LATVIAN STATE INSTITUTE OF AGRARIAN ECONOMICS

PERSPECTIVES FOR LATVIAN AGRICULTURAL SECTOR DEVELOPMENT

(Using of LAPA model approach for quantitative assessment)

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0. INTRODUCTION

The further development of Latvian economy including agricultural sector as well as the prosperous integration of Republic of Latvia into the European Union mostly will be dependent on possibilities to compete on internal and external markets of commodities and services. Today due to the low purchasing power of population and relatively high prices on food products Latvian agricultural producers and processors have lost their positions on Eastern markets. At the same time high strict protection measures and quality requirements adopted in the EU are not allowed for Latvian producers to occupy the considerable niche in the European market. Therefore, only due to the increasing of competitiveness of Latvian products by lowering the production costs and improving the quality of final products it is possible successfully to develop of Latvian Agricultural sector in the future.

Development of Latvian Agriculture is dependent on successful implementation of National agricultural and regional policy. For elaboration of such policy it is necessary to take into account a wide range of social and economical factors which might affect the development each particular production line as well as interdependencies between them in different territories of Latvia. Hereto elaboration of long-term policy requires also the consideration of various scenarios which refers to separate production line in specific region or to agricultural sector as a whole considered on the national level. In order to assess the possible economical effects on further development of each particular region or whole Agricultural sector it is necessary to use the economical-mathematical models. According to the results of analytical calculations these models might provide the plenty reliable and objective information which will be used in the policy making process.

Within the framework of Phare/CEAS/ ASA project LE 95 05 “Institutional development in support of Latvian agriculture” and in close co-operation with experts from MTTL[2] Institute (Helsinki) and LVAEI[3] (Latvia) the Latvian Model for long-term agricultural policy analysis (LAPA) was elaborated on the ground of Dynamic regional sector model of Finish agriculture (DREMFIA), which were adapted to the economical conditions of Latvian Agricultural Sector. There are some significant differences between the Finnish and Latvian agriculture and their economic environment and thus some rather fundamental structural changes had to be done before the modelling scheme employed in DREMFIA could be used in the Latvian case. The basic modelling approach in LAPA and DREMFIA, however, is the same. Like DREMFIA, LAPA model is a dynamic, partial disequilibrium optimisation model which assumes a gradual adjustment to changing of economic conditions. This model can be applied not only for agricultural policy analysis, but also for assessment of structural development, regional and environmental effects of different agricultural policies taking into account the requirements of CAP reform.

The present report contains the return (outcome) of 7 months’ joint scientific work (since May until October 1999) under the guidance of MTTL institute researches, who have provided the technical and theoretical support to Latvian researchers in elaboration of

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LAPA model. The above mentioned return includes 6 main chapters. Chapter 1 comprises the general overview about present situation of Latvian Agricultural Sector and main directions of National Agricultural Policy for the future. Chapter 2 is devoted to the comparative study of different modelling approaches which could be applied for long-term analysis of Latvian Agricultural Sector. The theoretical and mathematical background as well as some most important constituent parts of the model are described in the third chapter of the report. Chapter 4 contains the description of the most important features for each scenario elaborated as well as information about the main model assumptions and flows of input data. The analytical results of model approbation are described in Chapter 5. The last chapter is devoted to the recommendations for further application of the model.

This report contains also 1 Annex and list of references.

1. LATVIAN AGRICULTURE

1.1. Agriculture today

The share of agriculture, hunting and forestry in Latvian gross value-added was 4,5% in 1998. Taking into account that hunting and forestry could consist approximately 10 % of sector's value-added the separate share of agriculture could be estimated nearly 4 %. However even this relatively small share of agriculture has tendency to decrease, because according to the statistic data the share of agriculture, hunting and forestry in gross value-added fallen down until 2.9% during the first three months of 1999 instead of 3.9% in 1998.

As the whole economy, the agricultural sector is now under the structural changes, which were started in the beginning of transition period. As it is shown on table 1.1-1 a lot of new private farms were established since 1990. The number of state farms has gradually decreased during the transition period. Now private sector has a leading position in Latvian agricultural production. The sown areas have increased considerably in peasant farms, households plots and private subsidiary farms, also their share in total number of animals rapidly went up.

Table 1.1—1. Sown area and number of animals by type of farm

	1990	1995	1996	1997	1998
Number of farms:					
State farms	210	95	92	81	59
Statutory companies	424	656	617	474	421
Peasant farms	7500	64264	74097	94905	951667
Households plots and private subsidiary farms	18695[4]	243485	N.A.	173280	217401
Sown area, thsd ha					
State farms	790.7[5]	40	29.2	19	8.5
Statutory companies	1408.6[2]	334.2	245.2	112.8	49.7
Peasant farms	108.7	778	864.9	1297.9	1347.1
Households plots and private subsidiary farms	129.9[6]	625.9	688	885.4	825.4

[4] in 1993

[5] in 1991

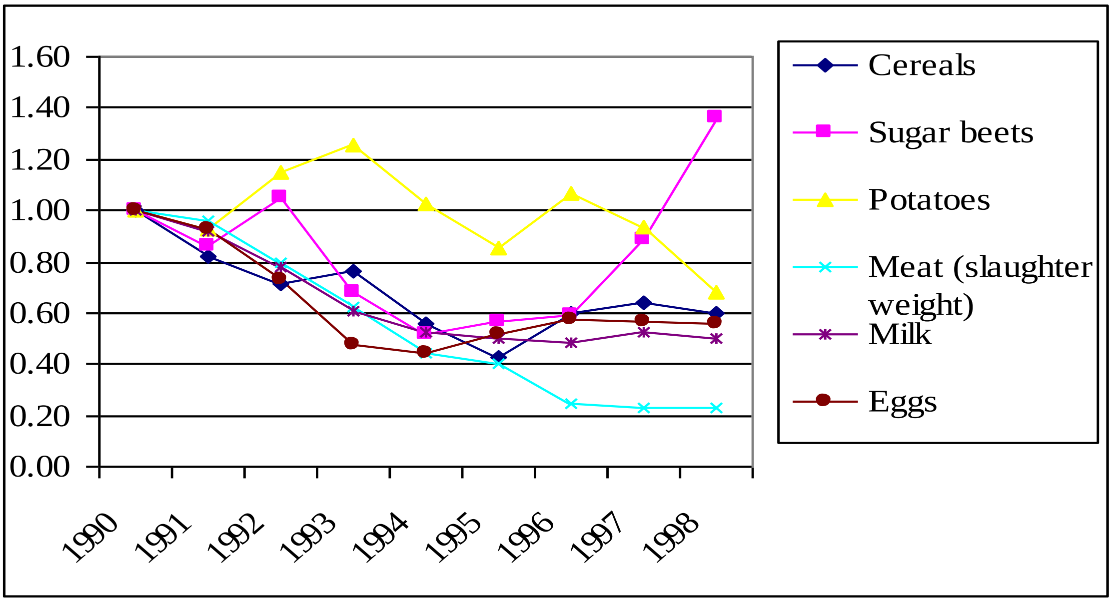
[6] including individual orchards in 1991

Share of peasant farms, household plots and private subsidiary farms in total number of animals, %:					
cattle	22	73.7	76	79.3	80.7
of which cows	29.8	79.8	80.9	84.0	85.1
pigs	14.2	63.4	63	64.6	61.2
poultry	9.5	32.2	34.2	30.3	29.0

Sources: 1) Unpublished information from Ministry of Agriculture, 2) Central Statistic Bureau of Latvia: Agriculture in Latvia, 1999, p 32; Agricultural farms in Latvia in 1997, p.37; Agriculture in Latvia, 1997, p 7, 14, 32, 34; Statistic Yearbook of Latvia 1997 p.195.

At the same time the average size of farms remains comparatively small. The average farm had 7.8 ha of arable land and only 1.4 units of cattle in 1998. In case of peasant farms these numbers comprise 14.6 ha and 1.6 units of cattle respectively.

Figure 1.1—1. Development of agricultural production (1990 = 1).



Source: Central Statistic Bureau of Latvia. Agriculture in Latvia, 1998, p 20, 37; Agriculture in Latvia, 1999, p 20, 38; Latvia in figures 1996, p. 77, 80.

Since the beginning of transition the volume of agricultural production has decreased dramatically. According to the information of Central Statistic Bureau the real volume of agricultural output in 1998 was only 40% of that in 1990. Practically production of all main agricultural products was decreasing until 1997, when it was seemed that certain stabilisation in agricultural production has been achieved (see figure 1.1-1). However during 1998 the production of such main agricultural products as cereals, potatoes, vegetables, meat (in slaughter weight), milk and eggs has decreased again. Only production of sugar beets, rape and flax continued to increase due to essential governmental direct support measures applied during last three years.

Production decrease in animal husbandry was accompanied by the gradual rising of productivity indicators at the same time. As it is shown in table 1.1-2 the level of 1990 was even exceeded in 1997 - 1998. However number of animals goes down without a breach of continuously since 1990. For instance in 1998 the number of dairy cows and laying hens comprised only 45% and 31% respectively of the level of 1990.

In the crop production yield's fluctuations cause the changes in volumes of production. Here the decrease in yield level is accompanied by the reduction of sown areas as well. Only for sugar beets, rape and flax the sown areas were increasing together with the productivity indicators.

Table 1.1—2. Productivity of livestock and yield of agricultural crops and in Latvia.

	1990	1995	1996	1997	1998
Average milk yield per cow, kg	3437	3074	3237	3585	3733
Average egg production per laying hen, pieces	210	192	205	214	219
Yield of agricultural crops, 100 kg per ha:					
Cereals and pulses	23.6	16.9	21.5	21.4	20.5
Wheat	26.3	22.2	24.0	25.9	25.5
Sugar beets	299	264	259	357	365
Potatoes	127	115	138	136	118

Source: Central Statistic Bureau of Latvia. Agriculture in Latvia 1998, p 24, 37; Agriculture in Latvia 1999, p 20, 35.

It is important to stress, that structural changes and agricultural policy liberalisation started at the beginning of transition period in 1990 have caused so considerable decrease in agricultural production. Before that the Latvian agricultural production as well as Lithuanian and Estonian agricultural sectors were oriented on excessive production of livestock products in order to supply other republics of the former Soviet Union. For these purposes strongly supported crop production (mostly production of grain) was maintained. As results of such policy production of agricultural products was not related to the internal demand in food products and feed-staff. Moreover, due to high level of state support and guaranteed marketing possibilities Latvian agricultural sector became very inefficient but nevertheless producing significant amount of main agricultural products.

When centralised economic planing and deliveries system of the economy collapsed and the previous diverse support system for agriculture was abolished it was recognised that Latvian producers are not able to compete (in terms of quality and prices) on open world market, and the wide market of former SU was loosed. All these changes, reorganisation of national economy and orientation to the open market policy have had the considerable influence on development of agricultural sector since 1990.

1.2. Agricultural policy and integration into the EU

The further development of agricultural sector is based on (is marked by) the main principles of Latvian agricultural policy, which was declared in Agriculture law, passed in 1996 and cover all substantial aspects sector policies as foreign trade, price policy measures, finances and credit, tax system, institutional and structural policy measures, support system to agriculture and rural development [22].

The year 1998 was the first year when:

- the new state agricultural support program was carried out. This program is turned to facilitate the preparation of Latvian agriculture for accession into the European Union and integration to the world economic environment;
- the special attempt was made in order to implement the state market intervention as a one of the CAP reform measure in Latvian agricultural policy mechanism.

However even before that year according to Agriculture law the policy objective in agricultural sphere was to ensure the development of Latvian agriculture as one of the basic sector of national economy and to elaborate the correspondent long-term agricultural policy. For these purposes the following preconditions should be created:

- elaboration of effective agricultural policy for transition period until the Latvian accession in the EU;
- rational and varied development of rural enterprises;
- economically stable, environmental friendly and socially orientated development of agriculture;
- alignment of average income in agriculture with average income in other economical sectors;
- implementation of basic principles in agricultural market regulation;
- security of employment in rural regions;
- rational activity of state institutions and organisations of agricultural producers;
- development of agricultural sciences and education.

On the ground of elaborated law several implementation and development documents have been prepared. The Latvian agricultural concept (autumn, 1997), “State support program to agriculture until 2002”(May, 1997) and “Bases for directions of agriculture sectors’ development” (1998) are the most important documents, which denoted the further perspectives for development of Latvian agricultural sector.

During the current stage of development the main goal of agricultural policy is to develop the agricultural sector, which would be able to integrate in the European market, to produce products meeting to the requirements of world market and to compete in terms of quality and production costs with foreign products. In order to reach the goal above mentioned the following main activities had to be fulfilled:

- technological modernisation of production;
- quality management in whole process from production to the sale;
- products' market promotion and development.

At the same time the State support program for the period 1998-2002 provides the main principles of state budget funds' use for implementation of agricultural support measures according to the seven primary subsided programs such as 1)"Agrotechnical amelioration of soil", 2) "Development of agricultural production and technical modernisation", 3) "Improvement of pedigree and basis of seeds", 4) "High quality crop production for processing", 5) "Support to non-traditional (offbeat) branches and rural environment, 6) "Credit guarantee fund", 7) "Quality attestation and adjudgment of origin marks". Observing of all these directions of national support policy gives possibilities to conclude, that State support program determinates the state long-term support policy.

However in order to prescribe the concrete activity measures for implementation of policy documents described above the "Bases for directions of agriculture sectors' development" were elaborated. Such program consists analysis of current situation for all main agricultural branches, as well as determinates perspectives for their development and correspondent tasks. Each branch is characterised by the problems, which limit its development, giving the possible solutions of the problems, by governmental activity measures (including creation of institutional environment, research and education, promotion of investments and technological modernisation, quality management, etc.) and by economical tasks (quality improvements, rational use of resources, creation of self-administrative institutions).

As the conclusion of the program all agricultural branches were distributed between four main groups according to priority in the further development.

The first group includes the branches of higher priority, development of which is related to the increase of its export potential These are the following branches: dairy-farming, production of feed closely related with dairy-farming, pork production and cultivation of grain closely related with pork production.

The branches from the second group are perspective ones, which have not so considerable export potential and oriented to meet the demand of domestic market: aviculture, production of potatoes, vegetable gardening, fruit-growing, horse-farming, sugar production.

Neutral branches with not so high production volumes, which can contribute to the diversification of agricultural employment and creation of specific market niches. They count the following branches: biological agriculture and other non-traditional agricultural branches, sheep and goat breeding.

The branches of last group requires additional analysis which are not able to produced the competitive products free of governmental grants. These are production of flax and beef.

“Bases for directions of agriculture sectors’ development” anticipate that total amount of governmental economic support is provided for all agricultural branches and serves as a base for elaboration of more detail action program. Such capacious national economic support, which covers practically all staple products produced in Latvia somehow opposes with more selective EU support policy. At the same time pursuant to the EU Commission’s proposals, Latvia as an associated country of the European Union will have an access to financial support for structural reforms in agriculture and rural development starting from the year 2000. SAPARD funding is envisaged to be operational from 2000 up to 2006. Joining the EU before the year 2006, Latvia may continue structural adjustments of economy receiving support from the EU structural funds.

For the purpose above mentioned the elaboration of Latvian SAPARD Rural development plan is started in 1999.

On the basis of questionnaire distributed to local social partners in 26 districts and consequent decisions of the SAPARD inter-ministerial working group, the following priorities have been included in the plan:

- Investments in agricultural holdings (including afforestation and land reparcelling);
- Processing and marketing of agricultural and fishery products;
- Economic diversification promoting alternative employment opportunities;
- Improvement of rural infrastructure;
- Environmentally friendly agricultural methods.

Thus, the further perspectives for development of Latvian Agricultural sector is closely related to the development towards to the integration with the EU, that is verified in all principal Latvian agricultural policy documents and in elaboration long-term policy strategies concerning to agriculture and rural development.

2. SELECTION OF THE TYPE OF THE MODEL

2.1. The problem definition and the available modelling tools

The sector model presented here will be used when analysing policy effects on the amount and location of agricultural production in Latvia. The model should provide information on how different agricultural policies affect the level of production and farm income, use of the main production factors- labour, capital and land, in different regions in the next ten years. The dynamic aspect should include the possibility to evaluate the impact of progress in agriculture, i.e. development of productivity and production efficiency, and also the possibility to count time lags for different policy measures applied. There should be reasonably many products in the model because product specific results are expected. Also policy effects on exports and imports and on self-sufficiency of different agricultural products are of importance. Thus, foreign trade should be included in the model, because EU integration will change the trade regime of Latvia. Environmental effects of agricultural policy will be of increasing importance. Thus, it is desirable if some environmental indicators could be included into the model as well.

These are very challenging objectives for a modelling project and it is expected that a single economic model may not be of equal strength in explaining and covering all these aspects in detail. Consequently, some trade off have to be made between the objectives when selecting the model type.

First, it should be stressed that the model should be dynamic since Latvian agriculture is not in a stable equilibrium but under constant changes and development. There is some time to prepare for EU integration and the effects of this integration on Latvian agriculture are of special interest when Latvia is preparing for EU membership. The early policy decisions made in Latvia prior the accession are in key role how successfully Latvian agriculture can integrate into EU. Consequently, the way, how Latvian agriculture develops up to the integration time is one central aspect to be studied using the model. Apparently, the dynamic aspects are somewhat dominating in this selection and some level of detail needs to be omitted in modelling other aspects.

Actually, the very first selection preceding the decision to build a sector model is to select between a national level model (like general equilibrium models) and a sector level model. This selection was done already before launching this project. General equilibrium models have some advantages over sector level models by including relationships between agriculture and other sectors in the national economy. If the national economy is in a process of a significant change and agriculture has a significant role in the economy then there are strong arguments in favour of general equilibrium models. However, construction of large economy wide models in such a detail that makes possible a detailed analysis of agriculture at the level of individual products requires more resources than are available in this project. Using sector level models it is easier to analyse agriculture in a more detail than in large general equilibrium models where high level of aggregation is necessary to avoid excessive complexity and computational burden. In addition, the interrelationships between different production lines and products, which are important in analysing effects of agricultural policy, are easier to model in sector level models. Furthermore, some dynamic and agricultural development issues - which are of particular interest in this study - are easier to model in a partial equilibrium model than in a general equilibrium model.

Different approaches used in agricultural sector modelling are reviewed by Bauer & Hendrichsmeyer (1989). The most common model types are sectoral programming models and econometric models.

