oilseeds decreases from 17.5 % in the reference run to an average of less than 10 % in the Agenda scenario as the Blair House agreement is not longer in effect. Accordingly, oilseeds can now receive premiums under the small producer scheme which in turn results in a substantial drop of the effective set-aside rate for oilseeds in many regions. The competitiveness of oilseeds hence increases as per ha of oilseeds cropped less land must be put into obligatory set-aside where it receives set-aside premiums only.

Effective oilseeds premiums in the reference run are reduced in several member states due to an simulated EU wide 8 % overshoot of base areas, so that a comparison between declared oilseed premiums before and after Agenda 2000 may be misleading.

These two effects countervail to a certain extent the expected decrease of oilseed areas due to uniform Grandes Cultures premiums. Further on, sunflower seed are much more resistant to dry periods, so that a substitution with cereals in southern regions is restricted by the costs and availability of irrigation.

Table 10: Balance sheet cereals (in 1000 tons)

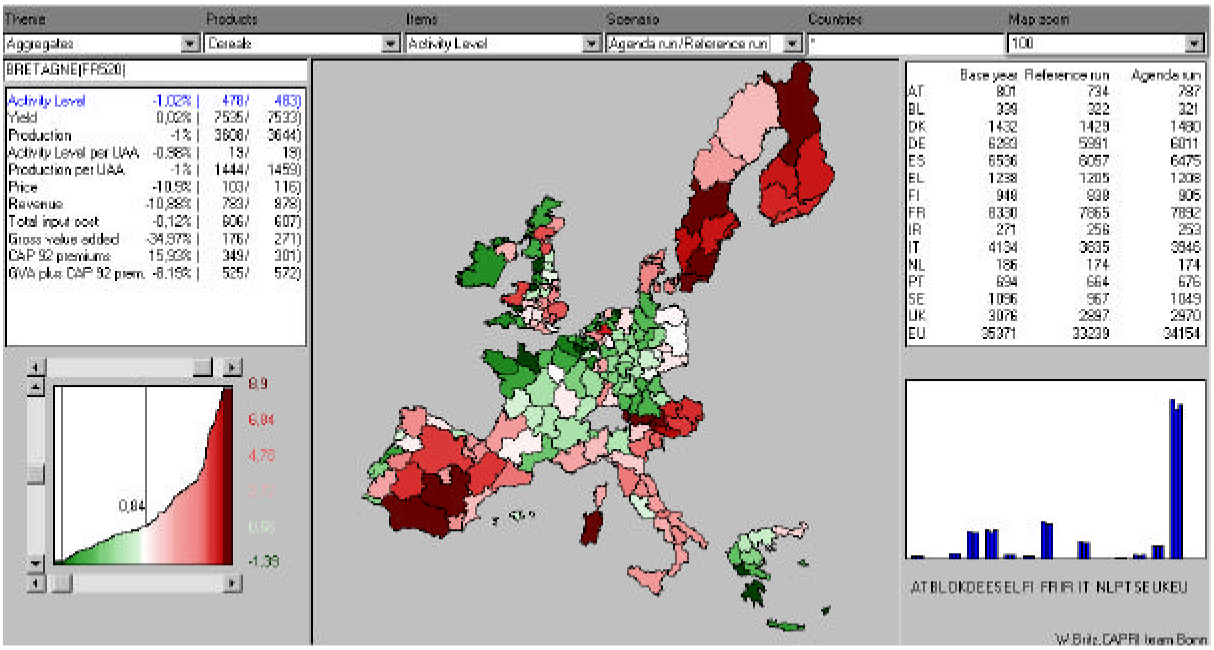
	Base year 1994	Reference 2005	Agenda 2005	Change Reference to Base year	Change Agenda to Reference
Wheat					
Domestic supply	81659	90325	91134	10.6%	0.9%
Domestic demand	67232	66676	66149	-0.8%	-0.8%
Final consumption	37191	37178	37202	0.0%	0.1%
Feed use	30041	29499	28948	-1.8%	-1.9%
Intervention	7799	8348	0	7.0%	-100.0%
Net trade	6628	15301	24985	130.9%	63.3%
Barley					
Domestic supply	42468	46150	47752	8.7%	3.5%
Domestic demand	29250	29719	30129	1.6%	1.4%
Final consumption	224	223	222	-0.4%	-0.1%
Feed use	29026	29497	29906	1.6%	1.4%
Intervention	4469	6430	7624	43.9%	18.6%
Net trade	8749	10000	10000	14.3%	0.0%
Other cereals					
Domestic supply	44530	47979	49309	7.7%	2.8%
Domestic demand	41046	40130	40683	-2.2%	1.4%
Final consumption	6530	6524	6516	-0.1%	-0.1%
Feed use	34516	33606	34166	-2.6%	1.7%
Intervention	4550	6445	1107	41.7%	-82.8%
Net trade	-1066	1404	7520	-231.6%	435.7%

Regional impacts

While a detailed presentation of regionalised results is not possible in this report regarding the great number of possible aspects to shed light on, we will focus on the impacts of Agenda 2000 on cereal and oilseed production in Europe. The following analysis and conclusions would have been not possible without the deep regionalisation of the model.

The impacts of Agenda 2000 on regional cereal production are presented in Figure 25. Compared with the reference run the cereal area stays stable or increases in most regions. Especially in Spain, Italy, Austria, east England and in the Scandinavian Countries it increases, whereas in the main cereal producing regions (France and Germany), production remains constant.

Figure 25: Impacts of Agenda 2000 on cereal production



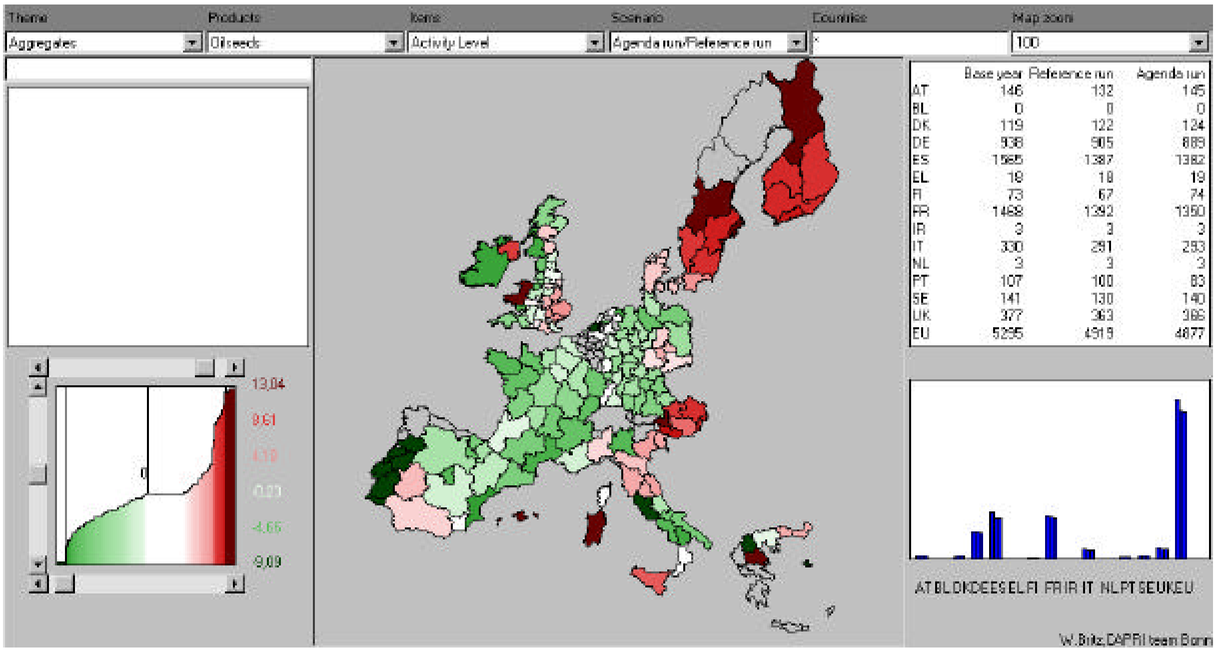
One reason for the differences are increased reference yields, that means higher area premiums for cereals in Spain and Italy due to a special agreement in the Agenda 2000. Premiums in Spain increase by about 27 %, in Italy by about 20 % and in the rest of Europe by 16 %. Another reason is the lower price reduction for maize and durum wheat. Whereas the intervention price for cereals falls by 15 % (from Reference to Agenda) the price for durum wheat falls by 13.7 % and for maize by only 2.6 %. Both crops (especially durum wheat) are primarily grown in South-Europe.

In the Mediterranean regions the Agenda 2000 will led to a comparable high reduction of set aside (in line with the changes of the official set aside rate), whereas in northern France, and in Germany set aside is reduced only between 0 and 10%. That means voluntary set aside will increase, because due to the under-compensation of the overall price cut in Agenda 2000 the cereal gross value added falls drastically. The increased cereal area premium in the Agenda 2000 scenario compensate only 50 % of the overall price cut. In all regions the compensation is even lower, because the direct payments are calculated based on the historic reference yields from the years 1986 to 1991 and expected technical progress will lead to much higher yields in 2005. This is especially a draw back factor for regions with high technical progress in cereal production, namely France and Germany. In most German regions a profitable cereal production with the standard technology is not longer possible, so set aside is the better alternative.

Cereal production in Belgium and in the Netherlands stays also nearly constant in the Agenda 2000 scenario, but due to other reasons: oilseeds and set aside are nearly not existent in both countries. That means the important substitution between cereals, oilseeds and set aside is not possible in this case.

As already mentioned the Agenda 2000 leads to a reduced oilseed area in the EU, but the impacts on rape, sunflowers and soybeans are quite different. One reason are different price changes from reference run to Agenda 2000: the price for rape remains nearly constant, for soybeans it increase slightly but for sunflowers it increase by about 17 %. Because of the clear regional concentration of oilseed crops, this results in different regional impacts as shown in Figure 26. In north Italy and south Spain the level of sunflowers increase from reference to Agenda 2000. The rape production on the other hand is reduced in most regions (mainly in north Europe) with the exceptions of Denmark, east England and parts of east Germany. In the new member states (Austria, Sweden and Finland) oilseeds production also increase in line with cereal production and a consequently strong decrease of set aside area.

Figure 26: Impacts of Agenda 2000 on oilseed production



3.2.2 Beef and Dairy Sector

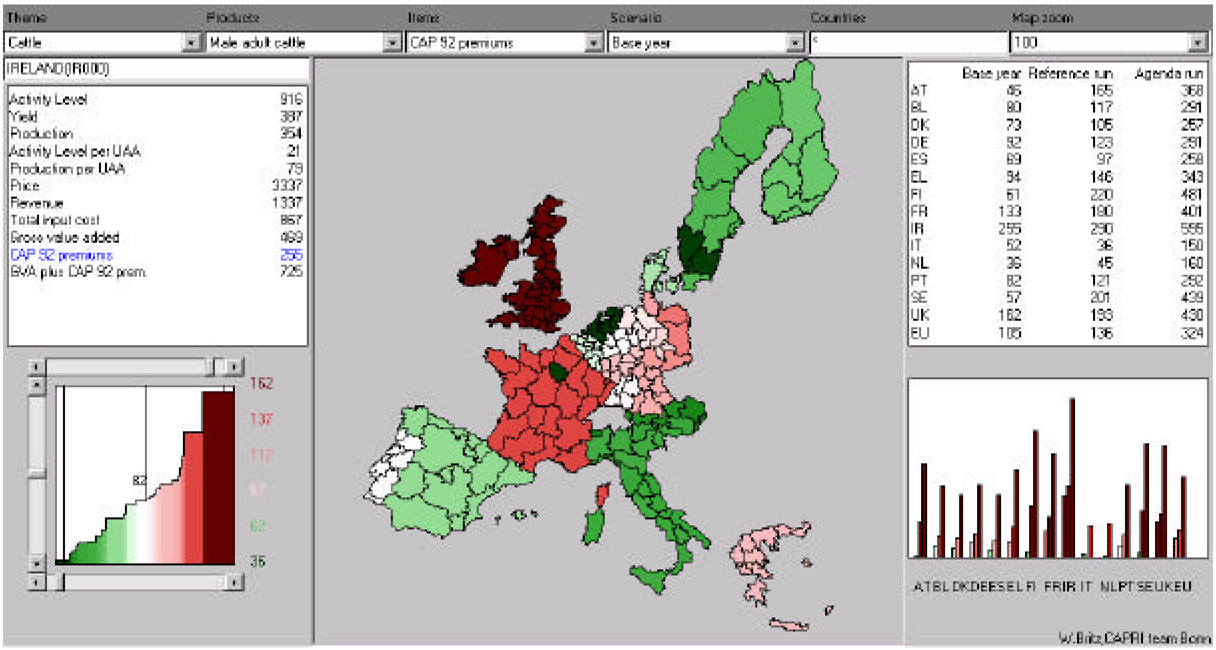
As the main political instruments of both scenarios are widely discussed, the following table 11 just present average changes of the quantitative measures in the sector at EU level.

Table 11: Political variables for the Cattle sector

	Base year 1994	Reference 2005 (% against base year)	Agenda 2005 (% against reference)
Administrative prices			
Beef	4285	3475	2780
change		(-19%)	(-20%)
Butter	3202	2954	2511
change		(-8%)	(-15%)
Milk powder	2377	2055	1747
change		(-14%)	(-15%)
Premiums			
Milk cows	0	0	157
Suckler cows	133	164	284
change		(23%)	(73%)
Male adult cattle	105	136	324
change		(30%)	(138%)
Milk quota	113879	115577	120335

Especially premiums for male adult cattle vary considerably between Member States depending on average live weight, the percentage of animals eligible for extensification payments as well as national supplementary premiums. An illustration is given in figure 27, which underlines the necessity for an appropriate regionalisation of the modelling system. In the case of Ireland, for example, low intensity of production leads to a long fattening period making almost every beef cattle eligible for the second payment. Additional extensification premiums as well as further deseasonalisation premiums for steers cause this exceptionally high average premium of male adult cattle.

Figure 27: Average premium in male adult cattle in base year



Apart from the settings for political instruments, other assumptions mainly relating to exogenous shifts from the base to the target year had to be made and are summarised in the following:

- Milk yields increase due to technical progress (specific trend for each Member States defined by partners)
- Long term trend to increased final weights continues to offset reduced availability of calves: + 10 % for male adult cattle and heifers fattening are assumed until 2005
- Adjustments of feed requirements
  - according to yield development (milk, final weight)
  - 0.5 % increase per year in feed efficiency
- Increased yields in fodder production, inputs adjusted accordingly, input saving technical progress of 0.5 % per year

In order to shed light on the income relevance of the cattle sector, the map in figure 28 shows the average gross value added plus CAP premiums for all cattle activities per ha UAA. It is obvious that cattle production plays a major role in Ireland, the Western part of UK and Brittany, a regional cluster formed by Belgium, the Netherlands and neighbouring German regions, the regions surrounding the Alps and most of Scandinavia. A comparison with the second map (figure 29) showing income from of all agricultural activities per ha UAA reveals that cattle has a high income share in many low profitable regions, especially in Scandinavia and the UK. On the other hand, the highly productive cluster around the Netherlands shows a high relative profitability in the cattle sector as well.