Econometric model specifications with parameters estimated from past data is probably not the best approach in analysing effects of future policy changes in Latvian agriculture. This is because the economic conditions of Latvian agriculture have changed dramatically in 1990's. There are two main reasons for this. The first is related to rapid changes in general economic environment and the other is related to institutional, structural and technological change in agriculture.

The economic conditions for Latvian agriculture changed drastically with 1990ties. Replacement of the previous socialist type of the farming sector, based on collective and state farms with privately owned farms started. Centralised economic planing and support system to agriculture were collapsed. Latvian producers were not able to compete (in terms of quality and prices) on open world market, and the wide market of former SU was loosed. All these changes, reorganisation of national economy and orientation on the open market had the considerable influence on development of agricultural sector since 1990.Production has been falling on all agricultural production lines.

Overall, there is a great uncertainty in the Latvian economy and agriculture in particular, which can be characterised also by high interest rates (appr. 20% at 1999).

The structure of Latvian agriculture has changed rapidly when the number of collectively managed farm enterprises has decreased and tens of thousands of relatively small family farms have been established. The future is subject to further changes in farm structure.

There are some possibilities in improving productivity and production efficiency of Latvian farms. This, however, requires investments in agricultural production systems. The initial productivity and efficiency level of Latvian agriculture is relatively low (compared with most western European countries) and there is some potential of development. It is, however, difficult to find funds and entrepreneurial ability in order to carry out investment projects successfully. Uncertainty about prices, subsidies and interest rates may be too high in order to attract investors in agriculture. If many small farmers exit (either due to unprofitable production or high age of farmers), production will further decrease if the remaining larger farms are not willing to take risks and invest.

To sum up, many great changes in economic conditions of agriculture make it difficult to apply econometric methods in modelling Latvian agriculture. Econometric model specifications with parameters estimated using past data is not the most appropriate approach in analysing effects of future policy changes in Latvian agriculture. Somehow to improve the approach econometric simulation models can be used.

However if major structural and technological changes are to be expected in Latvian agriculture, it makes the application of econometric modelling techniques even more problematic. Also some direct subsidies, different production technologies as well as explicit physical production quotas, fixed production factors, internal flows of agriculture and environmental regulations which may take place at EU integration are difficult to model using the econometric approach (Bauer 1988b, p. 15).

A widely employed sector modelling approach in agriculture is maximisation of consumer and producer surplus subject to market balance and resource constraints (see, for example, Hazell & Norton 1986 and Apland & Jonasson 1992). This approach assumes a sector level (partial) economic equilibrium with endogenous prices. Indeed, it is an application of spatial price equilibrium where movements of commodities between different regions is explicitly modelled. The model is calibrated to replicate the base year where an economic equilibrium is assumed. Some additional specifications need to be constructed in modelling foreign trade since exogenous import and export prices will result to high sensitivity on external price level.

In the Latvian case it is difficult to apply static programming models which calculate an equilibrium by maximising consumer and producer surplus. Prices of agricultural products for both producers and consumers have been subject to significant changes in Latvia since 1991. However, a programming model may tell us the direction of change how production will evolve. Different kind of subsidies and changes in production technology can be easily included in a programming model, as well as fixed production factors, internal flows of agriculture with explicit physical linkages between different production lines as well as possible production quotas and environmental regulations. In terms of policy analysis, a sectoral programming based methodology provides a more flexible approach in modelling Latvian agriculture.

When many fundamental changes in economic conditions take place at the same time, it makes difficult of applying any equilibrium based traditional techniques of economic modelling. The chosen base year should be reasonably close to an equilibrium in order to validate the model specification and its parameters. In the case of apparent disequilibrium and great changes in economic environment, many parameters (which are determined partly outside agriculture) can only be given some values based on expert opinions. For this reason, one should not have too high expectations concerning equilibrium based sector level economic models. They can only be used when explicitly recognising the difference between the assumptions of the model and reality.

However, economic models, which need not be based on equilibrium only, may help policy makers and agricultural economists to understand the aggregate behaviour of agricultural sector under changing conditions and different policy options. At least, the model can help economists and policy makers in analysing more carefully the range and magnitude of the effects of different agricultural and trade policies. Economic models are one of the few tools in providing an analytic and consistent treatment of aggregate level impacts.

In this study, no traditional equilibrium based methodology has been used in its pure form. Rather, this study is an attempt to create an integrated dynamic model of Latvian agriculture which contains the most important agricultural development mechanisms and can be used in assessing impacts of different policy alternatives. Because of many exogenous parameters (which are subject to uncertainty) the model results should be understood as possible future paths under different policy scenarios, not necessarily as a single one which will occur. The key idea in this study is to include the main driving forces of agricultural sector into a dynamic model. The major driving forces of agricultural sector can be divided into three parts: (1) short term market reactions which characterise aggregate level changes in production, consumption, and exports and imports, (2) gradual adjustment of production practices at farm level as a consequence of profit maximisation, (3) some parameters that are partly or fully exogenous for agriculture, like technical change and inflation.

If these driving forces can be included into a single model, the model can increase the understanding of the interplay of many simultaneously changing factors and dynamics in agriculture. Rather than asking what exactly will happen, we should ask, what is likely to happen in Latvian agriculture under different policy scenarios, given some exogenous parameters.

In this study a dynamic disequilibrium model has been built using the sectoral programming approach as a starting point. In the following, the basic hypothesis of the model is presented. The structure of the model is described in chapter 3. A simple application of the model is presented in chapter 4 to show how the model is can used in policy analysis.

2.2. Dynamic disequilibrium approach

There are many reasons why static maximisation of consumer and producer surplus is problematic in modelling Latvian agriculture. The static nature of the model assumes that the base year corresponds to an economic equilibrium. This is not always the case in reality. In Latvian case it is hard to find such a base year. Consequently, it is often difficult to replicate the base year and to perform agricultural policy analysis.

Economic adjustment to changing agricultural policy may take several years. During this time other changes that are partly independent of the policy may occur. Such changes may happen, for example, in consumption habits of consumers, prices of inputs, crop yield levels, average yields of livestock, and use of some production inputs (e.g. labour and capital) as a result of farm size growth or other rationalisation of production. These changes may strongly affect the direction of development and at least some of these factors should be taken into account in medium and long term policy analysis. This fact has been mentioned in some agricultural modelling applications which are based on static models (see, for example, Apland, Jonasson & Öhlmer 1994 p. 126-127). However, there have been relatively few efforts to model the internal dynamics or productivity growth of agriculture or farm level adaptation mechanisms. Some efforts in this direction can be found in Bauer 1988, Day 1978 and in Day & Cigno 1978.

Frequent changes in prices, subsidies and technology result in various kinds of adjustment pressures and reactions in agriculture. The market mechanism drives the sector towards equilibrium. However, due to biological and technical constraints as well as fixed production factors and other frictions, the equilibrium is not easily reached. Major changes and equilibrium in the agricultural sector are possible if the price relations and policies prevail for an adequately long time.

When creating a dynamic model of agricultural markets different time lags in different lines of production should be modelled. Production cannot change too rapidly because of biological and technical constraints. Also modelling some other special features of agriculture, like feeding requirements and animal and crop yield functions, increases the explanatory power of the model. Including the key driving forces and some specific characteristics and dynamics of agriculture into the same model may bring important insight to economists and policy makers.

The concept of dynamic disequilibrium applied in this study is similar to that used in Lehtonen (1998) which describes the agricultural sector model developed for Finland. However, the model described in this study is rather different from the Finnish model mainly because of a special kind of treatment of foreign trade which gives a very distinct character for the Latvian model. Some structural equations and dynamic development mechanisms are somewhat simplified from those presented by Lehtonen (1998). Complexity and level of detail can be increased later on. The model to be described is, however, already now fairly complex and large in mathematical terms. The results, nevertheless, are logical and easy to understand given the initial assumptions.

3. STRUCTURE OF THE SECTOR MODEL

3.1. The overall structure

The basic structure of the model is presented in figure A-1 (in annex). The core of the model is an optimisation block which maximises producer and consumer surplus. It provides an annual supply and demand pattern using the outcome of the previous year as the initial value. Different kinds of production lags in different lines of production are taken into account by imposing constraints on production variables in relation to the preceding year. Hence, production variables may change only within certain bounds each year. These constraints imply that an individual optimum outcome does not correspond, in general, to an economic equilibrium, but only a short-term reaction towards equilibrium. Continuously changing policy, production technology and consumption trends, which are given exogenously from the steering module, result in frequent changes in agricultural markets. However, even if the changes are restricted in the short-term, long-term changes may be considerable, if the price relations and policy causing the change prevail long enough.

The development paths obtained from a the dynamic model are to some extent dependent on the given limits for change. The absolute magnitude of the change varies when using different limits for change, but the direction of the change remains the same. Someone may argue that the exogenously given bounds, the so-called flexibility constraints, always determine the model results. This may the case in some simple dynamic models, but it is not the case in complex models like this one. There are many interdependencies between the decision variables in the model and most often the bounds for the decision variables are not binding. However, the bounds for the decision variables are important for ensuring the realism of the model. At the farm level there are clear technical and biological restrictions in livestock production, for example, which prevent large short-term changes in production. One can also use time series of agricultural production to justify the bounds for the decision variables. Flexibility constraints may, in principle, represent not only technical and biological restrictions, but also cautious sub-optimisation and risk averse behaviour of farmers.

Thus, the model uses a one-period optimisation as the basis of choice without considering long-run trajectories based on explicit representation of the dynamic feedback of the markets. It is assumed that farmers do not make forecasts of future prices and subsidies and do not make strategic long-term choices in the model. Rather, farmers respond to exogenous changes with more or less caution. This is quite reasonable assumption in the case of Latvian agriculture since future agricultural policy and general economic conditions are highly unpredictable. Some individual farmers may have some long-term decision making and strategies. At the aggregate level, however, it is hard to justify long term decision making and strategic behaviour in terms of representative farms. The agricultural sector as whole or some large groups of farmers do not make joint strategic decisions.

In the optimisation model there are certain fixed inputs and outputs corresponding to many production activities (Leontief-technology). In livestock sector, however, feed use coefficients of animals are decision variables, which means that animals may be fed using different feed stuff combinations. However, there are constraints relative to feed use. The required energy (measured in fodder units), protein and roughage needs of animals can be fulfilled in different ways. The use of each feedstuff, however, is allowed to change only 5-10 % annually due to fixed production factors in feed production. This means that feeding of animals may change only gradually because of biological reasons and fixed production factors. Furthermore, changes in feeding affect directly the milk yield of dairy cows. A quadratic function is used to determine the increase in milk yield as more grain is used in feeding.

The use of fertilisers and the resulting crop yield is determined each year outside the optimisation model. This means that optimal farm level fertilisation is calculated using expected price level for crops and exogenous price of fertiliser as well as crop yield functions. Market mechanism does not affect yearly changes in use of fertilisers or crop yield. Fertiliser use and crop yield depend on expected domestic prices (in case of EU scenario on the EU price level or EU intervention prices). Fertiliser prices, like other input prices are exogenous in the model. Yield functions are obtained by adjusting empirically estimated yield functions to the average fertilisation and yield level in each region.

Technological change is exogenous in the model. Crop yields and animal yields may increase according to a given percentage per year. The use of some inputs, like labour and capital per hectare and animal, may become more efficient in the model. The use of labour, for example, may decrease, say, 2% per animal per year due to growth in average farm size or some other means of rationalising the production. The rate of efficiency increase may be different for different inputs.

Thus, the model can be characterised as an agricultural development model suitable for a various kinds of scenario analysis. The model can be used in analysing effects of agricultural policies in case of different development scenarios. Thus, the model can be used in evaluating the direction and magnitude of changes in production, farmers’ income and use of inputs. At the same time one may evaluate the requirements for different development scenarios. Different amounts of capital, for example, are needed in different kinds of investments. This evaluation, however, has to be done outside the model since the model does not include explicit investment mechanisms. Some capital costs are assigned to production variables, like number of animals and hectares and thus continuous investment is assumed.

It is assumed that agriculture is a price taker of agricultural inputs, i.e. prices of agricultural inputs, like fertilisers, fuel, electricity etc. are independent on the amount of application of the input of those inputs. This assumption can be relaxed by specifying price elasticities of supply for different inputs. One should note, however, that this model concerns only agriculture and agriculture may have very little effect on electricity prices, for example. They are not explicit mechanisms in the first version of the model to include such price elasticities of supply, but such input price functions can be easily added to the model if necessary.

Inflation is assumed to affect the input prices as well as product prices and agriculture cannot affect this inflation rate or any other macro level variables in the national economy.

Also the price of labour is subject to inflation and agriculture cannot affect the price of labour. In other words, it is assumed that agriculture has no effect on the Latvian national economy. This assumption may not be fully justified in Latvian case.

The known subsidies for the different years and the anticipated subsidies for the future years (the effects of which are being examined) are determined by means of a separate policy section. Together with the support policy, a scenario of the price level on the single market of the EU is also formulated.

The consumption trends of each foodstuff are given up to year 2010 in the steering module. Food consumption is allowed to change only within some exogenously given bounds around a given trend value. This is important since prices of agricultural products do not explain adequately the food consumption. What is more, relatively small changes in prices have little effect or no effect on changing consumer habits on medium or long term.

The development of the agricultural sector is simulated from 1998 till 2010. The study includes seven main areas for which the production and consumption variables has been defined as well as transportation variables between the regions. The final and intermediate products move between the main areas at certain transportation cost. There is foreign trade from each main area at fixed average EU or world market prices.

The model includes most important production lines of Latvian agriculture, like crop production, dairy production, the production of beef, pig meat and poultry meat, as well as egg production. The arable crops include spring and winter wheat, barley, oats, rye, puls, triticale, buckwheat, flax, sugar beets, silage, green fodder, dry hay. Vegetables and some horticulture products are excluded in the first version of the model but they can be easily included when more data is found about production costs and foreign trade of those products. Open and green set-aside areas are also included in the model. In the processing of sugar, fixed margins in lats (Latvian currency) are used between the raw material and the final product. All the other products, like meat, milk, eggs and crops, are priced at the producer price level. The livestock includes dairy cows, sucker cows, dairy and suckler cow heifers, slaughter heifers separately from milk production and specialised beef production and, correspondingly, bulls of over one year and over 15 months, as well as sows and fattening pigs, laying hens, and other poultry.

3.2. Demand function specification and imports

The very special issue in the model is the way how foreign trade is modelled. Foreign trade flows are modelled separately between Latvia and EU and between Latvia and the rest of the world. It is assumed that Latvia cannot influence EU or world market prices.

For the part of imports from EU, the Latvian and the corresponding imported products are defined as imperfect substitutes (Armington assumption). The demand functions of the domestic and imported products influence each other through elasticity of substitution. A detailed derivation of demand functions based on this idea can be found in Lehtonen (1998, 1999), which follow substitution Dixit (1988) and Sheldon (1992). Due to imperfect substitution the model is not sensitive for exogenous EU or world market prices. There may be exports and imports of the same product between Latvia and EU but not between Latvia and the rest of the world. The substitutability and, thus, the sensitivity of the reactions of the foreign trade, is affected by the elasticities of substitution. These elasticities are difficult to estimate from data. What is essential in terms of the model and the analysis is that the relations between the elasticities of substitution of the different products are rational. For example, the domestic and EU crop products are almost complete substitutes of each other, but, according to the market information, the domestic and EU meat would seem to substitute for each other only partly.

Let Q_1 be the demand of domestic product and Q_2 the demand of the corresponding imported product in equations (1) and (2). P_1 and P_2 are the prices of domestic and imported products, respectively. Parameters A_1, A_2, B_1, B_2 and K are all positive and $(B_1B_2 - K^2) > 0$, when domestic and imported products are imperfect substitutes.

$$Q_1 = A_1 - B_1P_1 + KP_2 \tag{1}$$

The inverse demand functions are (3) and (4).

$$Q_2 = A_2 + KP_1 - B_2P_2 \tag{2}$$

$$P_1 = a_1 - b_1Q_1 - kQ_2 \tag{3}$$

$$P_2 = a_2 - kQ_1 - b_2Q_2 \tag{4}$$

The parameters of the inverse demand functions can be expressed as (5).

$$a_1 = \frac{A_1B_2 + KA_2}{B_1B_2 - K^2};\ a_2 = \frac{A_2B_1 + KA_1}{B_1B_2 - K^2};\ b_1 = \frac{B_2}{B_1B_2 - K^2};\ b_2 = \frac{B_1}{B_1B_2 - K^2};\ k = \frac{K}{B_1B_2 - K^2} \tag{5}$$

A demand system (3) and (4) is obtained when maximising consumer's utility function, which is concave and differentiable,

$$U(Q_1, Q_2) = a_1Q_1 + a_2Q_2 - \tfrac{1}{2}(b_1Q_1^2 + b_2Q_2^2 + 2kQ_1Q_2) \tag{6}$$

relative to budget constraint (income = $P_1Q_1 + P_2Q_2$). Differentiating (6) in respect to Q_1 and Q_2, inverse demand functions (3) and (4) are obtained. All parameters in equations (1-4) are positive and the utility function (6) is strictly concave.

In systems given by (1) and (2) and by (3) and (4) there are two equations and five unknowns in each, so additional conditions have to be defined in order to find the unknowns. Two more equations are obtained, when the total price elasticity of the product (7) as well as the substitution elasticity between domestic and foreign product (10) are defined. The total price elasticity is given by

$$\varepsilon = \frac{E_1}{E}(\varepsilon_{11} + \varepsilon_{12}) + \frac{E_2}{E}(\varepsilon_{21} + \varepsilon_{22}) \qquad (7)$$

where ε_{ij} is the price elasticity of demand of product *i* subject to the price of product *j*.

$$\varepsilon_{ij} = \frac{dQ_i}{dP_j}\frac{P_j}{Q_i} \qquad \text{i= 1,2: j=1,2} \qquad (8)$$

E is the total amount of money consumed for each product. $E_1=P_1Q_1$ is the value of domestic products and $E_2=P_2Q_2$ is the value of corresponding imported products.

Substitution elasticity between domestic and imported product is defined as

$$E = E_1 + E_2 = P_1Q_1 + P_2Q_2 \qquad (9)$$

$$\sigma = -\frac{dlog(\frac{Q_1}{Q_2})}{dlog(\frac{P_1}{P_2})} = \frac{(\frac{P_1}{P_2})\,d\,(\frac{Q_1}{Q_2})}{(\frac{Q_1}{Q_2})\,d\,(\frac{P_1}{P_2})} \qquad (10)$$

A substitution elasticity approaching infinity means that domestic and corresponding imported products are perfect substitutes. In that case, products are identical, and any difference in price, however small, between the products is a sufficient incentive for consumers to shift totally to the cheaper product. In reality, however, domestic and corresponding imported products are most often imperfect substitutes. If the substitution elasticity is 1, parameter k in (3) and (4) is zero and domestic and imported products are then totally different products. If substitution elasticity were smaller than 1, the k-parameter is negative, which means that utility function would be no longer concave. Thus, the substitution elasticity must be greater than 1. The greater the substitution elasticity, the more similar are the products.

Values for the substitution elasticities are obtained either from market data or as guess values from experts. Substitution elasticity for beef, for example, is given value 1.5 in the model. If consumers are suspicious about the quality of imported beef they are rather reluctant to change to imported beef. On the other hand, some cereals and sugar, however, are mostly intermediate products used by food industry, and thus domestic and imported products can be regarded as homogenous. The substitution elasticity of sugar and some cereals, for example, may vary between 4 and 7. In other words, agricultural commodities differ in terms of substitutability. The country specific substitution elasticity values may be based on country specific prior information or expert opinions. It is difficult, however, to find exact estimates for the substitution elasticities. This is one reason why the model should not be used in producing exact forecasts of the future, but to compare between different policy scenarios. Nevertheless, the model results are not sensitive for minor changes in substitution elasticities.

To be able to solve the demand function parameters one needs to assume homothetic preferences of consumers. After some algebraic manipulation one obtains the expressions (19) and (20). Dixit (1988) and Sheldon (1992) calculated the same expressions. Some more detailed calculation of the parameter values is also presented in Lehtonen (1998, 1999).

$$A_1 = Q_1^*(1 - \varepsilon);\ A_2 = Q_2^*(1 - \varepsilon);\ K = -\varepsilon \frac{Q_1^* Q_2^*(\sigma - 1)}{P_1^* Q_1^* + P_2^* Q_2^*} \tag{11}$$

$$B_1 = -\varepsilon \frac{Q_1^*(P_1^* Q_1^* + P_2^* Q_2^* \sigma)}{P_1^*(P_1^* Q_1^* + P_2^* Q_2^*)};\ B_2 = -\varepsilon \frac{Q_2^*(P_1^* Q_1^* \sigma + P_2^* Q_2^*)}{P_2^*(P_1^* Q_1^* + P_2^* Q_2^*)} \tag{12}$$

Using the imperfect substitution specification it is possible to specify, if appropriate, consumers' willingness to pay more for Latvian products than for imported EU products. This can be done in a simple way by specifying the level of the demand function of domestic product at a higher level (say, 5-10%) than the demand function of the imported product. At this point of the modelling exercise this possibility has been used only in the case of meat, where Latvian domestic producer price level is somewhat different from the import prices. Consumers are assumed to be willing to pay 10% more for domestic meat than for the meat imported from EU. For other products no such preferences were specified.

For the part of imports from the rest of the world, the domestic and the corresponding imported products are homogenous in the model. This means that small changes in world market price level may change considerably the imports from the rest of the world to Latvia. The Latvian production, however, can decrease annually only within the lower bounds given for the production variables. Thus, imports from the rest of the world may gradually overtake domestic production.

Perfect substitution between Latvian and the rest of the world products concerns only the case when Latvia is not a member of EU. Before EU accession there are two kinds of exogenous foreign trade prices in the model because of different tariff rates applied for imports from EU and for import from the rest of the world. There is no possibility of arbitrage, however, because the difference between those two tariff rate levels is rather small and there are some costs implied by the foreign trade actions in the model. In the case of meat, for example, the base price level is a forecasted world market price level. Slightly different tariff rates are imposed on meat imports from EU and from the rest of the world and no arbitrage opportunities exist. In the case of crop products the rest of the world price level is assumed to be proportional to EU price level which is to be decreased in CAP reform during 2000-2001. In later years the difference between rest of the world crop prices and EU crop prices is assumed to be only few percents and thus no arbitrage can occur.

After EU accession producers face always EU price level and trade of agricultural products with the rest of the world is fixed to zero. 'Rest of the world' actually means other Baltic states and CIS countries which are the main agricultural trade partners of Latvia. Latvia has been an exporter of many agricultural products to eastern European countries. It is assumed that Latvian products are homogenous with Eastern European products because of long traditions and established trade relations. The quality and hygienic standards of some agricultural products are different in EU and in eastern Europe. Thus, as a first approximation, it is assumed that EU products are qualitatively different from Latvian and rest of the world products.

Modelling imperfect substitution between Latvian and eastern European products is not straightforward in the present set up of the model. If desired, however, it can be modelled with some modifications to the model structure.

3.3. Exports

It has been noted above that the domestic and corresponding foreign products have been defined as different products. However, the export products are still homogeneous with the domestic products. It is possible that the exports of certain products may decline too rapidly or grow too fast without the frictions of exports to be modelled separately. In reality exports cannot in the short term grow too rapidly without considerable additional costs. Instead, if the support policy or other factors are in favour of the export of a certain product for an adequately long time, exports may grow significantly over time. In that case the export costs remain at a reasonable level.

Export quotas (for example, EU has imposed a quota for imports of Latvian milk products) can be modelled simply by adding one constraint into the model which restricts the sum of all regional export variables. Import quotas, if any, can be handled in a similar fashion.

In this study export costs have been modelled as linearly increasing in relation to the export quantities of the preceding year. The linear export cost function (13) is calibrated every year to the last year's level of exports.

$$EXC_{gi} = ftc_i + ftc_i k_e \frac{E_{gi}(t) - E_{gi}(t-1)}{E_{gi}(t-1)} \quad \text{if } E_{gi}(t-1) > 0 \tag{13}$$

$$EXC_{gi} = ftc_i \quad \text{if } E_{gi}(t-1) = 0 \tag{14}$$

Either (13) or (14) is chosen before each optimisation on the basis of $E_{gi}(t-1)$. This definition of the export cost function also means that the export costs remain constant if the export quantity does not change from the preceding year. On the other hand, the export costs decrease if the export quantities fall from the previous year. For this reason, the parameter k_e in equation (13) is non-negative but lower than 1. It is assumed that the exports and imports cannot influence the world market prices or the price level of the EU. The change in the export costs is considered to result from marketing costs, transportation arrangements, and other similar costs. These costs are only a fraction, less than 10%, of the price of the product. The definition of export costs of equations (13) and (14) is mainly a technical measure to prevent sensitivity to small changes in the EU or world market price level. The parameter k_e has been used for calibration, i.e. minor changes has been done in k_e to replicate the known exports at the base year. For most products this simple definition of export costs works well and prevents sensitivity of exports on the external price levels.

3.4. Optimisation model

Competitive markets are simulated by maximising the total of the producer and consumer surplus. (*CS*=consumer surplus and *PS*=producer surplus in figure 3.4.-1). The constraints of the optimisation are the conditions concerning the market balance (demand-supply), production capacity, quotas, crop rotation, and other restrictions. Often, there are certain fixed inputs and outputs corresponding to each production activity (Leontief technology). The outcome depends on the reactions of the demand and supply within the set framework, which also includes agricultural support. Agricultural policy measures are market interventions of the government, which influence the market balance and the consumer and producer surplus. As the final outcome we obtain the production and consumption in each region as well as the movements of products between the main areas under the assumption of perfect competition.

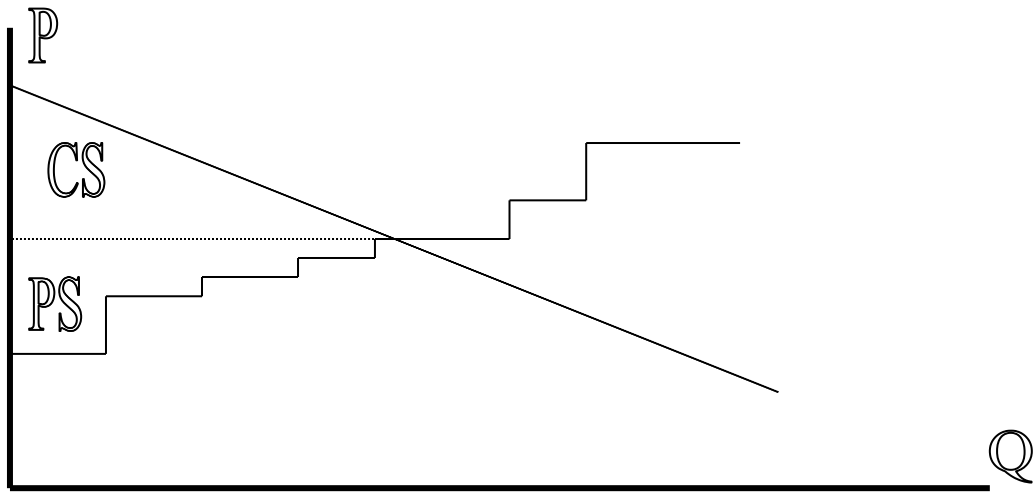


Figure 3.4—1. Consumer and producer surplus and the implicit supply curve given by the optimisation

3.5. Objective function

Objective function (equation 19 below) is of the second degree; i.e. price is an endogenous variable. The hypothesis is that efficient markets under perfect competition operate in an optimal way in terms of producer and consumer surplus. This is required in order to make the price of the product equal to the marginal cost of the production. This requirement, however, may not be satisfied because of flexibility constraints imposed on the production variables. Thus, the maximisation of the objective function simulates annual reactions towards an equilibrium, not necessarily achieving a particular equilibrium. Nevertheless, the task of the optimisation is to simulate the market (Hazell & Norton 1986 pp. 160-162, 167-168, Silberberg 1990 pp. 492-493. It is assumed that an individual producer or consumer cannot influence prices and that he is profit maximising. In addition, he may avoid risk and appreciate other than economic factors, too. The closer the reality is to the basic assumptions of perfect competition and neo-classical theory, the better the markets according to the optimisation model correspond to the reality (Hazell & Norton, pp. 161-162).

In the following equations uppercase letters denote the variables. Lower case letters denotes parameters and symbols. The symbols are as follows:

g denotes region (r pcs),

i product (n),

k production input (m),

l fixed production input (q),

z intermediate product (n_r),

j production activity (s),

f feed stuff (nf),

fu_f energy content coefficient of feed f and

$funits_j$ fodder units required by animal j.

The variables and parameters are as follows:

$Q1_{gi}$ denotes consumption of domestic food products in region g,

$Q2_{gi}$ consumption of imported food product,

$P1_{gi}$ price of domestic product i in region g,

$P2_{gi}$ price of imported product i in region g,

Z_{gk} use of input k on region g,

V_{gz} use of intermediate product z in region g,

w_{gz} price of intermediate product z in region g,

T_{ghi} transport of product i from area g to area h,

t_{ghi} unit transportation cost of product *i* from area *g* to area *h*,

$c1_{gk}$ and $c2_{gk}$ parameters of supply function for input *k* in region *g*,

$c1_{gk}$ is the fixed price of input *k* in region *g* (unless supply functions of inputs are defined),

X_{gbj} extent of production activity *j* in sub-region *b* of region *g*,

e_{gij} is the yield coefficient of production activity *j* when producing product *i* in region *g*

u_{gkj} the amount of input *k* required by the production activity *j* in region *g*

S_{bj} subsidy paid for production activity *j* in support region *b*,

E_{gi} export of product *i* from region *g*,

ER_{gz} export of intermediate product *z* from region *g*,

I_{gi} import of product *i* to region *g* (=$Q2_{gi}$),

IR_{gz} import of intermediate product *z* to region *g*,

ep_i price of product *i* in the EU,

erp_z price of the intermediate product *z* in the EU,

EXC_i export cost of product *i*, and

EXC_z export cost of the intermediate product *z*

ftc_i foreign trade cost of product *i*

ftc_z foreign trade cost of intermediate product *i*

$INTR_{gi}$ intervention flow of product *i* from region *g*

Consumer surplus (*CS* in (15)) and surpluses of processing industry and producers are obtained by adding up surpluses of products in different regions. The producer surplus can be divided to the surplus of the processing industry (PS_1) and to farmer's surplus (PS_2).

$$CS = \sum_{g=1}^{r} \sum_{i=1}^{n} [(a1_{gi}Q1_{gi} + a2_{gi}Q2_{gi} - 0.5b1_{gi}Q1_{gi}^2 - 0.5b2_{gi}Q2_{gi}^2 - k\,Q1_{gi}Y2_{gi}) - P1_{gi}Q1_{gi} - P2_{gi}Q2_{gi}] \quad (16)$$

$$PS_1 = \sum_{g=1}^{r} [\sum_{i=1}^{n} P1_{gi} Q1_{gi} + P2_{gi} Q2_{gi} - \sum_{z=1}^{n_r} V_{gz} w_{gz} - \sum_{i=1}^{n} PROC_{gi}\, pc_i$$
$$- \sum_{i=1}^{n} \sum_{h=1}^{r} t_{ghi} T_{ghi} + \sum_{i=1}^{n} npr_i\, INTR_{gi} + \sum_{i=1}^{n} (E_{gi} - I_{gi}) ep_i \quad (17)$$
$$+ \sum_{z=1}^{n_r} (ER_{gz} - IR_{gz}) erp_z - \sum_{i=1}^{n} (I_{gi}\, ftc_i + E_{gi}\, EXC_{gi})$$
$$- \sum_{z=1}^{n_r} (IR_{gz}\, ftc_z + ER_{gz}\, EXC_{zi})]$$

$$PS_2 = \sum_{g=1}^{r} \sum_{z=1}^{n_r} V_{gz} w_{gz} - \sum_{g=1}^{r} \sum_{k=1}^{m} (c1_{gk} Z_{gk} + 0.5c2_{gk} Z_{gk}^2) + \sum_{g=1}^{r} \sum_{j=1}^{s} \sum_{b=1}^{sr} X_{gbj}\, S_{bj} \quad (18)$$

When all surpluses are added up, the total surplus of the farm sector (*TS*), which is to be maximised, is obtained. Food consumption, production, processing, tranfers of products between regions, as well as import and export are the decision variables. Subsidies paid for farmers are exogenous parameters which are accounted as surpluses of the sector. Costs for taxpayers and connections to the other sectors of the economy are excluded. Subsidies are basically paid according to the production activities which are arable areas and numbers of animals. However, there are some price subsidies but they are paid only for few products.

$$TS = \sum_{h=1}^{r} [\sum_{i=1}^{n} (a1_{gi} Q1_{gi} + a2_{gi} Q2_{gi} - 0.5b1_{gi} Q1_{gi}^2 - 0.5b2_{gi} Q2_{gi}^2 - kQ1_{gi} Q2_{gi})$$
$$- \sum_{k=1}^{m} (c1_{gk} Z_{gk} + 0.5c2_{gk} Z_{gk}^2) + \sum_{b=1}^{sr} \sum_{j=1}^{s} X_{gbj} S_{bj} - \sum_{i=1}^{n} PROC_{gi}\, pc_i$$
$$- \sum_{h=1}^{r} \sum_{i=1}^{n} t_{ghi} T_{ghi} + \sum_{i=1}^{n} INTR_{gi}\, npr_i + \sum_{i=1}^{n} (E_{gi} - I_{gi}) ep_i \quad (19)$$
$$+ \sum_{z=1}^{n_r} (ER_{gz} - IR_{gz}) erp_z - \sum_{i=1}^{n} (I_{gi}\, ftc_i + E_{gi}\, EXC_{gi}) - \sum_{z=1}^{n_r} (IR_{gz}\, ftc_z + ER_{gz}\, EXC_{zi})]$$

3.6. Constraints

The objective function is maximised so that the markets clear in each region for each product. The equation (20a) is an equilibrium equation for domestic final products in different regions. The demand of the domestic product $Q1_{gi}$ can be satisfied only by

$$Q2_{gi} - \sum_{j=1}^{s} e_{gij} X_{gj} - \sum_{h=1}^{r} T_{hgi} + \sum_{h=1}^{r} T_{ghi} + E_{gi} \leq 0 \quad g = 1...r, i = 1...n \quad (20a)$$

domestic production, i.e. by production in the region *g* or by transfer from other regions. There may be several production activities producing $Q1_{gi}$. For example, beef can be obtained from bulls over 15 months old, bulls less than 15 months old, heifers, dairy cows and suckler cows. Dairy products and sugar are priced on the consumer price level in the model. In that case $Q1_{gi}$,, the demand for the domestic product i in region g, can be satisfied by processing of product i in processing activities j in region g when X_{gj} should be replaced by a corresponding processing activity. T_{ghi} is the transfer of products from region g to region h. E_{gi} is the export of product i from region g and I_{gz} is the import of intermediate product z to region g. The demand of the foreign product $Q2_{gi}$ can be satisfied only by imports. Inequalities (there has to be at least as much supply as demand in each region) are formed for both domestic and foreign products.

Another balance equation is formed separately for final and intermediate products (20b). In case of intermediate products, like raw milk or raw sugar used by food industry, $Q1_g$ in equation (20a) is replaced by a regional processing activity $PROC_{gi}$. Intermediate products and inputs used by industry may be imported. Production of raw materials may include yield coefficients e_{gbij} which have to be taken into account. This is necessary for the supply of raw materials, inputs for the production and proper cost calculation. In equation (20b) the same raw materials or intermediate products may be used in different processing activities which require different input combinations (denoted by v_{zi}). For example, different milk products consist of different combinations of skimmed milk and milk fat. The balance equations like (20b) ensure that there is enough skimmed milk and milk fat for processing in each region. Skimmed milk and milk fat can also be transported between the main regions as well as the final dairy products.

$$\sum_{i=1}^{n} v_{zi} PROC_{gi} - \sum_{j=1}^{s} e_{gij} X_{gbj} - \sum_{h=1}^{r} T_{hgz} + \sum_{h=1}^{r} T_{ghz} + ER_{gz} - IR_{gz} \leq 0 \quad g = 1...r, z = 1...n_r \tag{20b}$$

Inputs needed for each production activity are, in many cases, fixed in the model (Leontief-technology). Use of feed stuffs per animal, however, may change endogenously. Use of each feed stuff per animal per year is a decision variable (F_{gjf}) at each main region. This means that the use of each feed stuff (f) of each animal (j) may change on each main region (g). In total, there are 420 variables representing the feed use of animals in the model. Required energy, protein and roughage content of feeding can be fulfilled using different feeding alternatives. There are specific equations representing the feed requirements. The need for energy of each animal ($funits_j$) is ensured by equation (21). The similar linear equations are also constructed for protein and roughage needs of different animals.

$$\sum_{f=1}^{nf} F_{gjf}\, fu_f \geq funits_j \tag{21}$$

Endogenous feeding variable F_{gfj} means that the balance equation for feed stuffs (22) becomes non-linear. In equation (22) SF_{gf} denotes production of foodstuff f on region g. The total amount of foodstuff f needed in region g is given by the sum of all animals weighted by their consumption of the feed stuff f. Foodstuffs may move between regions at certain transportation cost and they may be imported and exported. Domestic and imported feed stuffs are assumed to be homogenous.

$$SF_{gf} - \sum_{b=1}^{sr}\sum_{j=1}^{s} X_{gj} F_{gfj} + \sum_{h=1}^{r} T_{hgf} - \sum_{h=1}^{r} T_{ghf} - E_{gf} + I_{gf} \geq 0; g = 1...r; f = 1...nf \tag{22}$$

The non-linear equation (22) makes the optimisation more tedious in technical terms, but there have not been any problems in obtaining an optimal solution using different initial conditions, like different combinations of feed stuffs. The changes in feeding and other reactions produced by the model are always consistent to the changes in prices and subsidies. Endogenous feed use affects land allocation and makes the model to react more realistically to changes in prices and subsidies.