Figure 28: Income from cattle activities in the reference run (Euro/ha)

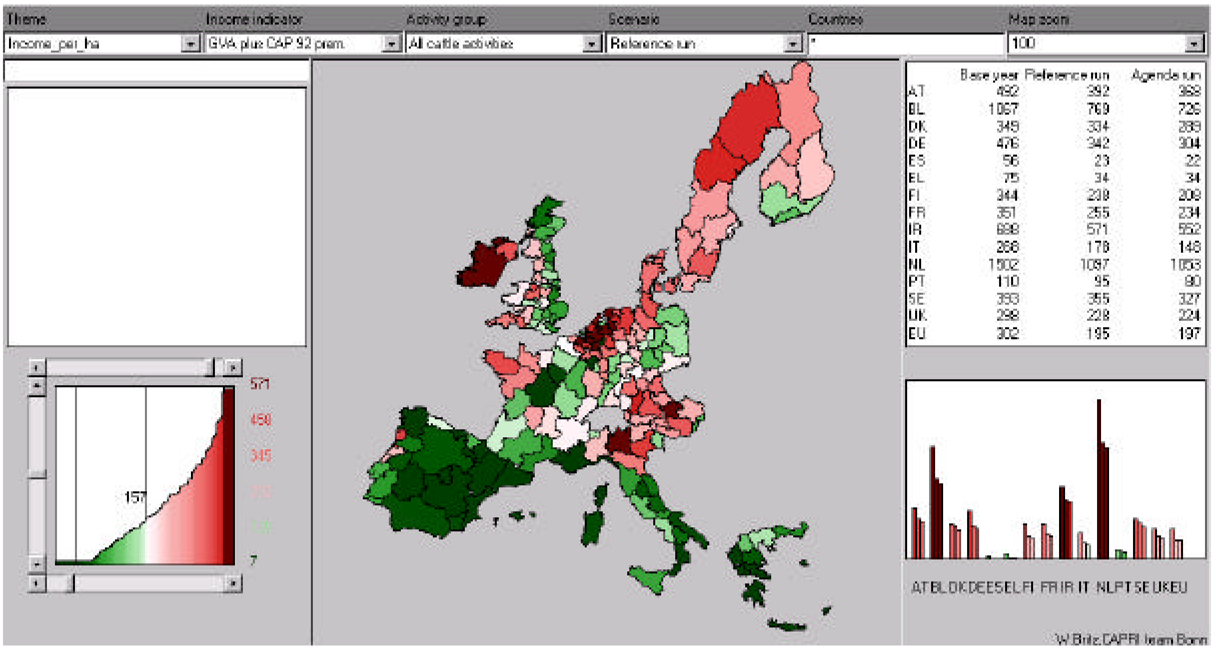
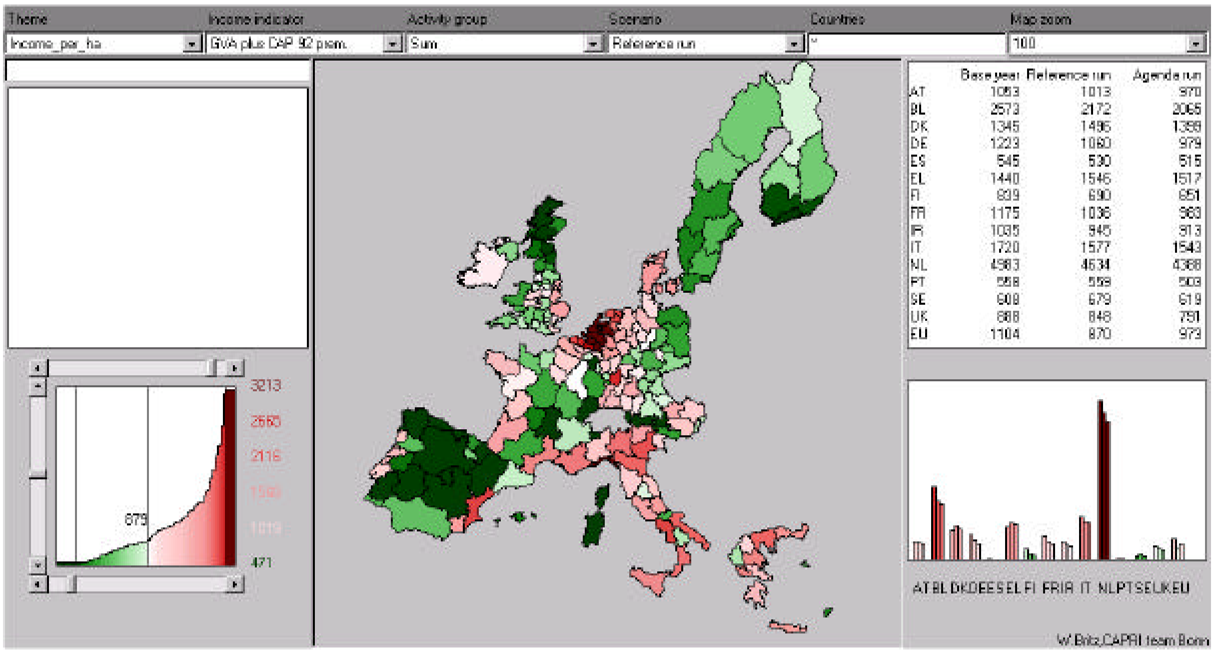
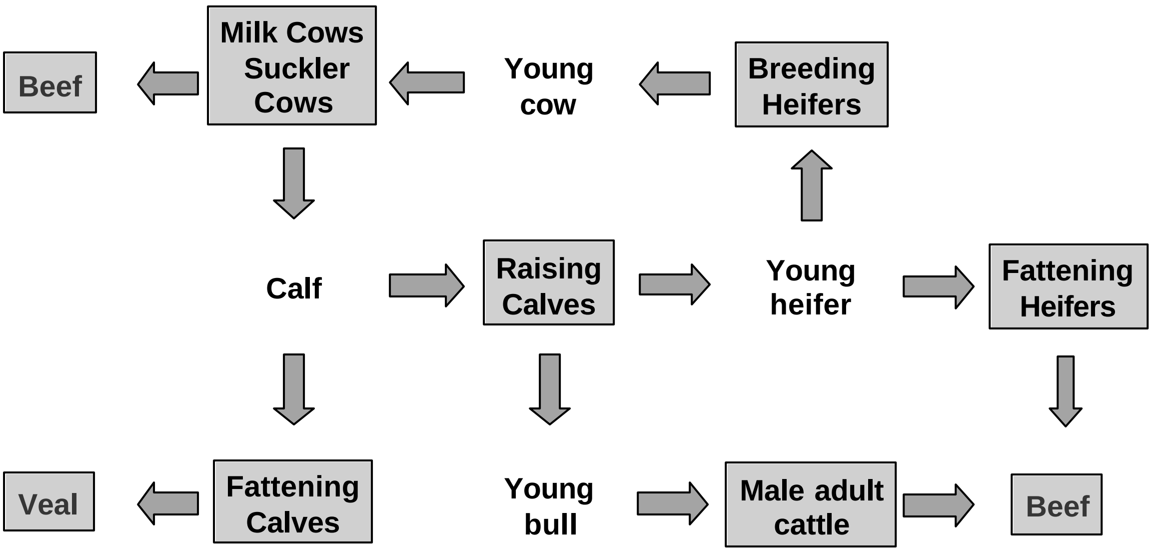


Figure 29: Income from agriculture (Euro/ha)



The cattle sector is characterised by direct links between the different activities based on young animal flows. Figure 30 shows how these streams are modelled in the CAPRI system as well as the marketed outputs of the different activities.

Figure 30: Activities in the cattle sector and flow of young animals



Under both scenarios (reference run and Agenda 2000), the production of milk is clearly quota driven. Whereas production slightly increases following the quota expansion, the increase of average milk yields per cow leads to a distinct reduction of the dairy cow herd in Europe, affecting other cattle activities due to reduced output of calves as well as decreased demand for young cows.