The use of the different feeding stuffs is allowed to change by only 3-10 % from the preceding year. This is partly due to biological reasons and also because certain fixed production factors are needed in the feeding of animals. Significant changes in the feeding occur only when the price relations in favour of the change are effective for long enough.

Equation (22) brings a non-convexity to the model. This can be shown easily using the Lagrangian function. However, the solution to the problem is still unique, since there are short-term restrictions on the production variables. The variables F_{gfj} representing feeding of animals are bounded, which results to a unique maximum of the optimisation model (see Lehtonen 1999 for details). The model always changes feeding towards a more economical direction, in terms of prices of final products, inputs and subsidies. If there were no short-term restrictions on the rate of change of feeding of animals, the use of feed stuffs would change immediately to the extreme where only the most economic feed stuff combination satisfying the energy, roughage and protein intake conditions were used. When short-term restrictions are imposed on the rate of change in feeding, the feeding changes only gradually.

In the case of dairy cows there is a concave quadratic milk yield function which determines the increase of milk yield when roughage is substitute for grain. In equation (23) $yield_t$ is milk yield per dairy cow at year t, $yield_0$ is initial yield, F_{grain} is the the use of each grain feed in feeding and w_{grain} is the weight of each grain in the production function (all grain based feeds may not be equally favourable in milk production). Parameters a and b are positive, but c is strictly negative, which means concavity of the production function and decreasing returns to scale.

$$yield_t = a + b \sum_{grains} w_{grain} F_{grain} + c\Big(\sum_{grains} w_{grain} F_{grain}\Big)^2 \qquad (23)$$

In other words, when increasing grain in the feeding of dairy cows, the milk yield increases. However, because of concavity of (23) the resulting yield increase becomes smaller the more grain is fed.

One should note that yield levels and other production costs of feed stuffs are different in different regions. Most feed stuffs, excluding silage and grass, can be transported between the regions. Also the transportation costs affect the most economic feed stuff combination in different regions. Feed stuff production and use of feed are dependent on each other. Because different agricultural supports can be paid for feed crops, like possible extensification premia in EU scenario, it is not always trivial to forecast the change in feeding in different regions without running the model.

Clearly, the model outcome is dependent on the short-term restrictions imposed on the rate of change in feeding. The restrictions are different for pigs, bulls and dairy cows, respectively. The physiology of dairy cows and other bovine animal does not allow rapid changes in the use of feed stuffs, even if energy, protein and roughage intakes are fulfilled. The changes in diet of pigs may be greater, but there are only few reasonable alternatives how to change feeding in pig farming. There are also technical factors and sunk costs in reality that prevent rapid changes in feeding. Due to sunk costs and the technical feasibility of the current production technique, only a fraction of farmers are able to make rapid changes in feeding. Thus, the short-term restrictions on the rate of change in feeding are needed in modelling dynamics of the agricultural sector. In the long term, however, changes in feeding are likely to happen if there are any changes in relative prices of inputs and outputs. Change in the use of feed stuffs is an important adaptation mechanism that helps farmers to survive in changing economic conditions. These changes may have great effects to land use and profitability of agricultural production.

In equation (24) regional production and processing activities require certain fixed quantities of inputs. u_{gkj} is the input k required by the production activity j in region g. Inputs are not traded in foreign trade, nor they move from a region to another. It is assumed that any amount of a variable input is available at a fixed price.

$$\sum_{b=1}^{sr}\sum_{j=1}^{s} u_{gkj}\ X_{gj} - Z_{gk} \leq 0 \qquad g = 1 \ldots r, k = 1 \ldots m \tag{24}$$

The equation (25) sets limits for production activities through fixed inputs. M_{gl} is the maximum for fixed resources l in region g and w_{glj} is the quantity of fixed input 1 required by the production activity j in region g. In case of agricultural production the only limit for fixed inputs is maximum area in each region. Some upper limits are set for regional milk processing capacities.

$$\sum_{j=1}^{s} w_{glj} X_{gj} \leq M_{gl}; g = 1..r; l = 1..q \tag{25}$$

All variables are non-negative. T_{ghi} = 0 when $g=h$, i.e. the model does not take transportation costs within the areas into account.

$$Q_{gi}, X_{gbj}, Z_{gk}, T_{ghi} \geq 0 \quad g = 1 \ldots r; b = 1..s_r; h = 1 \ldots r; \ i = 1..n; \ j = 1 \ldots s; k = 1 \ldots m \tag{26}$$

Restrictions are imposed for the production variables based on the production of the previous year. W_l represents lower bound and W_u represents upper bound in equation (27). The restrictions represent short-term technical and biological constraints in each production line. Crop areas may change faster than the number of animals. There are several biological and technical factors that slow down the rate of change in the number of animals.

In the same way as the number of animals, the use of feed stuffs of animals may change only gradually over time due to fixed production factors in the production and handling of feed stuffs.

$$(1 - W_l)\ X_{gbj}(t - 1) \leq X_{gbj}(t) \leq (1 + W_u)\ X_{gbj}(t - 1) \tag{27}$$

3.7. Increasing the efficiency of the production

The efficiency in the use of both variable and fixed production inputs may increase increase in the model. The rate of efficiency increase is modelled as an exogenous parameter that specifies the annual relative change in the use of different inputs per hectare or animal. The efficiency parameters may be set on the basis of earlier development, or it can be examined what kind of increase in the efficiency a certain support policy would require in order to maintain agricultural production at the desired level. In the first version of the model there are no explicit links between increasing production efficiency and productivity growth. The interplay of these two factors are taken into account outside the model when exogenous variables are specified.

The decrease in the use of inputs as a function of time has been set for the hours of human labour and machine work as well as depreciation of the machinery and buildings, interest expenditure, and overhead costs.

Increase in the efficiency of production may result from increasing farm size and other measures to rationalise production processes, such as joint investments of farmers and the introduction of new technology. The use of some production inputs may be assumed to stay at constant levels.

3.8. Fixed costs

There are no endogenous investment activities in the model. A certain depreciation cost is assigned for the production activities per hectare or per animal. This means that expanding production implies increasing total investments and depreciations while decreasing production means decreasing total investments and depreciation on each production line. One should note, however, that the exogenously given productivity growth affects directly the fixed costs in the dynamic setting but the fixed cost are constant per animal and hectare annually in each optimisation.

3.9. Development of crop levels and average yields

The crop yield level of the different crops is determined separately for each year and for the 7 production regions. The crop yield levels are obtained by determining the optimum fertilisation at the farm level using equation (28).

$$\frac{dF(N)}{dN} = \frac{P_f}{P_c} \tag{28}$$

F(N) is the fertilisation response function in terms of nitrogen, P_f is the price of nitrogen, and P_c the price of the crop product. Crop prices P_c may be expected prices, intervention prices or market prices of the previous year.

As the fertilisation response function, the quadratic function

$$F_q(N) = a + bN + cN^2 \tag{29}$$

is used for all crops. Some other functional forms can be used as well, but quadratic function was chosen for simplicity. The relative slope of the rise of the functions as the use of nitrogen grows is obtained from the fertilisation response functions estimated from fertilisation experiments (parameter of the first degree in the case of the quadratic function). The other parameters of the fertilisation response function in the different regions are obtained by assuming the current level of nitrogen fertilisation as the optimum at current prices at the base year.

Independent of the fertilisation level the response function intercept parameter ‘a’ will rise a certain percentage per year. This parameter is given exogenously and represents the expected yield development.

The average yield of cows as well as the egg yield per laying hen and piglets per sow increase according to given percentage annually. However, the milk yield per cow per year also depends on the given amount of grain based feed stuffs (equation 23). The yield of animals is assumed to be equal in all regions but milk yield of dairy cows is slightly different in different regions. It is assumed that the increase in milk yield (which is given exogenously) only slightly increases feeding requirements of dairy cows. Thus, a trendwise improvement in genetic production potential induces only a partial increase in feed requirements.

3.10. Consumption trends

The long-term consumption trends caused by the consumer habits concerning the most important foodstuffs are taken into account in the model. In particular, this may concern the consumption of meat and dairy products. No consumption trends, however, have been determined in the first version of the model, but the base level of consumption is assumed to stay at 1998 level. The food consumption is allowed to change only little from the given trend values each year. For the part of meat, for example, the consumer surplus is maximised within a range of only 2% annually. Also for the consumption of dairy products are bounded to the given trend value. In reality, food consumption is influenced by many factors that are very difficult to be modelled in a sector level model. In many cases prices and price changes alone do not explain adequately the food consumption. Consequently, the consumption is bounded close to trend values. Thus, the consumer surplus has less weight on the model. However, consumption may change and prices may fluctuate somewhat in the model, depending on the given price elasticity of demand and the substitution elasticity between imported and domestic products.

3.11. Solving the model

There are many software packages available which can solve mathematical optimisation problems. The problem at hand is mathematically very large and complex and not all software packages are equally suitable in solving it. The model was programmed using GAMS (an acronym for Generalised Algebraic Modelling System; Brooke et. al. 1992) and solved using MINOS solver which is specifically tailored in solving large scale non-linear problems.

The model is very large in technical terms. Even if GAMS is a matrix generator based modelling system which makes it possible to write the equations rather concisely, the model consists of appr. 4500 code lines (with many necessary comments between the actual code statements). The GAMS code consists of the main source code and 3 other subfiles. The data input is read in from 11 different spreadsheet files. There is a separate GAMS model which compiles the results, calculates agricultural income, for example, on the basis of the optimal variable values, and writes the results to specific spreadsheet files.

There are more than 3900 variables and 1700 equations in each annual optimisation model (the exact number of equations and variables depend on the solution year and the chosen scenario). There are more than 9200 data elements in the model which indicates that a lot of data work needs to be done before the model can be run. There are more than 1900 non-linear variables which makes the model rather difficult to solve. Non-linear equations concerning feeding and balance equations of crops are particularly difficult to handle because of a large number of variables in each equation.

However, the model can be solved reliably in appr. 15 minutes over the years 1998-2010. The functional forms are smooth and all variables have been scaled in a proper way and some crucial variables are bounded. In addition, the data has to be consistent to avoid infeasibilities. It also became clear during the model testing that consistent data is important in terms of computational feasibility. It was found that zero initial values of production and imports as well demand functions calibrated on zero consumption level may result to numerical instability in Armington system (specifying the imperfect substitution between the imported and domestic products) of the model. The demand functions of domestic and imported products influence each other through the elasticity of substitution. If imports change drastically (as was necessary in the test runs in order to cover the domestic consumption by imports which started from zero), there will be drastic changes in prices as well. This kind of numerical instability is further magnified by the fact that rest of the world products and Latvian products are classified as one group and EU imports as another group in the Armington system. This kind of problems detected during the model testing will not occur, however, if the consistency of the data is ensured. With consistent data the model can be solved safely and reliably with a unique solution for each annual maximisation problem.

The model is large and heavy because of endogenous feeding variables, seven regions and many crop products with nonlinear balance constraints, and because of two separate sets of foreign trade variables for EU and RoW. Foreign trade variables of each crop include import and export variables for each region as well as variables and equations determining the export cost functions. However, no numerical problems appear in the model solution and the results obtained are very consistent and logical also when tried with different initial values, policy scenarios as well as different production efficiency and productivity parameters. One can still include more products into the model if one makes sure that data is consistent. In particular, one needs to check the validity of import data and domestic production levels.

The solution time was reduced significantly by choosing specific options of the MINOS solver. It appeared that smooth functional forms make it possible to use quite many minor iterations between the major iterations when the equations are evaluated in the solution algorithm. Setting “assigned nonlinears nonbasic” means that nonlinear variables are not the first variables entering the basis, thus making it easier for the solver to find the steepest directions in the early iterations. Other solver options did not have any significant effect on the solution time.

The model can be solved also using CONOPT solver which is also part of standard GAMS system. This solver is somewhat different from MINOS by the solution algorithm. However, solving the model with CONOPT takes a lot of time (more than one hour). It seems that MINOS is more suitable for solving this particular model type which is characterised by some heavy nonlinear constraints with many variables.

The model is to be used in comparing results of different policy and development scenarios.

There are specific options in the beginning of the main source code which can be used in determining a scenario to be run. For example, EU accession scenario with accession year 2007 can be run assigning set “NOEUSC” to “yes” and “EUSC” to “yes” up to year 2006. Thereafter, “NOEUSC” is assigned to “no” and “EUSC” is assigned to “yes”. All subsidies and other parameters concerning the base and the EU accession scenario will be updated automatically during the model simulation. This will decrease the possibility of errors when running the model. The productivity and efficiency parameters, however, have to be adjusted manually in different productivity and efficiency scenarios.

If desired, the model can be used in a standard static equilibrium analysis by relaxing the flexibility constraints and solving the model only for one year for which the policy parameters as well some other parameters have been specified.

3.12. Application of the model

Because of the many assumptions and exogenously given variables the model is not intended to produce exact forecasts of the future. The model should be used in comparing between the different development paths, not primarily in predicting the single path which will occur. An analysis made by means of the presented dynamic model is based on comparisons between the results of the so-called basic scenario and alternative scenarios. The model yields a series of short-term disequilibria. Thus one needs to compare the whole development path of the basic scenario with the development path of some alternative scenario. This kind of analysis is not based on comparative statics, but on a kind of "comparative dynamics". The series of short-term disequilibria may or may not converge to equilibrium or to a stable development path. Policy measures or other changes may cause different dynamic patterns in production and its allocation between products and regions. There may be different turning points in the development paths in different policy scenarios. The development paths represent the whole adaptation process of the agricultural sector to a given policy change. The final state at the end of the simulation period represents one possible outcome of this dynamic process. However, one has to recognise that there are many assumptions behind this kind of analysis. Some assumptions, like fixed costs and investments as well as part of technological and biological improvement, will be modelled in detail in the future versions of the model.

One of the major benefits of this kind of dynamic model is that the dynamics and the assumptions are made explicit. Using static models the dynamic issues and other assumptions are difficult to evaluate and they are easily neglected.

The starting point for policy analysis is the basic scenario in which the regional support measures of the coming years are determined, assuming that no major changes will occur. This means that the subsidies and the price level will stay at some pre-specified levels. The basic scenario provides a kind of basic forecast of the development path of agriculture, subject to the assumption that there will be no significant policy reform. By comparing the outcomes of other policy scenarios with the outcome of the basic scenario we obtain a picture of the direction and magnitude of the changes.

For the basic scenario, the model should yield a feasible development path for the coming years in relation to the given development of productivity and amounts of support. In certain respects the basic scenario is a subjective picture of the development, because many of the exogenous variables cannot be defined in a reliable way. Thus there is no secure basis for the evaluation of the basic scenario except for the part of the known initial years. In the case of the following years the reliability of the basic scenario must be evaluated subjectively in relation to the current future prospects of each production line. Because of this the basic scenario is not intended to be used as a forecast of the future agricultural production level, but as the basis for the alternative scenarios.

The results of the basic scenario must be in accordance with the known production quantities, production costs, and incomes of the known years, i.e. 1998-1999. This makes it possible to validate the model, but it is not possible or in all cases even sensible to obtain results that would correspond exactly to the known years. Various kinds of random factors, like weather conditions etc. may cause deviations from the economic equilibrium.

4. MODEL SCENARIOS

4.1. Model assumptions

One of the most important part of long-term analysis of Latvian agriculture with the help of Sector models is elaboration of scenarios, which describes the assumptions about the development of national economy, general development of the sector in the world, and also development of sector related national policies. The application of LAPA model gives possibilities to asses the effects of different Latvian agricultural policy measures on agricultural sector, in particular changes of custom tariffs, sector support payments, production and trade quotas, as well as the impact of changes in the sector productivity. These were used as the main elements for scenario formulation.

For testing the model it was assumed to be reasonable to divide all possible scenarios for Latvian Agriculture in two main groups: Base and European Union scenarios.

The group of Base scenarios includes the scenarios of independent development of national economy and Agricultural sector as well, when current agricultural policy will be continued in the future without any considerable changes. Such scenarios comprise the ground for comparison with all other elaborated scenarios.

Under the group of EU scenarios it is possible to analyse the economic situation after accession of Latvia in the European Union. In this case it is necessary to consider how European agricultural policy will effect the Latvian Agriculture.

Considering the independent way of development of agricultural sector and even assuming the continuation of main principles of National agricultural policy it is possible to simulate quite different types of further agricultural progress, which could be based on assumption about productivity and efficiency growth. Therefore it was decided to create two principally different base scenarios:

1. Pessimistic (or base scenario 1), where it was assumed that annual productivity indicators in husbandry production will continue to remain on relatively low level (see column 2 of table 4.1-1). Efficiency growth for crop and animal production will also be quite slow or will not change at all (for instance in case of dairy production).

2. Optimistic (or base scenario 2), where it was assumed that during the simulation period the productivity and efficiency will increase essentially due to increase of annual growth rates, which are assumed higher than in pessimistic scenario (see column 3 of table 4.1-1).

These two base scenarios might also reflect the different degree of preparedness of Latvian Agriculture for EU membership. The analysing of policy decisions and possible ways of development during the pre-accession period give substantiation to conclude how successful could be Latvian integration in the EU.

Table 4.1—1. The main assumptions about annual productivity and efficiency rates for base scenarios simulated within the period 1998- 2010.

Indicators	Base scenarios	
	Pessimistic (Base scenario 1)	**Optimistic (Base scenario 2)**
1. Productivity growth:		
1.1. Annual increase of milk yield per cow	0,012	0,014
1.2. Increase in dairy feeding efficiency	0,5	0,5
1.3. Efficiency increase in feeding of fattening pigs	0,015	0,016
1.4. Annual increase of egg yield per hen, as % of current yield	0,005	0,007
1.5. Annual increase of yield per sow, as a % of current yield	0,015	0,017
1.6. Annual increase of yield per mother poultry, as a % of current yield	0,018	0,02
2. Efficiency increase:		
2.1. Annual decrease in the use of different inputs in animal production:		
▪ Dairy		
Labour costs	0	0,01
Other variable input	0	0,01
Fixed input	0	0,01
▪ Beef		
Labour costs	0,02	0,02
Other variable input	0,01	0,015
Fixed input	0,005	0,009
▪ Pork		
Labour costs	0,03	0,05
Other variable input	0,03	0,05
Fixed input	0,03	0,05
▪ Poultry		
Labour costs	0,02	0,04
Other variable input	0,01	0,02
Fixed input	0,005	0,009
2.2. Annual decrease in the use of inputs in crop production:		
Labour costs	0,04	0,05
All the rest costs	0,02	0,025

Profitability and efficiency indicators reflected in table 4.1-1 as a scenario parameters need some additional explanation. The meaning of productivity growth indicator 1.2 “Increase in dairy feeding efficiency” is as follows. When milk yield is increasing by some constant amount annually the feeding requirements, in terms of fodder units

(FU), produced per kilo of milk will decrease. For example, if 0.9 FU are needed, on the average, per kilo of milk in 1998, only 0.45 FU will be needed for the additional yield obtained due to gradual genetic improvements of dairy cows. Thus the improving genetic production potential of dairy cows means not only increasing yields but also increasing feeding efficiency of dairy cows: less feed is required per kilo of milk produced.

Both crop and animal yields increase linearly in the model. The rates given in table 4.1-1 mean that they are multiplied by the 1998 or a trend yield value. The resulting annual constant yield increment is then added to the intercept parameter of the quadratic yield functions. Thus, one should make a difference between the yield increase parameters and the efficiency parameters which are given as percentage improvements on annual basis.

The indicator 1.3 “Efficiency increase in feeding of fattening pigs” means that the fodder units needed per pig decreases at a certain rate annually while the slaughter weight of pig animals stays constant. This means that genetic properties of pigs improve over time.

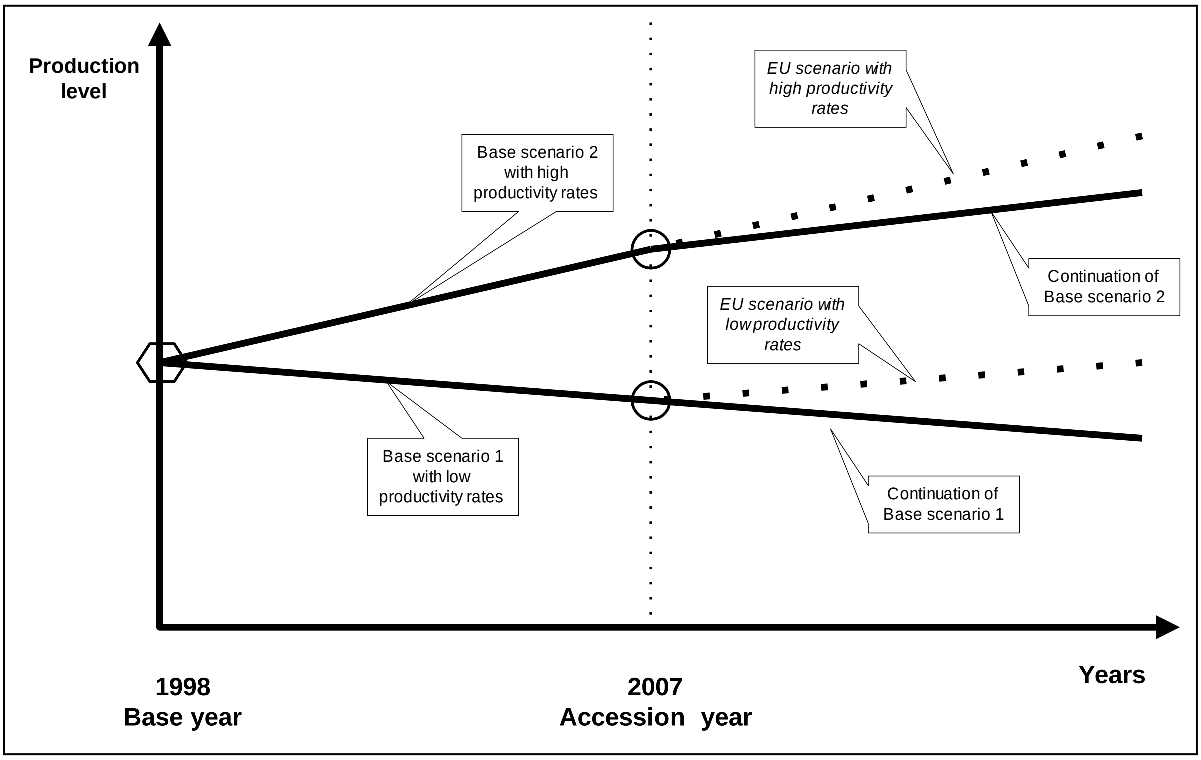
Some rates given in table 4.1-1 are relatively low and the difference between the optimistic and pessimistic scenarios may seem to be very small. One should note, however, that even relatively small efficiency improvements, in particular will cumulate over time and result to relatively large improvements over time. Thus there are clear differences, which, however, are not large, in the overall (both productivity and efficiency) improvements between the scenarios. The differences could be greater, however, but choosing only moderate difference one is able to evaluate how sensitive the model outcome is on the productivity and efficiency parameters. If the chosen productivity and efficiency rates given in table 4.1-1 will result to great differences in production volumes then it is problematic to apply the model because of such sensitivity on the exogenous parameters. In that case some additional nonlinear specifications like production functions based on production specific data would be required to enrich the model structure to avoid sensitivity which is typical for linear programming models. The model at hand, however, includes many nonlinear relationships and is not likely to be sensitive for minor changes in exogenous parameters. In some cases, however, small changes may cumulate to large changes in the long term. Thus one should be careful how much the given parameter values drive the results.

In order to analyse possible consequences of integration also two EU scenarios corresponding pessimistic and optimistic productivity and efficiency development were elaborated assuming that Latvia will be able become a real member of European Union at the beginning of 2007. Both EU scenarios describe the possible development of Latvian Agricultural sector after year 2006 starting with achieved production level during the pre-accession. According to the elaborated base scenarios it was assumed two potential levels of development up to the integration time.

However it is necessary to take into account that adopted program “Agenda 2000” covers a time period till the year 2006. But due to the absence of any well–grounded substantiation how CAP policy will be changed in the future it was assumed that all obligations of “Agenda 2000” will be also taken place after 2006, when Republic of Latvia might become a member of the EU.

The graph on figure 4.1-1 schematically illustrates the idea how the model is used in the analysis of policy changes and agricultural development. Comparing the results of different productivity and efficiency scenarios one may evaluate the direction and magnitude of policy effects on agricultural production and income. Using the model it is easier to understand the interplay and the dynamics of policy changes and agricultural development. One may evaluate what is the likely level of agricultural production and income in different policy scenarios assuming a certain development scenario, or one may evaluate the needed development in order to reach a certain production or income level at different policy options.

Figure 4.1—1. Comparing the results between the different scenarios.



Together with assumptions about productivity and efficiency levels in agriculture it is necessary to stress some general assumptions, which could be attributed on both base scenarios and sometimes on the EU scenarios as well.

For instance inflation might become quite important issue in long-term analysis. It was assumed, that in case of base scenarios inflation rates applied for foodstuff considered in the model will be 1% per year. There is exception only for pork and poultry, when assumed inflation rates are -1%, because domestic prices for these products exceed the level of EU prices, and therefore they could be decreased in the future. At the same time inflation rates for the corresponding inputs could be higher according to current statistic data [15]. That is way the 2% inflation was assumed for the inputs in agricultural production analysed in the model.

In case of EU scenarios it was accepted that there is not inflation in the outputs after the accession due to the stable EU prices stipulated by “Agenda 2000”. However, there is still inflation on inputs in the EU scenarios which means that improving productivity and efficiency should outweigh inflation if farmers want to retain their income levels.

Yield function

Another important assumption refers to parameters of yield function, which affects the basic level of yields and response of yields dependent of nitrogen use in long-term consideration (parameters k_a and k_b, which modify parameters A and B of quadratic function 4.1-1. The values of mentioned parameters k_a and k_b were assumed correspondingly 0,03 and 0,02 for all scenarios. This means that crop yields would increase 45-55% (depending on the parameters A, B and C) during 1998-2010 if there were no changes in crop and fertiliser prices, which, on the other hand affect the annual yields through parameters A, B and C. If there were no changes in crop and fertiliser prices the yield development would dependent only on parameters k_a and k_b.

$$Y = (1 + k_a)^t \cdot A + (1 + k_b)^t \cdot B \cdot N + C \cdot N^2 \quad (4.1\text{-}2)$$

Y – yield level; A,B,C, k_a, k_b – function parameters; N – nitrogen input per hectare; t – simulation period

In addition, it is important to emphasise that elaborated scenarios could be segregated by different instruments applied to agriculture according to the requirements of National and European policies.

Considering the set of policy measures for scenarios it is necessary to take into account policy assumptions, which significantly affect the forecast for further development of Latvian agriculture. Such policy measures as subsidies, price system, import tariffs, milk export quota are imposed for analysis in the model.

Subsidies

As subsidies, only direct subsidies per animal, hectare of arable land or ton of production are introduced in the model. So, national subsidies paid for dairy cows and different types of bulls will be continued until the end of the simulation period (2010). At the same time premiums per sow and pig will be stopped in 2000. For crop products all acreage payments for rape, cucumbers cultivated under the glass as well as payments per each ton of flax will be kept for the future as well.

In case of European scenarios it is expected that Latvian agricultural producers will get compensatory payments for grains, rape (oilseeds) and different types of cattle (mostly dairy cows, suckler cows and bulls).

Export and import prices

In case of base scenarios the world market prices which are used in the model as import prices for meat products imported from the rest of the world are taken from the FAPRI forecasts until 2006 (the last year in pre-accession period).

Prices for crop products imported from the rest part of the world were assumed to be slightly lower the level of EU import prices i.e. 85 – 99% of the level of EU prices. The EU's CAP reform will decrease the gap between the EU and world market grain prices.

The level of milk export price to the rest of the world was set to 0.1157 per kg which is 30% higher than Latvian internal producer price level (Ls 0.089 per kg). Using this price level it is possible to get export volumes somewhat close to the share of rest part of the world at the base year. Such assumption was made because of difficulties in calculations of average export price level for milk products.

In the case of EU scenarios, domestic prices are simply replaced by EU prices, when agricultural producers will be obliged to be a price-takers in case of Latvian integration in the EU. The flows of foreign trade are analysed only between Latvia and other EU countries.

Import tariffs

Import tariffs might essentially increase the level of import prices, that in one's turn can affect the structure of agricultural production and trade. Therefore in base scenarios, where it is assumed that agricultural products can be imported from the European Union or the rest part of the world the corresponding import tariffs are considered. Hereto 30% decrease of both types of import tariffs during the pre-accession period is accepted for future projections. In case of Latvian integration to the EU, only EU member countries are considered as an environment for the trade and all import tariffs will be abolished.

Milk export quota

According to "The free trade agreement with EU member countries" signed between Latvia and the EU in 1995, the special export quotas for Latvian dairy product such as cheese, butter, milk powder were introduced. For year 1998 the size of quota comprised approximately 6 % of milk amount currently produced. In model calculations it is assumed that this amount of export quota for milk be kept for whole simulation period (until 2010) for both base scenarios.

4.2. Data and parameter values in the model

In order to make the precise analysis the economical effects on the development of Latvian agricultural sector which might be arisen by conditions of internal economic environment and different policy measures assumed in scenarios the sets of the input information for the model should be described. Practically all exogenous information used in the model was collected (gathered) for year 1998 as a most recent year, for which existing statistic data are available. Whole set of input data necessary for the model might be divided in two main categories:

1. General information which is available from the Central Statistic Bureau, Ministry of Agriculture, Institute of Agrarian Economics, Agricultural Advisory and Training Centre about Latvian agricultural sector and more specific information about each production line (see chapter 3.1);
2. Exogenous parameters of the model, which values are based on the expert judgements (estimations) or particular reference books for long-term projections, recasting coefficients, normatives for resources' use and parameters of functional interdependencies imposed explicitly or implicitly in the model.

1.category of input data

It is necessary to mention that regional characteristic of the model envisages the dividing of territory of Latvia on several agricultural areas (regions). Taking into account the wide differentiation in climate conditions, relief, production and technological structures as well as the administrative division of Latvian territory applied in Statistic Bureau it was decided to consider 7 main regions. However imposing the regional aspect into the model causes the extra difficulties for gathering of necessary data from the first group above mentioned.

For instance generally available information about number of different types of animals presented by Statistic Bureau is not regionally differentiated. Moreover, such categories of animals as heifers and bulls derived respectively from dairy cow and suckler cows or mother poultry derived from total number of fowls are not considered at all in the Statistics. Therefore in this particular case it was decided to derive the necessary categories of animals and attribute structure of animals on national level to the each region considered. The unpublished information from the Ministry of Agriculture and data from Central Statistic Bureau [1], [2] were used for this purpose.

Table 4.2—1. Items of input analysed in the model for animal and crop production.

N	Crop production	Animal production
1.	*2.*	*3.*
	Variable inputs:	
1.	Labour	Labour
2.	Produced seeds	Medication
3.	Purchased seeds	Interest on cow
4.	Lime deposition	Interest on operating capital
5.	Pesticides	Repairing
6.	Electricity	Electricity
7.	Tractor use	Milling
8.	Harvester use	Litter
9.	Heating	
10.	Drying	
11.	Maintenance and repairing	
12.	Baler twine	
13.	Interest on operating capital	
	Fixed inputs:	
1.	Depreciation	Depreciation
2.	Land tax	Insurance
3.	Insurance	Interest on production capital
4.	Interest rates	Management and overhead
5.	Management and overhead	

1.	2.	3.
	Fertiliser and pesticide use:	**Types of feed:**
1.	Nitrogen (pure)	Winter wheat
2.	Potassium (pure)	Spring wheat
3.	Phosphorus (pure)	Barley
4.	Pesticides	Oats
5.		Rye
6.		Pulses
7.		Potatoes
8.		Silage
9.		Hay
10.		Green fodder
11.		Triticales
12.		Minerals
13.		Soya
14.		Pigsup (processed feed used in pig sector)
15.		Hensup (processed feed used in poultry sector)

Thus, the following main animal categories are considered in the model for each particular region: dairy cows, bulls, old bulls (over 2 years old) and heifers derived from dairy cows, suckler cows and corresponding number of bulls and heifers, sows, pigs, laying hens, meat poultry and mother poultry (poultry for production of animals).

In other cases when necessary regional data about input quantities and prices for crops and animals as well as animal diets and fertilise use were not available it was decided not to differentiate them by region. Thus, the same cost structure was assumed for all regions. Hereto the information about inputs and corresponding prices was provided by the Institute of Agrarian Economics where the profitability analysis and gross margin calculations were made for main agricultural production lines within the framework of ACE project "Competitiveness of the Baltic Agriculture and Food Sectors after Accession to the EU". The data about animal diets, fertilises and pesticides use were obtained from Agricultural Advisory and Training Centre [18]. All input items analysed in the model are reflected in table 4.2.-1.

Unpublished data about regional yield levels, total arable land use and its distribution for all crop considered were obtain from the department of information in Ministry of Agriculture.

One of the most important blocks in the model is the foreign trade block. All import and export flows to EU countries and rest of the world, as well as export and import prices were taken from Central Statistic Bureau. All detail information presented according to Harmonised System of coding and describing of commodities was aggregated by specialists from the Institute of Agrarian Economics.

The publications of Central Statistic Bureau and data from Agricultural Economic Accounts (LVAEI) were the main sources of information for getting the set of domestic farm gate prices, sometimes ex-factory prices (wholesale prices) and retail prises (for instance in sugar case). [8], [16], [21].

2.category of input data

Input information for the model from the second category above mentioned can be divided into the three main parts: upper and lower bounds for annual changes of decision variables, estimated or assumed parameters for explicitly or implicitly used functions in the model (demand, yield or export cost functions) and various technical and biological coefficients. These are scenario parameters which can be changed if needed.

Flexibility constrains (or upper and lower bounds for annual changes for decision variables) are very important parameters for the model run in order to fit the model results to the reality and not to get the artificial output far from the real situation in agricultural sector. Flexibility constrains mostly refers to the annual changes for such decision variables as hectares of different crops and number of animals, feeding for animals as well as allowed changes in consumption for demand functions. Upper and lower bounds for annual changes in number of animals are reflected in table 4.2-2.

Table 4.2—2. Upper and lower bounds for annual changes in number of animals assumed in the model.

N	Type of animals	Upper bound for annual changes (%)	Lower bound for annual changes (%)
1.	Dairy cows	3	6
2.	Sucler cows	3	6
3.	Bulls	20	20
4.	Old bulls	20	20
5.	Sows	5	10
6.	Hens	20	20
7.	Mother poultry	20	20

At the same time lower and upper bounds for changes in feed requirements were imposed not only for decision variables, but for all types of animals (see table 4.2.-3).

Table 4.2—3. Upper and lower bounds for annual changes in animal feed assumed in the model.

N	Type of animals	Upper bound for annual changes (%)	Lower bound for annual changes (%)
1.	Dairy cows	3	3
2.	Sucler cows	3	3
3.	Heifers from dairy cows	3	3
4.	Heifers from sucler cows	3	3
5.	Bulls from dairy cows	5	5
6.	Old bulls	5	5
7.	Bulls from sucler cows	5	5
8.	Pigs	7	7
9.	Sows	7	7
10.	Hens	7	7
11.	Mother poultry	7	7
12.	Poultry	7	7

Exports are allowed to increase 90% per year. Import volumes are allowed to decrease 90% per year. The lower bound for exports is zero and there is no upper bounds for imports.

Concerning to the bounds for demand change imposed in the model there are 2% upper and lower limits for all crops as well as 5% for milk products.

It is important to stress another group of model parameters used in calculations, which mostly refers to the parameters of separate function explicitly or implicitly imposed in the model.