Figure 31: Development of herd sizes in EU in reference run

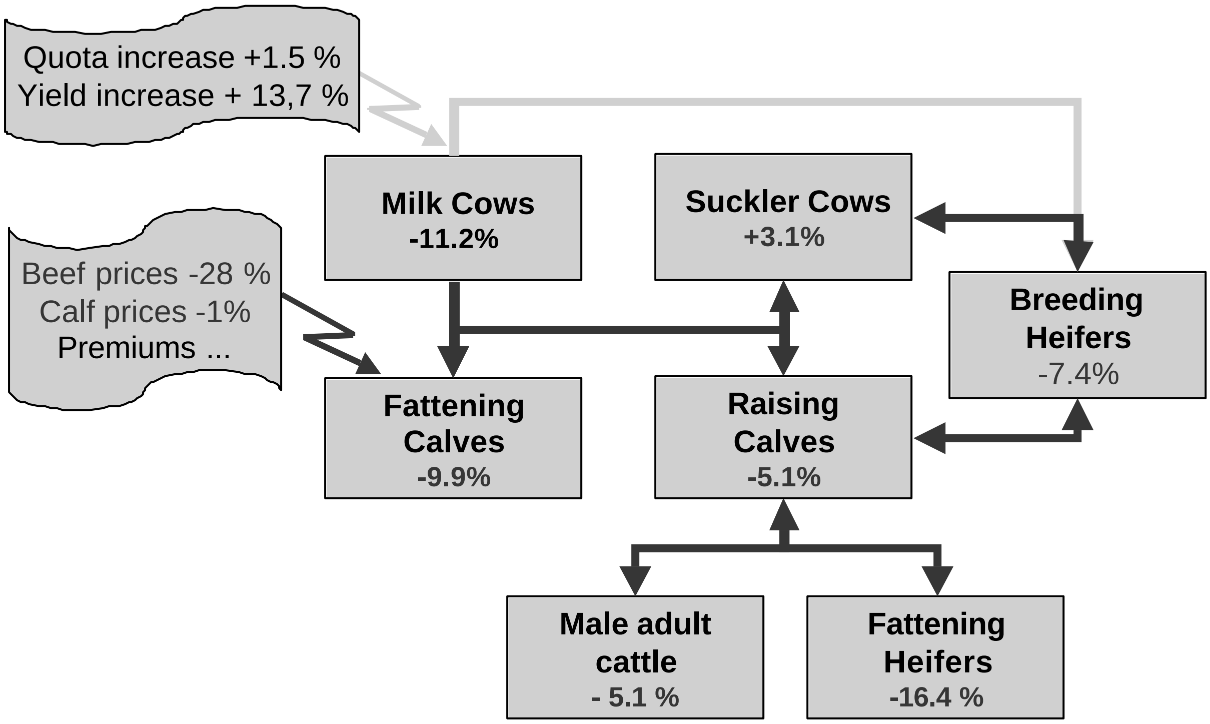


Figure 31 shows the results from the reference run: the dairy cow herd is more or less determined exogenously by the given slight increase in the quota (+1.5 %) and an average increase of the milk yield of about 14 % between 1994 and 2005. The reduced availability of calves keeps their prices relatively stable despite a drop of the beef price by 28 % percent due to changes in administrative prices. However, part of the price drop is levelled out by an increase of premiums for male adult cattle. The stable calve prices favour suckler cows whose herd size increases by 3.5 %. Reduced availability of calves decreases mainly fattening heifers (-17 %) and fattening of calves (-10 %).

The prices for final products relating to the cattle sector (beef, veal, milk and milk products) are mainly policy driven by the development of administrative prices. Effects on demand inside of the EU are rather low for these saturated markets. However, the outcome of the simulations runs depends on the endogenous prices for young animals. For further analysis of the cattle sector, two improvements are envisaged: a split-up of calves into male and female ones and endogenous final weights for fattening processes.

Tables 12 and 13 summarise the results on the herd sizes for the two scenarios. Changes inside the cattle sector in Agenda 2000 mainly result from a milk quota increase driving up the dairy cow herd (+4.6 %) and an increase the suckler cow herd (+2.8 %) based on a premium raise. The higher availability of calves compared to the reference run favours the fattening activities.

Table 12: Animal production in Europe, Herd sizes in 1000 heads

	Base year 1994	Reference 2005	Agenda 2005	Change Reference to Base year	Change Agenda to Reference
Cattle					
Dairy cows	23200	20600	21541	-11.2%	4.6%
Bulls fattening	12451	11848	12095	-4.8%	2.1%
Calves fattening	8011	7214	7745	-10.0%	7.4%
Calves raising	23152	22017	22512	-4.9%	2.2%
Suckler cows	10848	11179	11492	3.1%	2.8%
Heifers	12131	10842	10328	-10.6%	-4.7%
Pig fattening	197636	209131	207615	5.8%	-0.7%
Pig breeding	12645	11524	11599	-8.9%	0.7%
Ewes and goats	79784	74950	76078	-6.1%	1.5%
Sheep and goat fattening	76141	72837	72705	-4.3%	-0.2%
Laying hens	361046	380068	379822	5.3%	-0.1%
Poultry fattening	4627490	4322079	4303729	-6.6%	-0.4%

For other meat products, reactions mostly depend on the feed back from the market. The somewhat astonishing substitution between poultry and pig meat in the reference run is based on tariff reductions for poultry meat which leads to an exogenous price shift. Here, further insight in the application of trade policies in the meat markets is clearly necessary. It should be mentioned that generally tariff impacts on meat markets are a sensible and complicated field as instruments relate to specific cuts and qualities whereas the model deals with the combined effect on the raw product price. Presented results clearly reflect the current weighting scheme and must be carefully discussed and eventually re-designed by market experts. Additionally, pig and poultry markets are strongly influenced by assumed market developments in rest-of-the-world as well. Overall, the results show that the system is operational, but underlines the necessity for co-operation with market experts in order to better define trade policy measurements.

Table 13: Animal production in Europe, Physical production (1000 tons)

	Base year 1994	Reference 2005	Agenda 2005	Change Reference to Base year	Change Agenda to Reference
Meat	24268	24955	24753	2.8%	-0.8%
Beef	7694	7558	7471	-1.8%	-1.2%
Veal	849	775	824	-8.7%	6.3%
Sheep- and goatmeat	1284	1217	1220	-5.3%	0.3%
Pigmeat	16573	17397	17282	5.0%	-0.7%
Poultry	7757	7268	7246	-6.3%	-0.3%
Eggs	4893	5583	5579	14.1%	-0.1%
Milk (unprocessed)	129475	130436	135698	0.7%	4.0%
Cow milk	119741	121347	126497	1.3%	4.2%
Sheep and goats milk	9734	9089	9201	-6.6%	1.2%

Finally, it should be mentioned that changes in regional nitrate balances from the base year to the two scenarios in 2005 are only minor. As explained above, the nitrate balances are strongly related to the regional stocking densities and they do not change significantly.

3.2.3 Projections for Mediterranean and Perennial Crops

Before the 1992 CAP reform there was some fear about the risk of a "delocalisation" process that would involve a shift of agricultural area from "continental crops" to "Mediterranean crops". Recent developments in agricultural area in Spain and Portugal suggest that such delocalisation might have taken place, but only to a limited extent and without showing an uniform pattern across regions. Vegetable area decreased in most Spanish regions and in a higher extent than total Mediterranean crop area. Perennial crop areas (citrus, olive oil, vineyard) showed a more positive development than vegetables, increasing their share in the total Mediterranean crop area. During the first half of the nineties, arable crops showed in general a higher GVA (at factor cost) increase between 1989-91 and 1994-96 than the GVA rate of change in Mediterranean crops. Mediterranean crop area only increased substantially in regions where arable crops showed a relatively low profitability or where there were profitable monocultures, very often perennials.

From the preliminary tests (El Kamel and Iborra, 1998), it can be seen that the expected developments in the perennial crop sector are not uniform. Thus, in activities, such as "table wine" and the "apple, pear and peach", area reductions are expected in all the selected regions, arriving at an annual rate of change about -15,1% for the activity "apple, pear and peach" and -8,7% for the activity " table wine". For the same activity, there are significant regional differences concerning the future trends of the activity levels. Thus, Andalucia shows the highest rates of growth in activities *"table olives"* and *" table grapes"*, with a less favourable evolution in *"citrus"* and *" table wine"*. Valencia, Puglia and Algarve also show increases in the activity levels of *“table olives”* and *“table grapes”*, as compared with negative increases in the rest of regions. In *citrus fruit*, positive developments of activity levels are expected in Valencia, Peloponnisos and Algarve compared to negative increases in the rest of regions.. Negative growths are also expected in *"citrus"* and *"olive oil"* in the region of Puglia, *"table wine"* in Kriti and *"citrus"* in Peloponnisos.