Since no empirical estimates are available it is necessary to assume values for substitution elasticities between domestic and imported products. A priori knowledge can be used in giving values for such parameters which signify the differences in preferences of domestic consumers for imported and domestically produced products. The substitution elasticity value approaching infinity means homogenous products. Substitution elasticity values close to 1 (but slightly higher than 1) means that the domestic and the corresponding imported products are different for the consumers. The chosen substitution elasticities represent consumers' preferences between domestic and imported products. Values of substitution elaticities for all products considered in the model as well as price elasticities of demand for demand functions are shown in table 4.2.-4.

Table 4.2—4. Values for prices elasticities of demand and elasticities of substitution between domestic and imported products assumed in the model.

	Winter wheat	Spring wheat	Rye	Barley	Oats	Pulses	Triticals	Buckwheat	Potatoes	Flax	Rape	Sugar	Beef	Pork	Poultry meat	Milk	Eggs
Value of substitution elasticities	3	3	3	4.2	3.6	3.6	4.2	3.6	2.4	3.6	4.2	3	1.5	2	3	2	4
Price elasticities	-0.3	-0.3	-0.3	-1*	-1*	-0.5*	-0.5*	-0.1	-0.3	-0.1	-0.2	-0.5*	1.2	1	1	-0.3	-0.5*

* marked values of price elasticities (for barley, triticals, pulses, sugarbeet and oats as intermediate products) are used in calculation of producer prices. All other values of prices elasticities are used in calculations of consumer surpluses as inverse demand function parameters. All products except sugar are priced on the producer price level, however.

Assumed slope for export costs is the other necessary parameter of corresponding functions. All slops were assumed as 1 for all crops, milk, eggs and different types of meat.

Parameters of crop yield functions dependent on nitrogen use for such crops as wheat, oats and barley were estimated with the help of MicroTSP software on ground of published results coming from the specially organised trials at the end of 80-ies [Ltnrjdcrfz & Kbvfynjdf 1987]. The crop yield parameters for all other crops were taken from the Finnish data sources [Heikkila 1969-1978], [OHRA: Backman 1973-1993] due to relatively close Finish yield levels to Latvian ones and lack of information based on fertilisation trials for types of crops in Latvia.

In case of parameters' estimation for milk yield functions dependent on grain use the data about necessity of different types of fodder for yield increase in Latvia [23] were used.

It is also necessary to mention the following coefficients and normatives:

- Dry matter content in the grains or grain based feedstuffs;
- Kilos of each fodder needed for one fodder unit;
- Dry matter content in feeds;
- Protein content of pig fodder (grams of utilised protein);
- Seed use per hectare;
- Pure nitrogen content in different types of fertilisers produced in Latvia;
- Animal unit transformation coefficients, etc.

All these Latvian specific data were obtained from the corresponding reference books [19], [Ositis 1998], [25].

5. MODEL RESULTS

The implementation of economic-mathematical models in analytical studies requires the necessity of approbation of calculations in order to clarify how adequate the applied model is for analysis of real economic situation and how adequate consequences described are to reality due to the model assumptions.

In the results of model approbation the analytical calculations were carried out according to the four main scenarios (Base-optimistic, base-pessimistic, EU-optimistic and EU-pessimistic), which differentiated by assumptions about accession of Republic of Latvia into the EU, as well as by assumptions about productivity and efficiency increase in various agricultural branches. All calculations were done with the help of GAMS software system and solver MINOS. It was assumed that the duration of simulations period is 13 years, since 1998 up to 2010.

Due to the little experience in working with LAPA model and lack of reliable information in regional aspect, it was decided to analyse the results on national (not regional) level and mostly focus on the following main issues according to four mentioned above scenarios for all simulation period:

- Number of animals;
- Use of agricultural land and total cultivated areas;
- Production volumes in livestock production (meat and milk);
- Total labour hours spent in agricultural sector;
- Total agricultural income.

5.1. Number of animals

Number of animals is important indicator for analysis of further perspectives in development of husbandry production. For instance essential reduction in number of dairy cows might be the important prerequisite for decrease of milk and beef production or it could arise some obstacles for relatively fast renewal of herd in the future.

It is important to stress that many categories of animals are considered in the model. But not all of them are decision variables, which could be changed in different combinations and on the base of these changes the other types of animals could be derived. The dairy cows, suckler cows, bulls and old bulls as well as sows, hens and mother poultry are specified as a decision variables, which can affect essentially the number of heads in other categories of animals and whole meat and milk production.

Main groups of cattle as dairy cows, suckler cows and old bulls present the animals, which are over 2 years and could considered as a potential for production of milk, other cattle (mostly from suckler cows) and meat, when production of beef meat from the animals with higher slaughter weights (old bulls instead of young bulls) is more efficient.

However as it is shown on figure 5.1.-1 number of dairy cows gradually goes down in all scenarios considered up to possible accession year (2006), where the tendencies are separated on the further decrease in base scenarios and increase in EU scenarios.

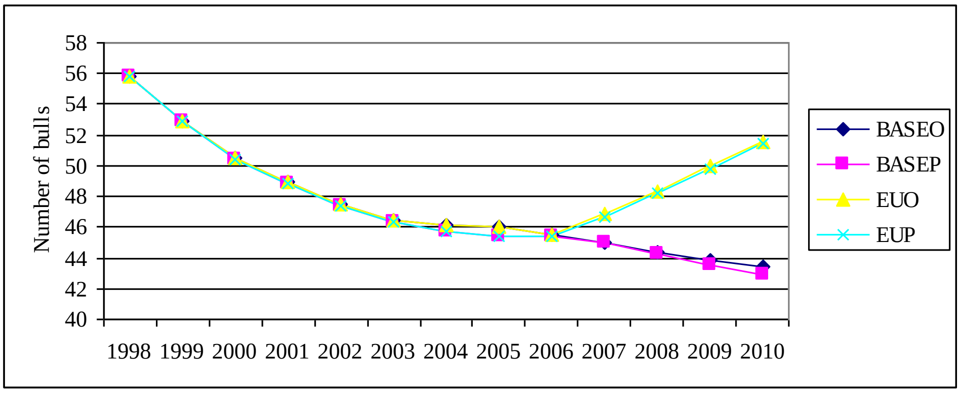
Figure 5.1—1 Number of dairy cows in Latvia since 1998 up to 2010.

Source: according to the results of calculations.

It is necessary to mention that during the pre-accession period (up to year 2007) reduction in number of dairy cows is around 22% in both cases of optimistic and pessimistic assumptions about efficiency and productivity increase in meat and milk sectors. However such decrease takes place partly due to the increase of milk yields per cow. In fact, production of milk might decrease only slightly, stay constant or even increased. The production volumes are to be reported separately.

As result of abatement of dairy cows the other categories of animals as bulls and heifers produced from dairy cows decrease as well (see figure 5.1.-2.).

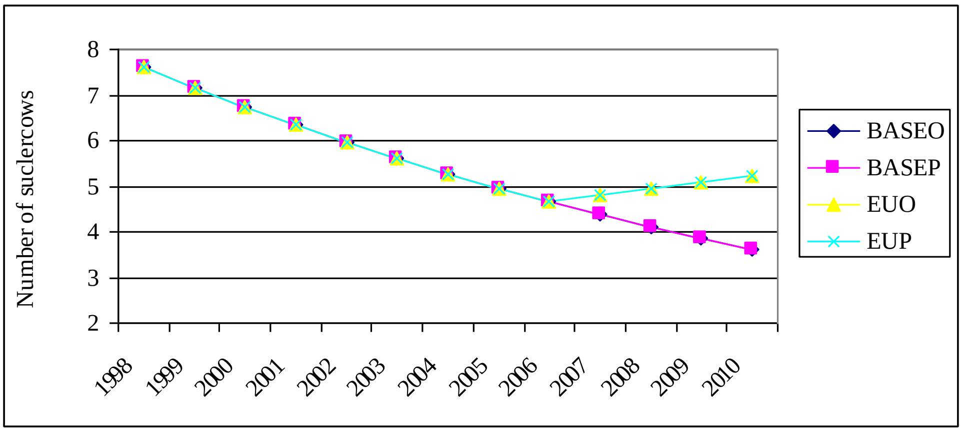
Figure 5.1—2. Number of bulls derived from the dairy cows in Latvia since 1998 up to 2010.



Source: according to the results of calculations.

In the case of suckler cows (see figure 5.1.-3) the number of animals at the end of pre-accession period might be around 60 % from the level of starting year for all scenarios. However according to the base scenarios annual decrease in number of animals during the whole simulation period is up to 6 %, what is the lower bound exogenously given for annual changes in number of cows in order to ensure the reality conditions in the model. The continuous decline in the number of suckler cows means that growth of cattle mostly for meat production not be attractive incentive for farmers at least in case of independent development of Latvian agricultural sector. At the same time after the joining the EU the situation in meat sector will be able to be changed, because of relatively fast growth of number of suckler cows after the integration. 3% annual increase are the maximum level of growth allowed in the model or so-called the level of upper bounds of flexibility constraints, exogenously given for annual increase of both types of cows. Hereto number of bulls and heifers derived from the suckler cows has the similar tendencies of development for all scenarios considered.

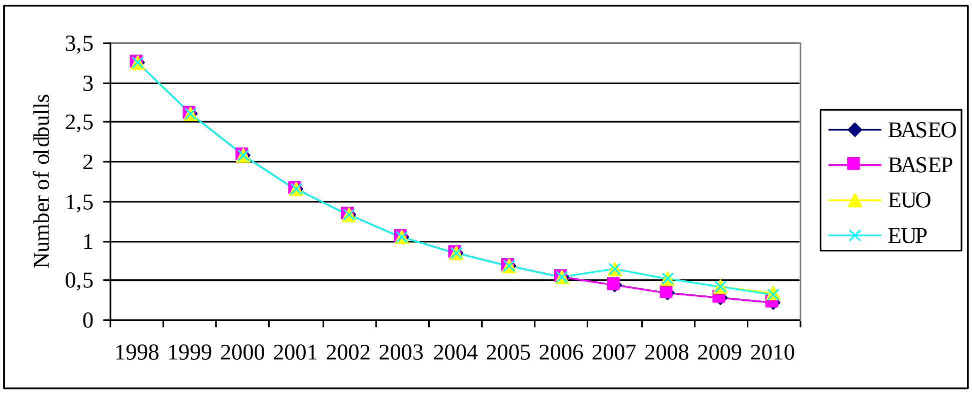
Figure 5.1—3. Number of suckler cows in Latvia since 1998 up to 2010.



Source: according to the results of calculations.

The tendencies in changes of number of cows essentially affect the number of old bulls. As it is reflected in figure 5.1.-4. the annual decrease in number of old bulls is kept constantly up to 20% (maximally possible level of reduction in the model) until the end of simulation period in base scenarios and even in EU scenarios with one exception for 2007 when some increase is taken place. Such considerable reduction in number of old bulls illustrates the orientation of farmers towards the animals at the lower slaughter weight instead of animals at the higher weights as old bulls are. Number of bulls which are slaughtered at lower weights is not reduced so rapidly as a number of old bulls and, moreover, reduction rates for number of bulls are far from the extreme values of flexibility constrains. This fact means that unprofitability of beef production could be a result of quite low slaughter weights for animals.

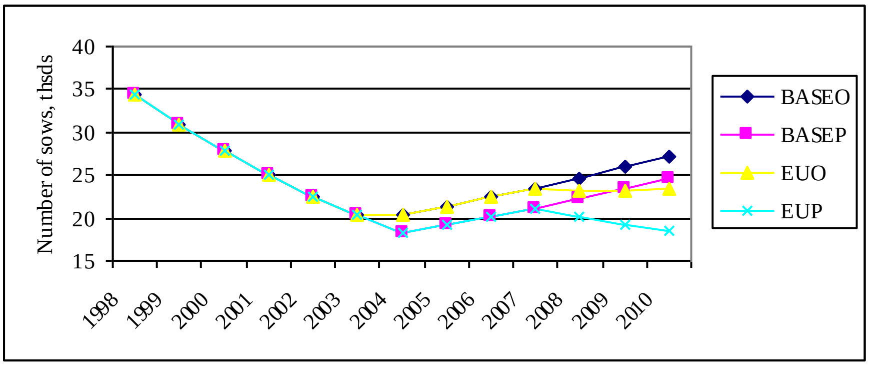
Figure 5.1—4. Number of old bulls in Latvia since 1998 up to 2010.



Source: according to the results of calculations.

Concerning to the pig sector it is possible to conclude that there is quite a rapid decrease in number of sows in the base scenarios up to year 2003 (or even 2004 in pessimistic case). Hereto the annual decrease in number of animals achieves 10 % that is lower bound of flexibility constrains for number of sows (see figure 5.1.- 5). Decrease of pork production at the same time means, that until mentioned above years production of pig meat is not profitable. However in 2003 (2004) number of sows increases again what characterise the positive changes in Latvian pig sector. This means that the productivity and efficiency rates applied are adequate to retain the profitability of production after 2004.

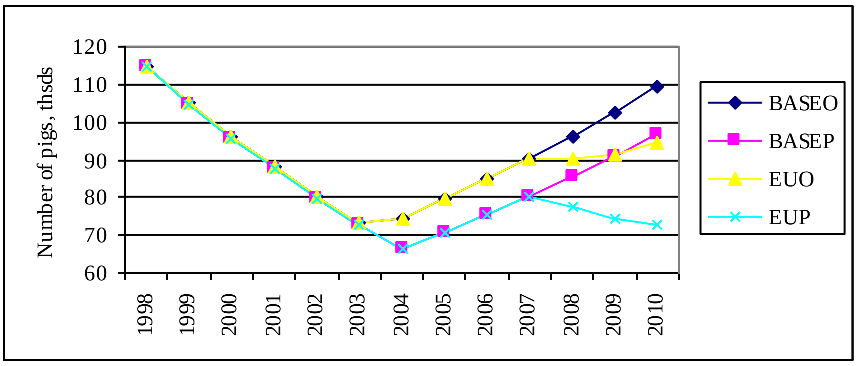
Figure 5.1—5. Number of sows in Latvia since 1998 up to 2010.



Source: according to the results of calculations.

The number of pigs is derived from the number of sows and that is way the shape of tendencies of development for sow and pigs are quite similar. Fewer sows are needed, however, per a fattening pig because the number of piglets produced by a sow increases (see table 4.1-1). It is interesting to note that in case of EU optimistic scenario since 2007 the number of pigs is relatively constant with the small increase in last year of simulation (see figure 5.1.-.6). At the same time the tendency in changes of number of sows during this period is even more homogenous comparing with number pigs. Such interdependence between numbers of sows and pigs could led to constant production volumes for pork only if slight productivity increase for sows is taken place during this period.

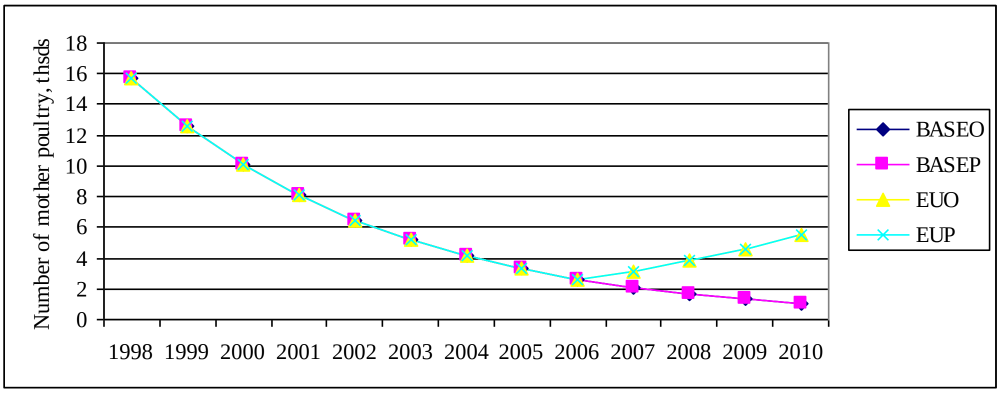
Figure 5.1—6. Number of pigs in Latvia since 1998 up to 2010.



Source: according to the results of calculations.

As it was above mentioned for poultry sector the number of mother poultry as a potential for poultry meat production and number of laying hens as a potential for production of meat and eggs are the decision variables, which should be analysed in order to consider further perspectives for development of whole Latvian poultry sector. Figure 5.1.-7. illustrates significant decrease (around 83 %) in number of mother poultry during the pre-accession period. However such sharp decrease, which is maximally allowed (up to 20% annually) in the model is accompanied by essential productivity growth for the same period. Such reduction in number leads to a considerable decline in the production of poultry meat since the productivity per mother poultry is no more than 2% per year in all scenarios. This means that this production is not profitable any more. The reason for this are the very low import prices of poultry meat which are further lowered because of tariff rate reduction by 30%. Moreover taking into account considerable increase of number of laying hens (see figure 5.1.- 8) together with the increase of their productivity it is possible to conclude that there could be some switching over from meat to egg production in the pre-accession period. The egg prices are relatively favourable for Latvian egg producers compared to poultry meat prices. There is not so much import competition in eggs than in poultry meat.

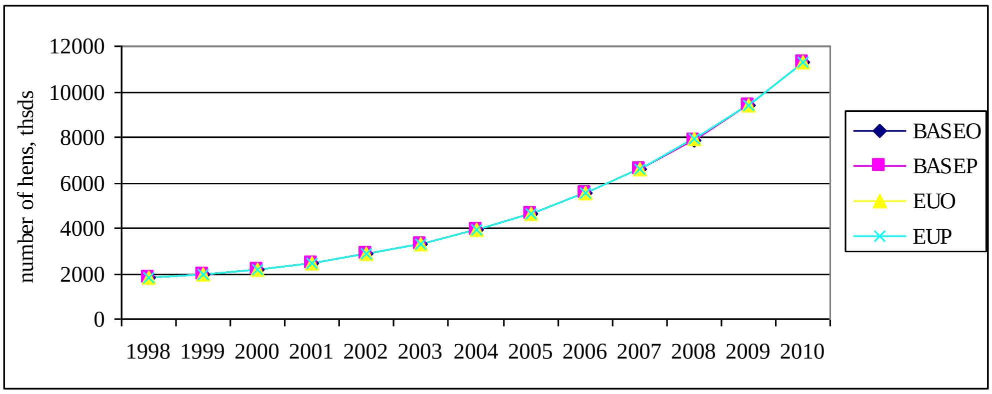
Figure 5.1—7. Number of mother poultry in Latvia since 1998 up to 2010.



Source: according to the results of calculations.