3.3 Results of Case Studies

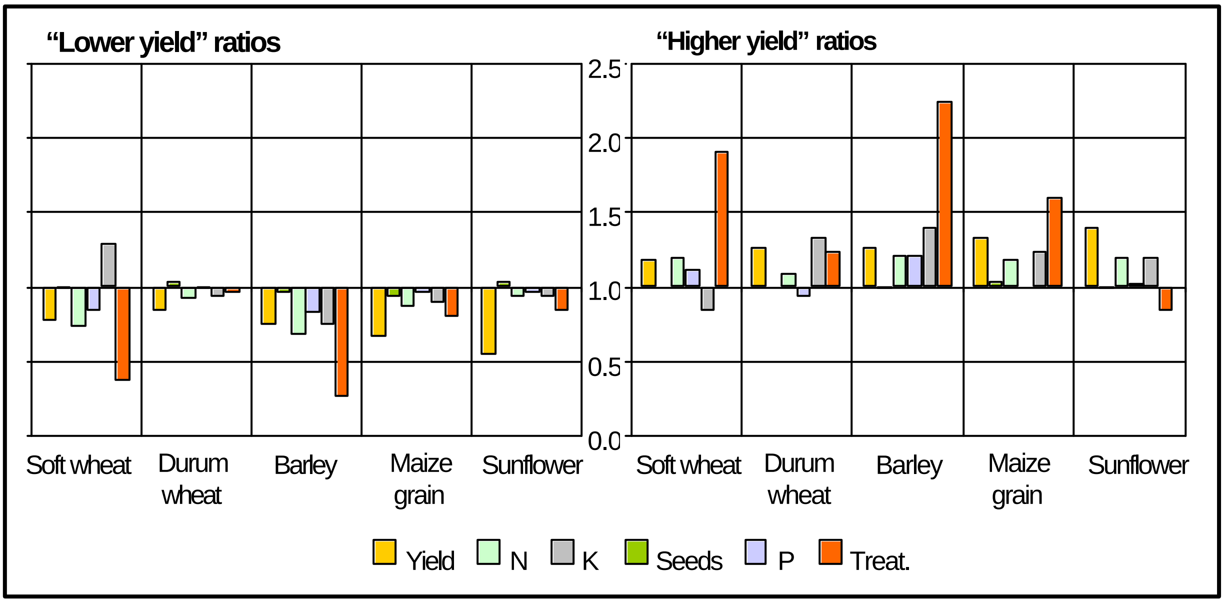
3.3.1 Analysing Alternative Techniques

Results based on a national questionnaire

The ratios in figure 32 show variations between the low and high yield alternative techniques compared to the average. The alternative techniques represent the 20% of area with “Lower yield” and the 20% with “Higher yield”.

Generally, lower and higher yields are connected with a move of input use in the same direction. However, there is no clear tendency regarding a over or under proportional relation. It is hard to judge if the high variation in the number of plant protection treatments is a typical outcome as weather and disease condition in single years play a major rule in determining plant protection measurement. Similarly, interpretation on the use of Potassium (K) use is restricted as it is no applied on a yearly basis to individual crops. Yield variations are higher for maize and sunflower than for other crops, probably due to irrigation, that is not represented here. The definition of alternative techniques, which corresponds to CAPRI input parameters, could be ameliorated by indicators of irrigation and working time, which are not completely available in the data base.

Figure 32: Ratios between alternative and average technique parameters



The ratios shown above have been calculated for all regions and grandes cultures of the survey. They help to precise input variations related to a yield variation, in a statistical point of view, and they show yield distribution around regional average. Besides possible problems relating to the use of data stemming from just one specific year, further limitations relate to the aggregation problem. In a pure linear model, each alternative would be interpreted as an interdependent possible choice for each production activity. In reality, the technology set of each single farm is however restricted by his specific natural, market and on-farm condition which are not captured in the model's constraints. We cannot simply assume that a farmer currently cropping soft wheat according to the input/output relations of the lowest 20 % has simply to switch his input use to the upper 20 % relations and achieve the same increase in yields. On top, farmers extensify and intensify usually not just simple crops, but the total rotation.

CAPRI attacks the problem by defining an own set of PMP parameters for each alternative, derived from calibrating each regional model to observed shares of the different alternatives. Rotational effects occur inside an alternative, which compete which each other for available land. The calibration ensures perfect calibration to observed land shares, yield and input relations for the different alternatives and matches the regional average observed. Accordingly, reaction of the model can be simulated relating to, for example, :

- changes in relative price of output and input;
- alternative policies for input or production reduction.
- Using regional information

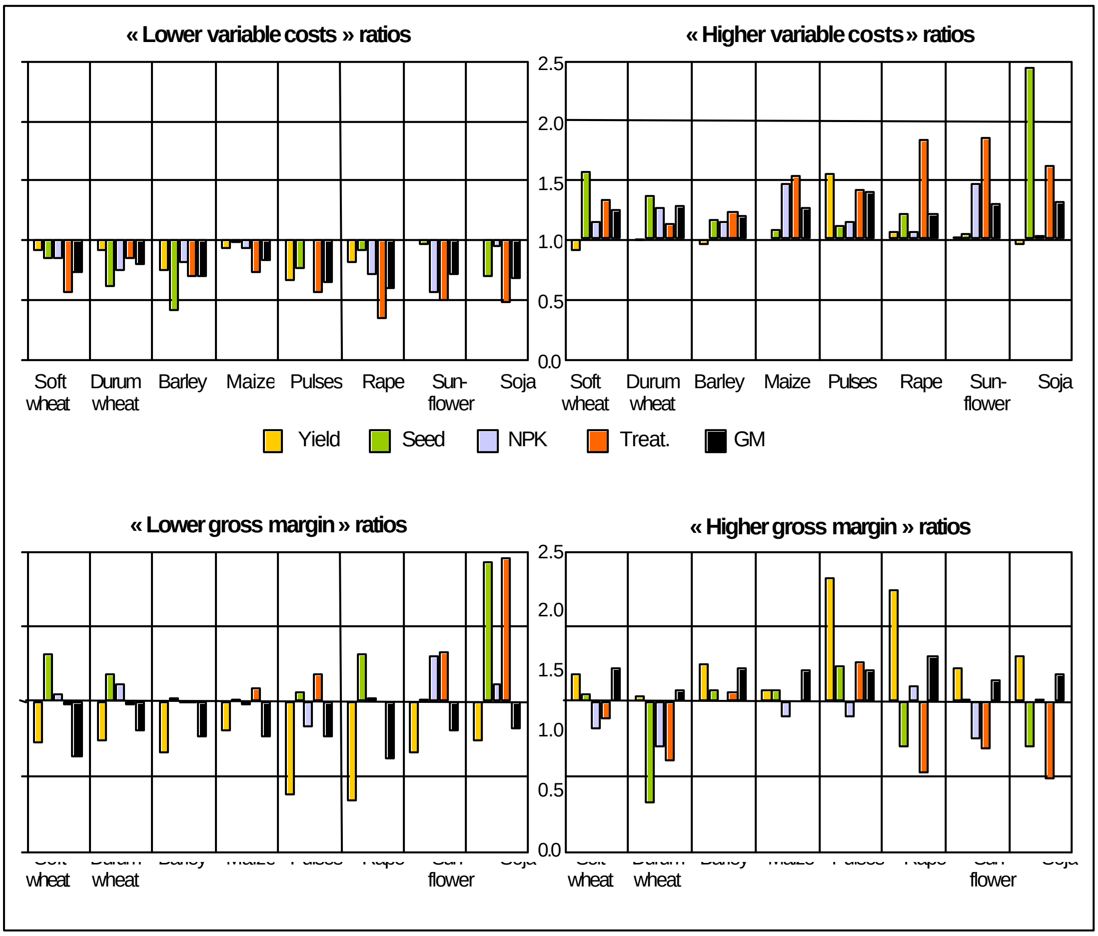
Results based on regional information

We used two classifications in order to define alternative techniques. First, plots are classified by level of variable costs (VC): 20% of surveyed plots with "Lower VC", and 20% with "Higher VC". These categories define our alternatives. Results of relations to the regional average are shown in the first two graphics of figure

33. High variable costs are not always linked with higher yields, probably due less favourable agronomic conditions or inefficiencies. The point become obvious in sunflowers, where yields are almost identical between the two groups.

In the second classification, plots were ranked by level of gross margin (GM): the 20% of plots with "Lower GM", the 20% with "Higher GM". "Higher GM" category, e.g., is selecting plots with relatively higher products and lower variable costs, in a given market and policy context. Results of this technique specification and ratios calculation are the last two graphics of figure 33.

Figure 33: Ratios between input costs of alternative techniques and average costs



For "Higher GM", yield increases are greater than for "Higher VC", so that better agronomic and structural conditions could have more effect than higher input costs. Moreover, these yields are often obtained with less inputs than the average, so that input efficiency is very high. The large variations of pulses and rape yields may be due to some storms that affected production, even more for a local survey. Seeds and treatments have generally a strong influence on costs and gross margin, because of prices of "high technology" inputs, and because of local weather variability.

The analysis of the data above shows several aspects of the discussion regarding the relation of input and outputs in an aggregated sector model:

Observed differences in yields and economic performance relate to a multitude of factors as agronomic conditions, farm structure, and farmer's efficiency

Hence, a simple linear-combination approach is unrealistic when based on observed differences inside the farm population

Any analysis in the context is highly data demanding, in only source EU-wide available regarding farm results are however FADN data which do not report the input use in single activities. A wide-spread application of similar exercises is therefore currently not possible.

3.3.2 Results of CAPRI Application to Switzerland

The sectoral changes in plant cultivation volume with regard to the year 2005 reference scenario allows for the following statements to be made:

- Compared to the extent of the reference scenario in the year 2005, the forage crops volume in the EU scenario will continue to increase in 2005. In particular, the cultivation surface of soft wheat (for feed production) will rise to a total of 5000 ha (approx. + 5%). Silage production surfaces, however, will decrease to approx. 7000 ha (- 4.8%). The volume of the other plant cultivation activities will remain basically the same. Within this group, in particular rye surfaces will increase by 4% to 6500 ha, maize surfaces by nearly 4% to 27 800 ha, potatoes by 4.6% to 17200 ha, and rape by 2%. Besides the silage surface (- 4.7%), set-aside agricultural land (- 4%), sugar beet (approx. - 3%) and other "root crops" surfaces (mostly fodder beets: - 6.5%) will also decrease in size.

The sectoral changes in animal population with regard to the EU scenario "Full membership" as compared to the reference scenario in the year 2005, permits the following statements to be made:

- In animal production, in the EU scenario (as compared to the "non-joining the EU" scenario) bull fattening will increase by 18%. Contrary to this, fattening pig production will decrease by approx. 10%.
- Assuming a constant growth of milk yield per cow, dairy cow population will remain unchanged in comparison to the reference scenario. The number of mother cows, however, will decrease by 18%.
- Furthermore, dairy sheep production will increase and mutton sheep numbers will drop correspondingly.
- Veal calf fattening will drop an additional 14%.
- Heifer rearing will increase by approx. 2%. It must be taken into consideration that heifer fattening animals also belong to this category.
- As far as poultry is concerned, laying hen production will drop by approx. 5.5%, whereas the fattening hen population will decrease by approx. 4.5% in the year 2005 (as compared to the "non-joining the EU" scenario).

Given the models as to future scenarios in Swiss agriculture, the following developments are to be expected:

- In the "non-joining the EU" scenario as well as in the EU scenario, there are basic tendencies towards changes in production due to the similar development of producer prices. Most differences in surface usage and animal production can be led back to different political conditions.
- The use of feed will increase because of a decrease in prices. Silage production will drop and forage crops production will rise. With regard to forage crops, a tendency towards high-yield crops (soft wheat) can be noted.
- The decrease in feed costs will lead to an increase in meat production (bull and pig fattening). In comparison to this, feed costs will decrease more significantly than meat prices.
- Because of the higher yields, competitive farming activities - that are nevertheless restricted by quotas (sugar beet surfaces, number of dairy cows) - will drop in number. Consequently, production volumes will remain unchanged.
- The decrease in dairy cow population will have sustainable effects on heifers and rearing calves. However, these drops in number will have an additional influence on the development of alternative production branches (heifer fattening).
- Oilseed production is advantageous for political reasons (re. Swiss market regulations concerning oilseeds and the market regulations for oilseeds according to the "Blair House Agreement" in the EU scenario for the year 2005 and in compliance with the Agenda 2000).

In conclusion, it can be maintained that because of the novelty of the model, it is not possible to supply an extensive analysis of all domains of relevance for the Swiss project.

4 Discussion and Conclusion

The results of the project underline the feasibility of the CAPRI approach. The research network has also proven his usefulness for the complex overall task. Nevertheless, the time constrained process of data collection and model building for an EU-wide regionalised information system left some areas for further research to improve the value of the information system to political decision makers. The following paragraphs give an assessment of merits and remaining problems of the realised data collection process and the modelling activities. Promising directions for further research are also identified.

The task of *data collection* was successfully completed in the sense that it provided a differentiated, regionalised, and EU-wide data base for an ex-post analysis of agricultural production and the necessary input for a corresponding agricultural sector model. Complete coverage of yields and activity levels as well as a set of regionally differentiated CAP-related political variables for the years 1990-1995 could be obtained. However, the data collection proved to be more difficult than initially expected. EUROSTAT's REGIO data base - the main regional data source envisaged when the project started - revealed an insufficient differentiation in some agricultural subsectors (crop production), a significant amount of data gaps and errors, and a considerable time lag in publication. This caused a time consuming collection of additional data based on national statistics and a considerable effort to ensure comparability and technical integration. Also, with 1995 as the final year of complete coverage, only limited information on recent regional developments is available due to these problems.

Nevertheless, these complications initiated the development of valuable tools to handle this process and could be overcome through an intensive co-operation of all partners in the network. As suitable sources at national and regional level are now known and easily accessible, an update of the CAPRI data base can be expected to require far less time.

The currently available data sources did not allow to base the specification of variable cost of the production activities on regional information. A potentially suitable source for this information would be the Farm Accountancy Data Network (FADN). However, a complete and sufficiently differentiated - with respect to regions and activity definitions - data set could not be obtained in the course of the project. Instead, a "regionalisation tool" breaks down national information from the SPEL data base exploiting yield dependency of major variable inputs and incorporating available engineering information. The employed methodology not only ensures consistency to the national Economic Accounts of Agriculture, but is also capable of flexibly incorporating additional regional information that are available. Consequently, this approach could make use of appropriate regional, farm based information on variable cost in the future. Furthermore, the use of FADN data would potentially allow to regionally differentiate farm level prices and contribute to a more realistic picture of the regional profitability of various production activities. Note, however, that the currently limited information on "realistic" regional profitability has only a small impact on the allocation behaviour of the supply models due to the applied calibration approach.

The joint research activities of all partners, each responsible for a cluster of Member States, made a lot of national expert knowledge available with favourable implications for the depth of analysis. The ex-post analysis of CAP-reform 92 impacts using the CAPRI data base made extensive use of this advantage. The results of this analysis disclose that a regionally differentiated modelling of political instruments is an important characteristic of the CAPRI model as it is able to improve the interpretability and quality of modelling results compared to models at aggregate national level.

The *modelling activities* performed during the project achieved their objectives. The CAPRI core model represents an unprecedented EU-wide agricultural sector model which combines almost 200 regional supply modules with a market model. This concept allows to simultaneously and consistently combine regional economic and political conditions with developments on EU- and world markets for agricultural commodities, which gives new insights into the feedbacks involved. The results of an explorative application to evaluate the impacts of Agenda 2000 shows that the system is operational and able to simulate the relevant policy measures of the CAP.

Given the comparative strength of the system, a considerable part of time was devoted to the specification of the regional supply models, especially to achieve a plausible response behaviour of annual crop rotation to changing economic and political conditions. For this purpose, an advanced approach of Positive Mathematical Programming was developed with two major advantages: First, the specification of the models was based on observed producer behaviour which not only ensures calibration of the models to base year allocations, but also provides an empirical foundation for the implied supply response. Second, the mathematical structure of the programming models could be kept simple enough to solve the resulting overall model in a reasonable time and to guarantee the necessary transparancy for the future survival of the system. The underlying approach already created significant interest in the scientific community and represents a promising path for further research to improve the methodology. Possible avenues include the use of time series observations for the specification, especially when further data are available after updates of the data base.