However switching between production lines in poultry sector is not so irreversible as it could be in livestock sector. Production of poultry meat can be easily renewed during the relatively short time period particularly in case if productivity of mother poultry and number of laying hens increase. That is way the total production of poultry meat might stay stable even if the rapid decrease in number of mother poultry and poultry meat production can be observed.

Figure 5.1—8. Number of hens in Latvia since 1998 up to 2010.

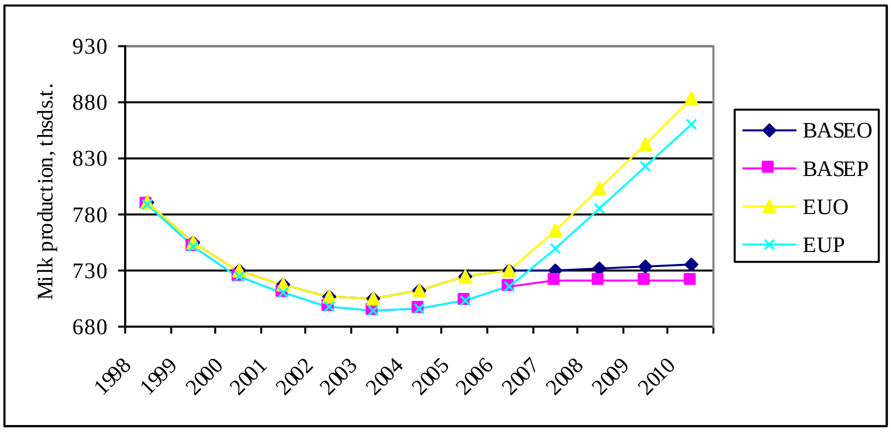


Source: according to the results of calculations.

5.2. Production volumes in husbandry production

The tendencies in development of number of animals, structural changes in crop production and animal diets observed in the model as well as different measures of Agricultural policy are the main factors which could affect essentially production of livestock products. The dynamics of production of milk and meat are reflected on figures 5.2.-1 – 5.2.-4.

Figure 5.2—1. Milk production in Latvia

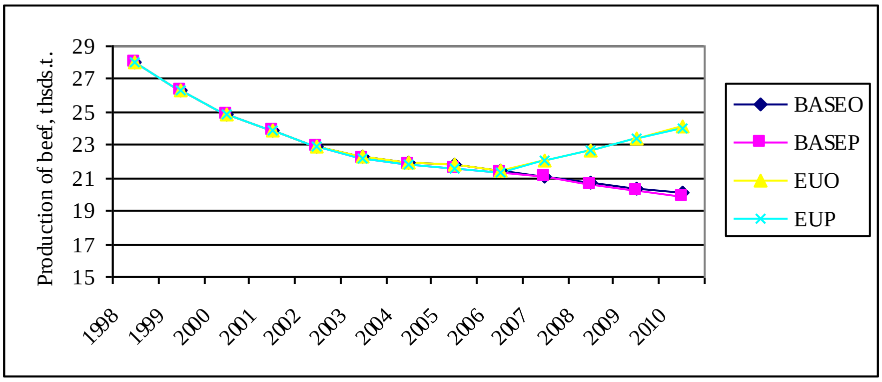


Source: according to the results of calculations.

As it is show on figure 5.2.-1 production of milk has ability for rapid growth after the Latvian integration into the EU when even the constant efficiency level in dairy sector, assumed in pessimistic scenario (see table 4.1-1) is not the essential obstacle for such sharp increase of milk production due to CAP support payments influenced the increase of number of dairy cows as a potential for milk production.

Essential reduction in number of dairy cows during the pre-accession period cause the decrease of milk production. However due to productivity growth as well as increase of efficiency level reduction of number of dairy cows in both base scenarios is accompanied by flattening or slight increase of milk production after 2007 respectively for pessimistic and optimistic independency scenarios. In both opimistic and pessimistic scenarios the efficiency increase is very modest (see table 4.1-1). Some efforts needs to be done in reaching the assumed productivity increase (milk yields), but basically one would expect that it is possible for Latvian farmers to retain their current level of milk production. The differences in productivity and efficiency in improvement rates are small – as are the differences in the production volumes between the scenarios. This means that the future milk production volumes are not sensitive to dairy sector development. Even with a rather modest improvements the Latvian dairy sector may retain its competitiveness in the long term.

Figure 5.2—2. Beef production in Latvia



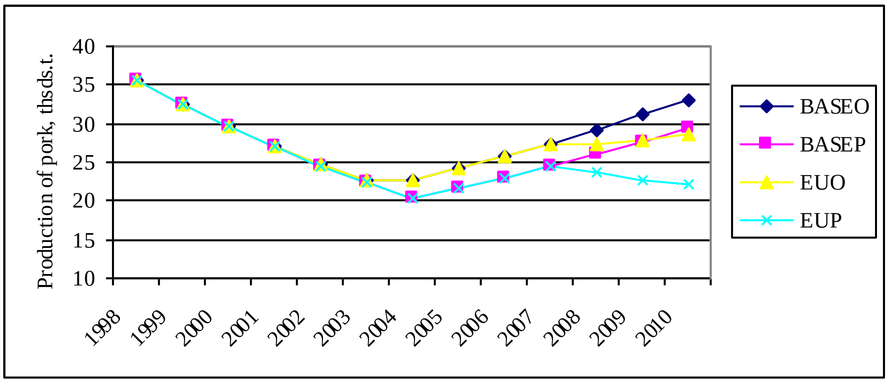
Source: according to the results of calculations.

In the case of EU integration the future development seems to be rather favourable for Latvian dairy producers. One should note, however, that the quality of Latvian milk is not always comparable to EU hygienic and quality standards. Thus, some efforts and investments are needed in order to meet the standards and the Latvian milk production may not be that successful in EU as one would guess when looking the figure 5.2-1.

In case of beef sector the efficiency growth will be not able to stop the dramatic decrease of meat production in base scenarios. The relatively low level of domestic prices on beef, which might comprise only 42% on level of EU price in 2007 does not favour the domestic production as well. Only in case of Latvian accession into the EU production of beef could be renewed on the ground of increase of number of suckler cows and bulls, because of essential premiums paid per animal according to “Agenda 2000” requirements.

During the simulation period the consumption of beef slightly increase from 29.2 up to 32.83 thsds.t. for all scenarios considered. However share of meat imported from the EU differs essentially depending on scenario. For instance in case of base scenarios where there is the dramatic decrease in production the constant level of consumption is kept due to the beef import volumes from the rest part of the world, which comprise 36 % of total consumption volumes in 2010. For the same year share of EU meat is only 3%. In the EU scenarios consumption of meat imported from the EU comprises already up to 27% in 2010 whereas the import of beef from the rest part of the world will be stopped at all after accession according to the model assumptions.

Figure 5.2—3. Pork production in Latvia



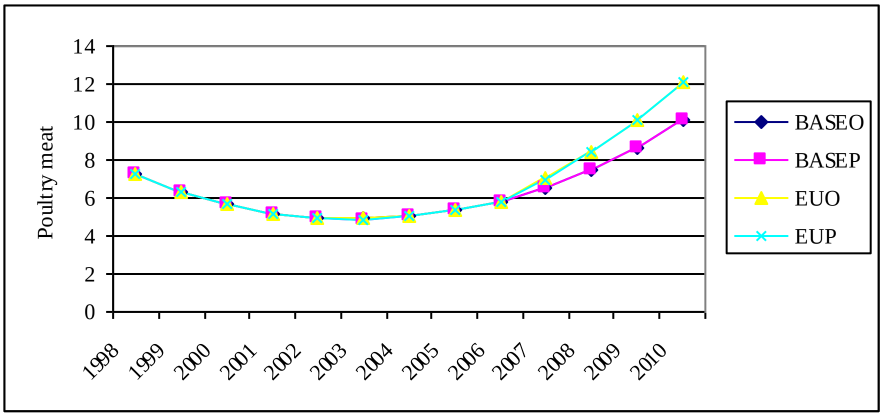
Source: according to the results of calculations.

Pork production is characterised by sharp decrease util year 2004 due to quite rapid reduction in number of pigs and sows as well as assumed abolishing of all national support measures for pig sector after 1999. However, gradual and considerable increases in efficiency and yields per sow stop the decline of meat production and up to integration time production volume are increasing. The assumed increase in feeding efficiency (see table 4.1-1) would also mean that more efficient pig breeds needs to be imported. As it is reflected on figure 5.2.-3 in opposite to beef production of pork become more attractive in both base scenarios comparing them with the case of integration into the EU. This could happen because of differences in levels of producer prices for pork, when domestic prices are higher than EU price level. In case of joining the EU the higher domestic prices have to be reduced to the level of EU price, which will not be so attractive for domestic producers. That is way in EU pessimistic scenario after accession the pork production will decrease. Seeing that after 2007 number of sows and pigs is declining as well for mentioned scenario it is possible clearly to conclude the pork production will be not profitable according to the circumstances of EU pessimistic scenario.

While the sharp decrease of pork production until 2004 the total consumption of pork is relatively stable (with some small deviations before integration) and comprises annually up to 56 – 57 thsds.t. during the whole simulation period for all scenarios. However after the accession (already in 2007) the share of pork imported from the EU considerably increases (from 0.2 up to 32.76 thsds.t. in EUP scenarios) and even exceeds the level of consumption of pork domestically produced (per 8 % and 34% respectively for EUO and EUP scenarios).

At the same time in base scenarios the share of EU import of pork is tiny and relatively stable level of consumption is kept due to the pork import from the rest part of the world. Hereto since 2004 these import volumes slightly decreases, when recovery of pork production is started (see figure 5.2.-3).

Figure 5.2—4. Poultry meat production in Latvia



Source: according to the results of calculations.

Analysing the poultry meat production it is necessary to mention that production of poultry meat will not be profitable until 2003 taking into account the decrease in number of poultry rearing for meat and animals. Even rapid increase of laying hens can't stop the rapid decrease of production of poultry meat until 2003. However gradual continuation in the growth of yield per mother poultry and efficiency might cause the shift to upward tendencies in production of poultry meat. Hereto essential reduction of number of poultry and increase in efficiency and productivity in this sector at the same time can make production of poultry meat very attractive for domestic producers even in case of independent development of Latvian agriculture.

Production tendencies in poultry sector affect the slight changes in consumption trends as well. Until year 2003 consumption of poultry meat could be on level of 19.5 thsds.t. for all scenarios. However after this year consumption amount increase till 21.5 thsds.t. In common with pork before the integration considerable share of poultry meat comes from the rest part of the world (around 71% of total consumption in 2006). However in base scenarios this share is diminishing at the end of simulation period and might comprise already 52% of consumption.

In case of EU scenario after the accession instead of rest part of the world the EU countries become the main importers of poultry meat to Latvia. However their share of meat imported in consumption gradually decreases as well from 64% in 2007 up to 40% at the end of simulation period (2010). Decrease of share of poultry meat imported at the end of simulation period for all scenarios confirms the statement above mentioned about increasing of attractiveness of production of poultry meat for domestic producers.

Thus, analysis of main tendencies in development of number of animals, productivity and efficiency indicators in different sectors of Latvian agriculture, as well as tendencies in structural changes in crop production give possibility to conclude that the in case of Latvian accession into the EU production of milk, beef and poultry might have quite strong potential for development of competitive productions. This, however, is not true in case of pork and crop sectors where very large improvements in both productivity and efficiency are needed in order to retain the current level of production. However in order to be competitive and powerful enough on European market environment the CAP support measures should be eligible.

5.3. Use of agricultural land and total cultivated areas

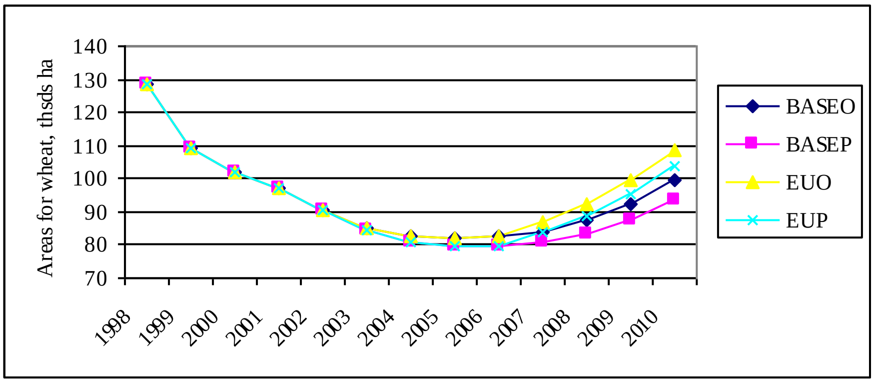
It is important to mention that animal production is heavily related to the crop production by quite considerable share of production of feeding crops for feed requirements. Therefore, changes in the feeding diets might essentially affect structure of crop and animal production.

Following to the model tendencies in changes of diets for different animals it is possible to conclude that while the annual model restrictions set on changes of feeding components for each group of animals (up to 3-7% of both lower and upper bounds) the current structure of animal feeding is shifted to the consuming of more grains (particularly wheat and barley) instated of potatoes, sometimes green fodder or silage. Within the feeding grains the share of oats and rye is reduced particularly for bulls and old bulls. Such tendencies in feeding practices as well as changes in feeding efficiency assumed for pigs and dairy cows for different scenarios (see table 4.1-1) are reflected on structure of cultivated areas and volumes of crop production.

One should also note that the productivity improvement of crop production (see equation 4.1-1) means that less area is needed for producing the same production volumes. The parameters representing the annual productivity gain result to yield improvements of 48-53% during 1998-2010. This means that total crop area may decrease even 33% during the simulation period without any decrease in the production volumes. This high increase in crop yields is possible since the current yields in Latvia are clearly lower (20-50%) than the crop yields in Finland, for example, even if the Latvian yield potential is clearly higher due to a longer growing period and soil are relatively well suited for crop production in some parts of Latvia.

As it is shown on figure 5.3.-1. while the cultivated areas for wheat goes down till 2005 while decrease of wheat production is not so rapid for the same period (see figure 5.3.-2) due to the yield level increase. Moreover after year 2007 the production volumes even exceed the production level in starting year and at the end of simulation period wheat production will increase per 28 – 43% (depending on scenario) compared to the 1998 level.

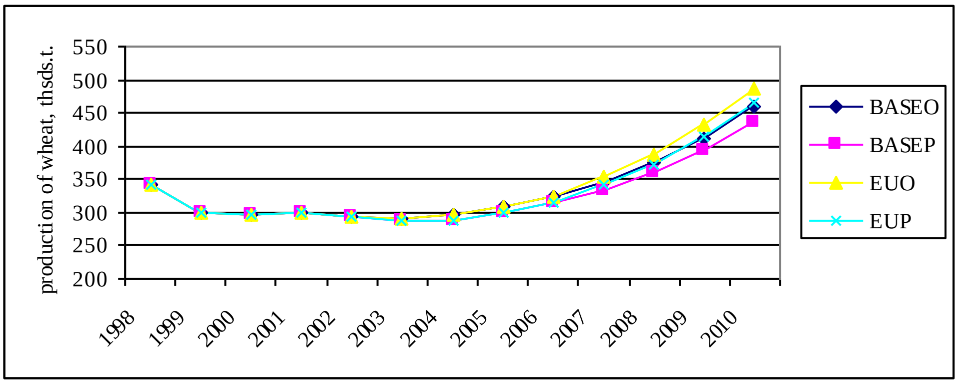
Figure 5.3—1. Cultivated areas for wheat since 1998 until 2010 in Latvia



Source: according to the results of calculations.

In addition comparing with base scenarios cultivated areas and production volumes of wheat will be higher in case of integration of Latvia into the EU due to essential acreage payments paid for grain in EU (82 ECU per ha) according to "Agenda 2000" program.

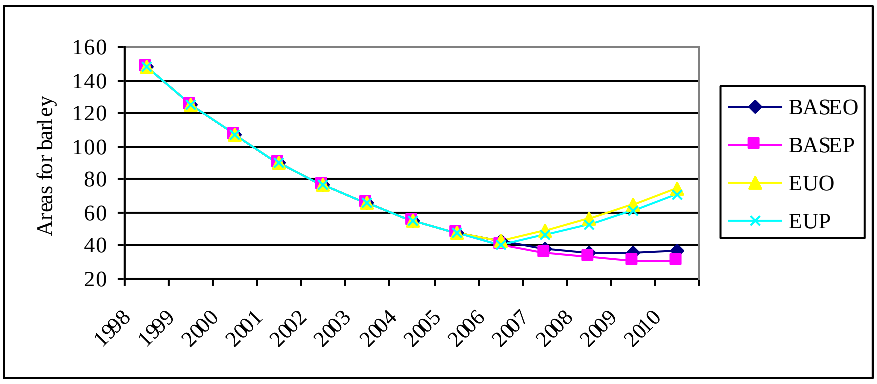
Figure 5.3—2. Wheat production in Latvia.



Source: according to the results of calculations.

At the same time for barley reduction of sown areas (see figure 5.3.-3.) might not be compensated by yield increase during quite long time, because reduction of sown areas is accompanied by reduction of production. So in case of European Union scenarios production volumes are decreasing during the whole pre-accession period. Only after the integration the production of barley arises, but nevertheless does not achieve the production level of starting year. In base scenarios production of barley started to increase only at the end of simulation period (in 2009 and 2008 respectively for BASEP and BASEO scenarios). This is an indication that due to increase of productivity and efficiency production of barley can become more attractive for cultivation (not be unprofitable) and its production can be increased in the future during the latest years of simulation. Hereto according the EU scenarios the cultivated areas for barley even can be increased due to considerable direct support measures.

Figure 5.3—3. Cultivated areas for barley since 1998 until 2010 in Latvia

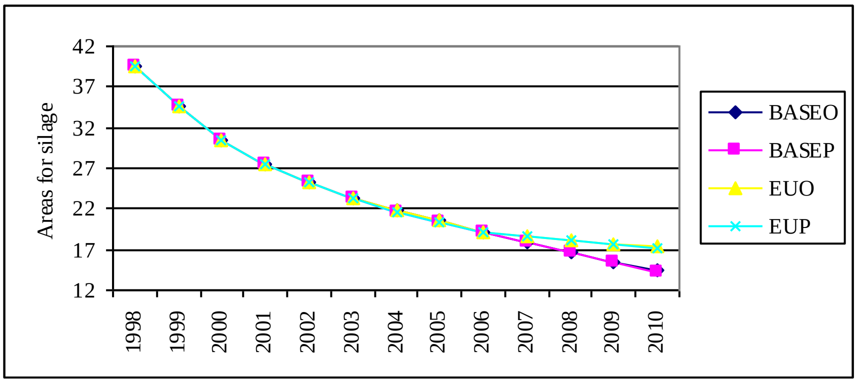


Source: according to the results of calculations.