Projections of *perennial crops* in simulation runs could not be based on the same methodology as employed for annual crops. In fact, the general comparative static layout of the CAPRI model is incompatible with the dynamic nature of perennial crop supply. The considerable relevance of perennial crops for Mediterranean regions, however, made an exogenous forecast of allocated area for the target year necessary. The methodological work carried out and the empirical specification of the perennial module led to the realization of projections for perennial's activity levels for 75 regions in the year 2005. These projections represent only "reference-run" forecasts for the area cultivated by perennial crops. However, one could accept that most area developments in perennial crops could be considered as exogenously determined, or at least not strongly affected by the price changes as it might happen in continental cultures and livestock activities. The lack of relevant data at the regional level forced to avoid a structural econometric model with a separate account of plantings, replanting and removals and inhibited a potential improvement of the land allocation forecasts and the modelling of a price responsive supply of perennial crops.

An important feature of the regional supply models is the possible definition of *alternative technologies* for the production of a specific product where each alternative is characterised by its own set of input and output coefficients. This allows to model the substitution behaviour between the technologies under different economic conditions and the representation of policy measures that support certain practices. However, this possibility has been used so far only by complementary regional or national case studies due to the considerable time required for the definition of alternative technologies. Potential future simulation scenarios with larger changes in relative prices (inputs and outputs) or with more differentiated national and regional policy measures might make a general specification of alternative technologies a fruitful exercise.

When trying to define alternative technologies, two different approaches had been tested (1) Questionnaire data on technological practises at farm/plot level and (2) crop growth models. Questionnaire data report the combined and interrelated effect on yields of input levels, plot specific natural conditions as soil and climate and differences in efficiencies between farmers. Agronomic crop growth models could simulate systematically the effect of input levels on yields. However, the data need necessary for such simulations is tremendous, so currently, it is hard to imagine that crop growth models could be applied throughout CAPRI's 200 regions.

A third possibility to use alternative technologies relates to environmentally friendly farming, for example ecological farming. Here, aggregated data on average input and output relations for crops are known, information which can be mapped quite easily in the current model structure.

With regard to the separate task of analysing *rural development*, issues regarding farm labour, holders and structure were examined quantitatively. Data on AWU’s across the regions has been compiled. The trends constructed for AWU’s at regional level are essential for income per head calculations for each region. The agelines and cohort analysis provide a clear demographic picture of the main patterns among EU holders at national and regional level. The analysis of farm structure provides a direction for a possible methodology to analyse the effects of income changes on farm structure. Regarding farm structure the main efforts were twofold:

(1) the construction of a Markov Chain model to forecast farm structure based on fixed transition probabilities and (2) an initial exercise in the application of PMP techniques to questions of farm structure. The question of farm structure is related to the overall issue of rural development in a number of ways. Pluriactivity, for example, tends to be less on larger farms. Underemployment tends to be more common on smaller farms. Rates of decline of numbers of holders depend to some degree on how inheritance customs and the workings of the land market affect farm structure.

According to the project's objectives a set of appropriate *environmental indicators* related to the regional supply models was defined, validated and applied. The EU-wide implementations comprise nutrient balances and gas emissions relevant for global climatic change. These indicators are appropriate in the context of the CAPRI system because they are directly linked to the agricultural production system, have a meaningful interpretation at CAPRI's current regional level of differentiation, were operational with respect to data availability, and - last but not least - have considerable political relevance. An important advancement in the definition of nutrient balances is their calculation based on the regional animal production technology, i.e. they take into account regional feeding practices and fattening periods. Additional environmental indicators and methodological possibilities for refinement were successfully explored for sub-sets of regions. An relevant candidate for an EU-wide application would be an energy module, tested for Switzerland, which calculates the use of non-renewable energy use by agricultural production.

The *market model* is a necessary complement to the regional supply models in order to assess the effect of trade related policy measurements such as tariffs as well as the demand responsiveness of EU- and world markets. The rather conservative layout of the market model which follows the tradition of so-called "multi-commodity models" reflects the project's main task of concentrating on regional aspect of the CAP. Compared to systems focussing on international trade in agricultural commodities, the market model is naturally rather simplified as it aggregates all non-EU regions into one aggregate "Rest-of-the-World" and is based on a net-trade approach. Nevertheless, the most important policy instrument - sales quotas, tariffs, administrative prices combined with flexible levies as well as WTO restrictions on subsidised imports - are incorporated in the framework. The market model can be easily ameliorated without requiring changes in other model parts due to the modular approach. In the simulations, it has proven to be operational, some markets, however, react quite sensible to assumed shifts in demand and supply in the "rest-of-the-world". A future co-operation with market experts, especially on international developments and more appropriate specifications of the price transmission between world and EU-markets for some commodities could improve the quality of the market simulation results.

Considerable time was invested to embed the data base and the modelling system in a *software* environment which allows an easy access to the system. Since the system was under permanent development, often simultaneously by several teams to meet the time constraints, training and documentation systematically lagged behind. Training sessions and the so-called "melting down meeting" in Switzerland were important "tools" to keep all team members up-to-date and to ensure an efficient use of the system. The process of updating and checking the regional data base may be further sped up if tools developed and applied for Italy and Greece could be adopted by other Member States as well.

A similar comment relates to the *exploitation* of the project results. During the development phase, working papers, internet pages and intensive e-mail exchange were mainly directed towards the network itself. Many results achieved can only be fully appreciated in the context of the overall integrated system. This made it difficult to communicate them to the scientific community during the phase of development. However, some important results, for example relating to Positive Mathematical Programming, were presented at international conferences and submitted to professional journals. An article describing the developed modelling system and the explorative application is in preparation. The CAPRI internet pages will be restructured and updated to present the results of the project and to provide an easily accessible documentation.

Concluding generally, the CAPRI project has been successful in developing a regionalised agricultural information system for the EU. It is now in the position to establish an enduring usefulness for EU- and national policy makers to address the manifold expressed interest during the development phase. In order to insure a survival of the system, a regular update of the data base, partial methodological improvements as well as the validation of the model in the context of relevant political scenarios are necessary. It is quite clear that this can only be achieved (1) in the network approach which ensures the in-depth knowledge of regional aspects of agricultural production and the access to national data sources and (2) in a close dialogue with policy makers to efficiently use the system for policy design and evaluation.

5 Literature

AMMAN, H., (1996): Machinery Costs 1996. Federal Agricultural Research Station, Tänikon.

BMU (1994): Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit: Beschluß der Bundesregierung vom 29. September 1994 zur Verminderung der CO_2-Emissionen und anderer Treibhausgasemissionen in der Bundesrepublik Deutschland, Reihe Umweltpolitik, Bundestagsdrucksache 12/8557, Bonn.

BRITZ W. (1997): Regionalization of EU-data in the CAPRI Project, CAPRI Working Paper 97-02, University of Bonn

BRITZ W. (1998): A Synthetic Non-Spatial Multi-Commodity Model as Market Component for CAPRI, Capri Working Paper 98-07, University of Bonn

BRITZ W. & T. HECKELEI (1997): Pre-study for a Medium-term Simulation and Forecast Model of the Agricultural Sector for the EU, Capri Working Paper 97-01, University of Bonn

BRITZ W. & T. HECKELEI (1999): Calibration of Feed Requirements and Price Determination of Feed in CAPRI, CAPRI Working Paper 99-06, University of Bonn

CABELGUENNE M, JONES CA, MARTY JR, DYKE PT, WILLIAMS JR. (1990): Calibration and validation of EPIC for crop rotations in southern France, Agricultural Systems n°33 ; pp153-171.

CAPRI Team (1999): Regional Structure of Production - Ex-post Analysis of Changes from 1991 to 1995, CAPRI Working Paper 99-07, Bonn, Galway, Montpellier, Valencia, Bologna.

CHAMBRE RÉGIONALE D'AGRICULTURE DE MIDI-PYRÉNÉES, CHAMBRE D'AGRICULTURE DE HAUTE-GARONNE ET DU TARN (1996): Références technico-économiques en systèmes de grandes cultures: Résultats 1994.

DEBLITZ C. & PLANKL R. (eds.) (1998): EU-wide Synopsis of Measures according to Regulation REG (EEC) 2078/92 in the EU, Federal Agricultural Research Centre, Braunschweig.

DEHIO J. (1993): Analyse der agrar- und umweltrelevanten Auswirkungen von Auflagen und Steuern im Pflanzenschutzbereich. In HENRICHSMEYER W. (HRSG.): Studien zur Wirtschafts- und Agrarpolitik (9), Witterschlick/Bonn.

DONALDSON AB, FLICHMAN G, WEBSTER JPG. (1995): Integrating agronomic and economic models for policy analysis at the farm level: the impact of CAP reform in the two European regions". Agricultural Systems n°48; pp163-178.

EL KAMEL, H.A. & J.M. GARCIA ALVAREZ-COQUE (1997): Modelling the supply response of perennial crops: is there a way out when data are scarce? CAPRI Working Paper 97-09, Technical University of Valencia, Department of Economics, Sociology and Agricultural Policy.

El Kamel, H. A. and Iborra, S., (1998): A regionalised data base and forecasts for the supply of perennial crops. Working Paper, 98-10, Technical University of Valencia, Department of Economics, Sociology and Agricultural Policy.

EL KAMEL, H.A., OLTRA, P. & J.M. GARCIA ALVAREZ-COQUE (1999): *Reference Forecasts For Perennial Activity Levels For The CAPRI Model. 1997 - 2005*. CAPRI Working Paper 99-08, Technical University of Valencia, Department of Economics, Sociology and Agricultural Policy.

EUROSTAT (1995), „REGIO, Regional data bank, Description of content", June 1995

FISCHER, J. (1999): Energy Inputs in Swiss Agriculture. CAPRI Working Paper 99-01, Federal Agricultural Research Station, Tänikon.

FLICHMAN, G. (1990): International Comparisons of Efficiency in Agriculture, OECD Technical Papers n°21.

GAILLARD, G., C. CRETTAZ, J. HAUSHEER, (1997): Environmental Inventory of the Agricultural Inputs in Crop Farming, series of publications no. 46. FAT Tänikon.

HAYAMI, YUJIRO AND RUTTAN, VERNON. (1985): Agricultural development: An international perspective, The Johns Hopkins University Press.

HECKELEI T. (1997): Positive Mathematical Programming: Review of the Standard Approach, Capri Working Paper 98-02, University of Bonn

HECKELEI T. & W.BRITZ (1998) EV-Risk Analysis for Germany, CAPRI Working Paper 98-01, University of Bonn

HECKELEI T., BRITZ, W. & W. LÖHE (1998): Recursive Dynamic or Comparative Static Solution for CAPRI, Capri Working Paper 98-02, University of Bonn

HECKELEI T. & W. BRITZ (1999): Maximum Entropy Specification of PMP in CAPRI. CAPRI Working Paper 99-08, University of Bonn

HOWITT, R.E. (1995): Positive Mathematical Programming. Amer. J. Agr. Econ, 77(2), pp. 329-42.

KAMPEN, VON, R. (1991): Die Entwicklung und Anwendung eines Ansatzes zur Bedeutung landwirtschaftlicher Nutzflächen hinsichtlich Ihrer Bedeutung für den Arten- und Biotopschutz, Dissertation, Universität Bonn.

LAMPE, VON, M.(1998): The World Agricultural Trade Simulation System - An Overview. Agricultural and Resource Economics Discussion Paper 98-05, Institute for Agricultural Policy, University of Bonn.

LÖHE W. & W. BRITZ (1997): EU's Regulation 2078/92 in Germany and Experiences of Modelling Less Intensive Production Alternatives, Capri Working Paper 97-05, University of Bonn

MACK, G. (1998): Model calculations for the agricultural sector established with the aid of the SILAS prognosis system. Federal Research Station for Agricultural Economics and Engineering, Tanikon.

MAPINFO CORPORATION (1998): MapInfo Professional, User's guide, New York.

MINISTÈRE DE L'AGRICULTURE, SCEES (1996): Les pratiques culturales sur grandes cultures en 1994, AGRESTE Données Chiffrées Agriculture n°85.

MEUDT, M. & W. BRITZ (1997): The CAPRI Nitrogen Balance, CAPRI Working Paper 97-04, University of Bonn.

MEUDT, M. (1999): Weiterentwicklung und Anwendung eines Politikinformationssystems für die Landwirtschaft der Bundesrepublik Deutschland: dargestellt am Beispiel der Treibhausgasproblematik. Dissertation, Universität Bonn

MÖLLMANN C. (1977): FADN/RICA Farm Accountancy Data Network Short Introduction, , CAPRI Working Paper 97-06, University of Bonn

MONOT C, FLICHMAN G. (1997): Evaluation d'une politique d'extensification en alternative à la jachère de la PAC, Rapport pour la Cellule Extensification au Ministère de l'Agriculture.

NÄF, E. (1996): Economics of Labour Calculations. FAT Tänikon.

NASUELLI P., G. PALLADINO, M. SETTI, C. ZANASI & G. ZUCCHI (1997): FEED MODULE: Requirements Functions and Restriction Factors, CAPRI Working Paper 97-12, University of Bologna

NASUELLI, P., G. PALLADINO, M. SETTI, V. TAMPELLINI, C. ZANASI (1998): A regionalized analysis of the environmental impact of the animal production activities - nitrogen and methane emissions. CAPRI Working Paper 98-11, Bologna: University of Bologna, DIPROVAL – Economics Unit.

NASUELLI P., G. PALLADINO., M. SETTI M. & C. ZANASI (1999a): "*A Demographic Model for the Definition of the Livestock Activity Level for the EU Regions*". CAPRI Working Paper 99-01, Bologna: University of Bologna, DIPROVAL – Economics Unit

Nasuelli P., Palladino G., Setti M., Zanasi C. (1999b): "*Un DBMS come strumento di raccolta e gestione delle statistiche agricole europee per lo sviluppo del modello CAPRI*". Bologna: University of Bologna, DIPROVAL – Economics Unit

NASUELLI, P., G. PALLADINO, M. SETTI., V. TAMPELLINI, C. ZANASI (2000): Livestock Economics and Environment in the EU Regions: an Integrated Approach for the CAPRI Model. CAPRI Working Paper 00-02, Bologna: University of Bologna, DIPROVAL – Economics Unit.

Offermann, F. (2000): Quantitative sector modelling of organic farming - Estimating the impacts of a widespread conversion to organic management in the EU,

PARIS, Q., & R.E. HOWITT (1998): An Analysis of Ill-Posed Production Problems Using Maximum Entropy, Amer. J. Agr. Econ., 80(1), pp. 124-138.

SANCHO M,. & J.M. GARCÍA ALVAREZ-COQUE (1997): Changing Agricultural Systems in the Context of "Compatible" Agriculture. The Spanish "Experience", Capri Working Paper 97-08, University of Valencia

SCHMIDT, H.H., A. HOLZMANN & E. ALISCH (1999): Art und Menge der in der Bundesrepublik Deutschland abgegebenen und der exportierten Wirkstoffe in Pflanzenschutzmitteln (1987-1997) - Ergebnisse aus dem Meldeverfahren nach § 19 des Pflanzenschutzgesetzes. Berichte aus der Biologischen Bundesanstalt für Land- und Forstwirtschaft, Heft 49.

STEELE S.R. & GARVEY E. (2000): Notes on Agricultural Labour in the EU, CAPRI Working Paper 00-01, University of Galway

VDI (1995): Cumulated energy expenditures. Notions, definitions, calculation methods. VDI directives 4600, draft of May 1995, Association of German Engineers, Düsseldorf.

WEBER G. (1995): SPEL system, Methodological documentation (Rev. 1), Vol. 2: MFSS, EUROSTAT Luxembourg 1995

WITZKE, H.P & W. BRITZ (1998): A Maximum Entropy Approach to the Calibration of Highly Differentiated Demand System, Capri Working Paper 98-06, University of Bonn

WOLF W. (1995): SPEL system, Methodological documentation (Rev. 1), Vol. 1: Basics, BS, SFSS, EUROSTAT Luxembourg 1995

ZSCHALER, H., B. RUBACH, S. ENZIAN & U. WITTCHEN (1995): Status-quo-Analyse des Pflanzenschutzmittel-Einsatzes in Feldkulturen der Bundesrepublik Deutschland (1991/1992), Nachrichtenbl. Deut. Pflanzenschutzd., 47(4), S. 86-95.