Similar situation is observed with potatoes and rape for all scenarios, when the production volumes start to increase after the integration or at the end of simulation period according to the base scenarios. Together with production even sown areas are raised that means the regain of these production lines in the future.

In case of feeding crops it is necessary to mention that only after accession (in case of EU scenarios) production of silage and green fodder will become attractive and while the decrease in sown areas production volumes will slightly increase (see figure 5.3.-4). In the base scenarios even the assumed yield increase might not stop the reduction of production volumes.

Figure 5.3—4. Cultivated areas for silage since 1998 until 2010 in Latvia



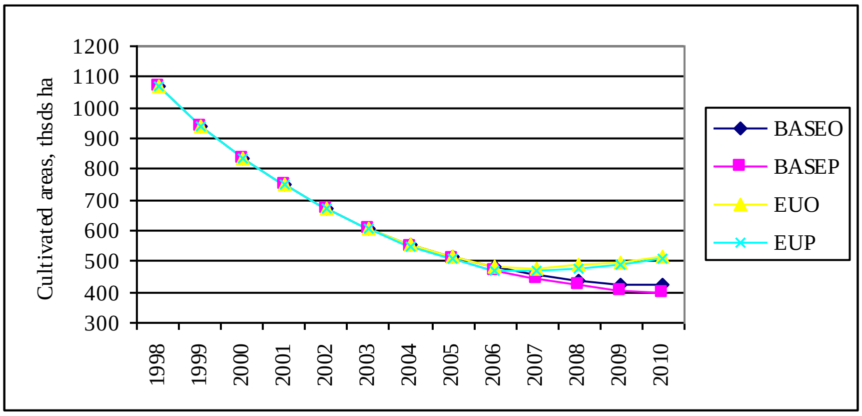
Source: according to the results of calculations.

At the same time sown areas and production of hay will decrease respectively on 86% and 80% for all scenarios observed due to changes in structure of diets for animals. It is more attractive for a farmer to use other feeding stuff instead of dried hay.

There is the interesting situation in flax cultivation. This is practically only one type of crop observed in the model when its sown areas will increase considerably (5 time more) and production volume in base scenario will exceed the possible production amounts in case of Latvian integration in the EU. Such significant growth in flax production might be motivated by essential national support applied to this particular crop (Ls 85 per ton of cultivated flax), which will not be continued in case of Latvian accession in the EU.

Evaluating the general long-term perspectives for Latvian crop production it is necessary to point out that mostly the productivity and efficiency growth are the main prerequisites for creation of competitive branch of agricultural production in spite of definitely distinct ways of further development: in case of independency or integration into the EU.

Figure 5.3—5. Cultivated areas since 1998 until 2010 in Latvia.



Source: according to the results of calculations.

As it is shown on figure 5.3.-6 the decrease of total amount of sown areas will stop at the end of simulation period practically according to the all scenarios considered and even will begin to increase slightly in case of integration, that it is the indication of extension of Latvian crop production with simultaneous efficiency and productivity growth.

5.4. Employment (labour use) in Latvian agricultural sector

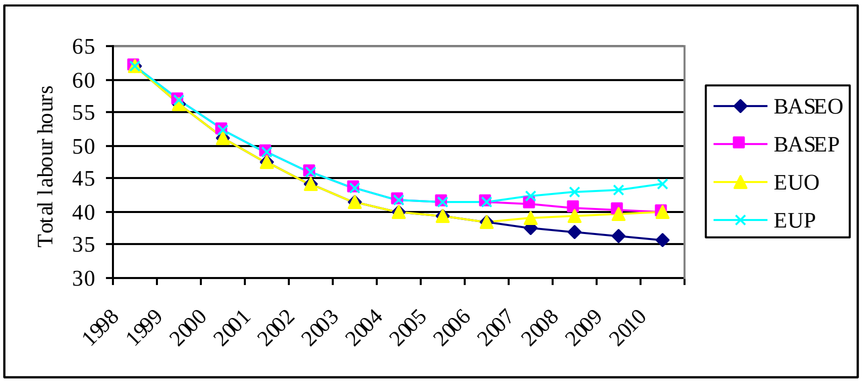
Changes of employment level on rural areas, including the agricultural production is another very important issue which has to be considered in analysis of perspectives for development of Latvian agricultural sector as a whole. Since the beginning of transition period in Latvian economy employment level has not fallen down so essentially as the level of agricultural production. Moreover taking into account very sharp decrease of agricultural production the employment level in agricultural sector remains relatively stable. According to the information from Latvian Statistic Bureau since 1990 number of employed persons in agriculture, hunting and related service activities was reduced only per 21% whereas that real volume of agricultural output has decreased per 60% for the same period. This fact indicates how inefficient is Latvian agriculture in terms of labour use. The hidden unemployment increases and quite considerable share of people is obliged to stay in rural areas only partly being engaged in activities related to agriculture because usually they are unclaimed in urban areas as well as in rural areas for other types of activities due to lack of their market orientating skills and knowledge.

Thus the increase of unemployment rate is not only economical, but rather social problem, when hidden unemployment makes the situation on rural areas more dramatic.

At the same time structural changes in agriculture, creation of competitive, market–orientated agricultural sector, efficiency and productivity growth objectively (without fear and favour) should lead to the decrease of employment. That is way according the results of model calculations and taking into account the assumptions about annual growth rates for labour efficiency total number of labour hours spent in various production lines considered in the model is decreasing essentially in all scenarios during the whole pre-accession period (see figure 5.4.-1).

This result, however, is dependent on the assumed increase in labour efficiency. In principle it is possible to retain the 1998 year agricultural employment level if a very high rate of productivity increase will take place and no improvements are expected in labour efficiency. It is very unlikely, however, that the productivity would improve so fast that no improvements in labour efficiency were required. Already the assumed productivity rates given in table 4.1-1 present a major challenge for Latvian agriculture. Thus, it may be easier to cut production costs by increasing labour efficiency which is low in Latvia and could be improved. Furthermore, if market prices are relatively low compared to unit variable costs, it may be advisable for farmers to concentrate their effort in increasing efficiency rather than searching for high yields with high production costs per hectare and animal. This is especially true if any CAP premia per hectare and animal are paid in the EU scenarios. In that case there are very high incentives in improving efficiency instead of productivity.

Figure 5.4—1. Total labour hours spent in Latvian agricultural sector, mln hours.



Source: according to the results of calculations.

Inasmuch as efficiency growth for labour in pessimistic scenarios was assumed lower than in optimistic scenarios (see table 4.1-1) decline of total labour hours spent in agriculture in optimistic scenarios is faster comparing with pessimistic ones.

At the same time only in EU scenarios the stabilisation (EUO scenario) or even slight increase (EUP) of employment is observed at the end of simulation period that could be reached by relatively fast recovering of agricultural production in case of Latvian accession into the EU comparing with scenarios of independency for Latvian agriculture.

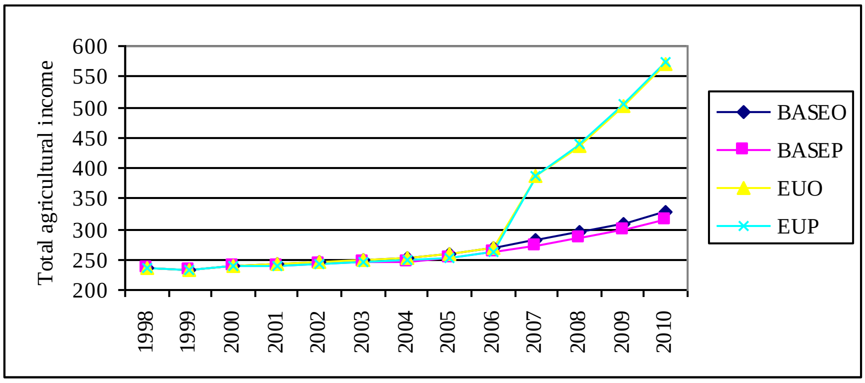
5.5. Total agricultural income

The total revenues from agricultural sector are calculated on the base of market revenues considered in current prices and support level for each production line observed in the model. Faster recovery of agricultural sector in case of EU accession is confirmed by calculations of total agricultural income as well. According to the model calculations at the end of simulation period the total amount of agricultural income might be 1.8 time higher if Latvia will join the European Union (see figure 5.5.-1).

One should note, however, that the agricultural income is calculated (and presented in figure 6.5-1) in nominal terms. If the general inflation rate is assumed to be 2% then the agricultural income would remain constant only if it increased 2% annually. This means that agricultural income should increase from 235 million lats in 1998 up to 303 million lats until 2010 to remain at the 1998 level in real terms.

The development of agricultural income exceeds 300 million lats in 2010 in base scenarios. This means that the real agricultural income stays constant (or increases slightly) in base scenarios while increases considerably in EU scenarios.

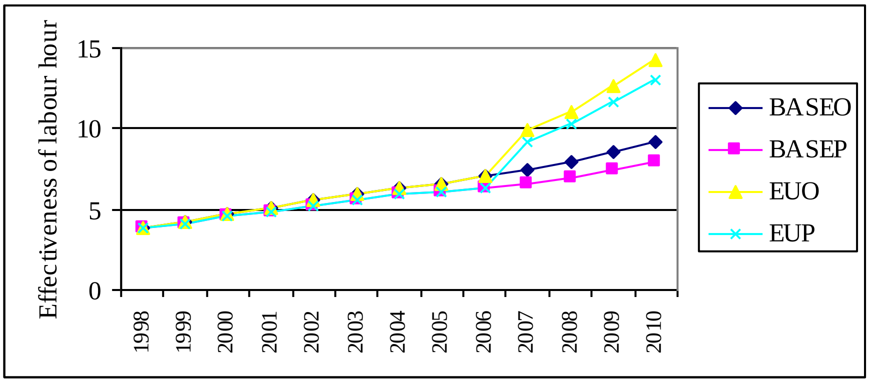
Figure 5.5—1. Total agricultural income in Latvia, mln Ls.



Source: according to the results of calculations.

Due the higher price level and essential agricultural support measures adopted in "Agenda 2000" program as well as taking into account more rapid increase of production volumes in the EU scenarios it is possible to conclude that after the accession of Latvia in the EU the agricultural income will increase significantly comparing with the independent way of development of Latvian Agricultural sector. After discounting the agricultural income by 2% rate, however, the resulting income development would not appear as optimistic in the EU scenarios as is the case in figure 5.5-1.

Figure 5.5—2. Effectiveness of labour hour



Source: according to the results of calculations.

In case of base scenarios the gradual increase of agricultural income will also take place. There are 3 major reasons for such a development. First, unprofitable production (which makes actually loss if full production costs, including labour costs, are taken into account) goes down which increase the agricultural income. Second, improving productivity and efficiency result to lower production costs and thus increase the agricultural income. Third, lower production costs result to expanding production volumes of the profitable production activities and the number of such activities may increase over time due to agricultural development.

In reality, a decline in production of some agricultural production lines decline is carried out mostly because of weak farms which will be not powerful enough in order to survive in market-oriented environment. Only existing of competitive farms makes possible to increase the income of Latvian Agricultural Sector.

The future development of the agricultural income depends crucially also on the inflation rates assumed in the model for agricultural inputs and outputs, and especially the difference between the output and input inflation rates, i.e. if it is possible to increase the producer prices of agricultural products because of increasing input prices. This depends very much on the general economic development in Latvia and at a sector level analysis only sensitivity analysis can be done in this respect. However, it is reflected in figure 5.5.-2. the effectiveness of each labour hour spent in agricultural sector, which is calculated as a ratio between agricultural income and total labour hours spent in the sector increases quite rapidly comparing with total income. This means that the income per labour hour and a worker will increase if the efficiency of production together with productivity are enough to keep the production competitive with the imports. As it already became clear in the results, there should be a considerable agricultural development if the 1998 level of agricultural income are to be retained.

5.6. Concluding remarks

The production of most products starts declining at the starting year and declines at a fast rate for 6-8 years. The differences between the model runs of different scenarios will take place only after the decrease slows down. When looking at the figures of the results it may seem that there are little differences in the outcomes of different scenarios. In fact, there are clear relative differences in the final production level. These differences, however, do not show properly (i.e. they are not clearly visible) since the production goes down by 30-50% before there are any changes between the scenarios during the last 4-5 years. For this reason the results are not the best possible ones to demonstrate the application of the model.

Looking at the figures one may believe that the production costs are too high in the model. For this reason the results should not be given too much emphasis and practical meaning at this point. Checking the cost data (especially at regional level) of the representative farms in the model is difficult and takes time. The actual applications of the model should be done only after this work has been completed.

If the production costs are close to reality, the conclusion to be drawn from the model results is clear: the production will decrease further by 30-50% and there will be some stabilisation and possible increase in the production levels only after the production costs have been significantly reduced. Relatively fast improvements in productivity and efficiency are needed in order to stop the decline of production. Rapid agricultural development, however, does not seem probable now because of a great uncertainty in the Latvian national economy.

The agricultural income may increase gradually when decreasing unprofitable production and expanding production on the profitable production lines. Together with increasing efficiency, this will result to increasing farm income and labour earnings on those production lines and farms which are able to develop their productivity and efficiency level. It seems, however, that labour hours and agricultural employment are inevitable either because of rapidly declining production volumes or because of significant improvements in production efficiency. In other words, labour and capital inputs used per hectare and animal has to be reduced significantly because it is not probable that productivity alone would solve the problem and improve fast enough to retain the 1998 production and income.

The general conclusion – which is conditional on the level of production costs in the model – of the first results of the LAPA model is that intensive agricultural development programs should be launched if import tariff rates of agricultural products are to be reduced and if the production and income level are to be retained in Latvian agriculture. Different, probably higher, inflation rates do not change this general conclusion: in the case of high inflation the agricultural development must be even faster in order to keep Latvian agriculture competitive with the imports. The general tendency of the results is not sensitive on slight or even moderate changes in many of the parameters assumed in the scenarios presented. Somewhat different substitution elasticities or price elasticities, for example, change slightly the annual reactions in production and foreign trade volumes. However, as long as consumer and producer surplus is to be maximised, even very low substitution elasticity values, for example, will not result to stable production and income levels in the long term in the case of uncompetitive production. It is also true that production will decrease considerably in the long term despite of slight or moderate changes in the flexibility constraints. The direction of changes is the same with different upper and lower bounds given for the decision variables but some sensitivity analysis could be done when evaluating the magnitude of the changes. Nevertheless, the flexibility constraints are rather reasonable when compared with the production time series and biological and technical constraints facing the farmers.

The productivity and efficiency development is somewhat optimistic in the scenarios. For example, crop yields increase by 45-55% in all scenarios until 2010. Even if such an increase in the average yields are biologically possible, there must be major changes in technology and skills of farmers before such an improvement can take place. Also it is necessary to invest heavily in modern production equipment in order to reach the assumed efficiency level. This study could be extended by evaluating the capital needs of such an agricultural development program. One could also analyse the legal and institutional conditions needed for such a change in Latvian agriculture. There are many small scale farmers in Latvia who are not able or willing to take high risks of investment and committing to developing their farm for many years. If the general economic environment provides many more attractive options for entrepreneurs it may be difficult to stop the decrease of agricultural production and the number of farms.

The dynamic sector model and its results can be best utilised in an interdisciplinary way which combines the main driving forces of agricultural development in the analysis. In other words, analysis should not be based on the model results only because no model can include all aspect of the reality. Rather, the model results should be analysed by taking into account some issues which are not included in the model. Thus one may use the model in order to get a better understanding what is the relative importance of the key factors affecting the research questions at hand. One may use the model in many different research projects with minor modifications.

A quantitative sector model can be used as a tool providing answers to many kind of “what if” –scenarios. The advantage of a model based economic and policy analysis is that one always gets consistent and comparable results of different scenarios. A quantitative model may help to explain different changes going on in agriculture and it also provides one way of deepening understanding on complex issues of agricultural development and policy analysis where many issues are interacting and influencing each other. Changes in crop prices and subsidies, for example, does not only affect crop producers and their production and income levels, but also animal producers through changing feed costs (both industrially produced and farm feeds). Under sectoral and regional resource constraints changes in crop prices and subsidies may result to considerable changes in land allocation between crops. In a sector level analyses endogenous prices may provide different information than farm level analysis using fixed prices. Sector level price and resource (land) allocation mechanisms provide a model of feedback system that affect indirectly farmers' production decisions. In other words, a sector model includes the market mechanisms that determines the aggregate outcome of the profit maximising behaviour of individual farmers. Thus, a sector level model combined with dynamics and foreign trade, provides a useful tool for agricultural and interdisciplinary research. Using such a tool, however, requires a lot of data work and careful evaluation of the model results. One needs to understand which part of the results are directly related to given assumptions and which are the ones to be used in making robust conclusions.

6. RECOMMENDATIONS FOR FURTHER APLICATION OF THE MODEL

The designing and approbation of LAPA model is long, time and labour-consuming process. In order to carry out the more deep analysis of each agricultural branch (production line) and to obtain more reliable and objective information on the basis of scenarios elaborated it is necessary to continue the improvement of model also in the future. In this respect the following main directions of development and the model improvement could be mentioned:

- The very first requirement for the future use of the model is that cost data should be carefully checked for validity. The total costs of agricultural production should be close to those in reality as well as the costs of each product separately. The regional disaggregation of production will increase the need of reliable cost data. Such an effort is necessary, however, if regional aspects are to be studied using the model since the production costs drive the production allocation between products and regions. Even relatively small differences in production costs between the regions may have a significant effect on regional production allocation.

- Imposing the environmental aspect in the model. For these purposes the environmental indicators have to be included considering each particular production line and possible effects from various policy measures;

- Implicit introduction of Investments policy module in the model. In this respect one extra module should be created in order to formalise the distribution of definite investment fund among the different production lines and calculate the possible economical effects coming from various scenarios of distribution;

- More regional consideration of causes and consequences of different policy measures, taking into account the specific regionally orientated policy measures. For these purposes more detailed information about each particular region considered should be collected;

- The further improvement of input information for the model. It is necessary to concretise the input information already collected and to use the more recent information available from the different sources of information. Such activity allows to avoid the coincidental errors in calculations, which could appear due to the usage of inexact data.

- The further use of the mentioned model as a tool in other joint projects oriented on the assessment of perspectives not only for agricultural, but also for rural development.

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Annex 1. Basic structure of the sector model