Modeling the General and Task Environments of Agricultural Sector in European Union – 1960–2100

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Abstract

In strategic management, environmental scanning is important for organizations to determine opportunities and threats during strategy formulation. A top-level manager should anticipate the changes in the environmental variables. In this study we applied literature-based modeling and extracted causality from scientific journals. Then based on this study we used System Dynamics modeling to develop two models: Agricultural Dynamics and initial Common Agricultural Policy of EU and run computer simulations.

Simulation results of the Agricultural Model indicate that agricultural dynamics justify the three initial policies of the Common Agricultural Policy of EU. Simulation results of the Common Agricultural Policy of EU Model show that the effects of EU policies on EU are more important in the long run than the short-term effects of enlargement on the agricultural sector.

Keywords: EU, CAP, System Dynamics, Agricultural sector

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1. Introduction

According to the system theorists in the field of organization and management, organizations are open systems that exist within a larger system called environment. Systems theory views an organization as a complex set of dynamically intertwined and interconnected elements, including its inputs, processes, outputs and feedback loops, and the environment in which it operates and with which it continuously interacts (Shafritz and Ott, 2001).

Causal relations point in both directions: environments influence organizations, but organizations also affect environments (Scott, 2003). A change in any element of the system causes changes in other elements; the interconnections tend to be complex,

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dynamic and often unknown (Shafritz and Ott, 2001). Hence, it is necessary for an organization not only to monitor the ongoing changes in the environment but also to anticipate the possible future scenarios and proactively formulate an action plan.

The environment is categorized as societal and task environments (Wheelen and Hunger, 2004). Societal environment, also called general environment, consists of economic, technological, political/legal, and socio-cultural forces that influence the organizations indirectly. General environment includes those sectors that might not have a direct impact on the daily operations of a firm but it will indirectly influence it (Daft, 2004). On the other hand, task environment, also called industry environment, directly affects the organizations and consists of shareholders, suppliers, employees, competitors, trade associations, communities, creditors, customers, special interest groups and government. In our study, since the level of analysis is on country level, the primary focus is on general (societal) environment.

Hence, the causal relations related with the general environment will be depicted. Agricultural industry is selected as a task environment in this study because of its importance for both Turkey and the European Union (EU). Two related simulation models are constructed: (1) Agricultural sector and (2) Initial Common Agricultural Policy (CAP) of EU.

In this research, we aim to first extract causal loop diagrams of Agricultural Dynamics and the initial CAP of EU and then develop System Dynamics (SD) models according to the causal relationships that are scientifically accepted by the researchers in each academic discipline. After we develop the SD models, we verify the models by applying the various lists and checklists proposed in SD literature. Then we do sensitivity analysis and interpret the results.

In order to extract these relationships the academic articles are examined and the generic structures of systems thinking are used. Causal Loop Diagrams (CLD) are drawn to indicate the relations in models. Then based on these CLDs, Stock and Flow Diagrams (SFD) and their mathematical equations are set in the Agricultural and CAP models and computer simulations are done. The simulation results provide possible scenarios, patterns and future developments in order to assist managers to formulate their long-term strategies.

The paper is structured as follows. Section 2 is the literature review on Agricultural Dynamics and the CAP of EU. In Section 3 the methodology is introduced. In Section 4, the dynamic models are constructed based on causal loop diagrams. The SD models are simulated and the results are given in Section 5. Sensitivity analysis is carried out in Section 6 where the results are discussed. Section 7 concludes the paper.

2. Literature Review on Common Agricultural Policy of EU

This section covers a literature review on the agricultural dynamics and the CAP of EU. Organizations and management literature is scanned in order to extract the causal diagrams to be used in the SD models. Since most of the articles written do not have the systems perspective, the causal relations and feedback mechanisms are either indirectly or implicitly stated. These statements are transformed into SD language by completing the feedback loops and explicitly articulating the relationships.

2.1. Common Agricultural Policy

After years of food shortage during the Second World War, Europeans became aware of the fact that they depend on imported food. They set the initial objective of the early agriculture policy during the late 1950s to encourage production, productivity and to guarantee food supply with affordable prices to consumers. In order to realize this aim, policy should offer farmers incentives to produce. Subsidies and guaranteed prices are offered to farmers to ensure a fair standard of living.

Initial objectives of the CAP have been defined in Article 39 of the Treaty of Rome which has been signed on March 25th 1957 by the representatives of the founding six countries:

1. To increase agricultural productivity by promoting technical progress and by ensuring the rational development of agricultural production and the optimum utilization of the factors of production, in particular labor;
2. To ensure a fair standard of living for the agricultural community, in particular by increasing the individual earnings of persons engaged in agriculture;
3. To stabilize markets;
4. To assure the availability of supplies;
5. To ensure that supplies reach consumers at reasonable prices.

In the Stressa Conference 1958, agricultural ministries have defined single market, community preference and financial solidarity as the principles of CAP. As emphasized by Candan (2003) the initial CAP was also regarded as a tradeoff between Germany and France. France had the largest agriculture sector among the EU-6 and Germany had a growing industry. France approved for a free market which enabled Germany to have an access to French market, while Germany accepted subsidies to French farmers by supporting the agriculture policy.

The policy helped to realize the first four objectives at the expense to provide consumers with food at reasonable prices (Leonard, 2005). As suggested by Patterson (1997) "*attempts to maintain all these objectives simultaneously resulted in a complicated* *system of border measures and subsidies that led to virtually uncontrollable overproduction*". Patterson (1997) indicates EU's moving from an overall net importer of agricultural produce to being a net exporter of cereals, sugar, wine, beef and veal between 1975 and 1986 as evidence to overproduction. 'Fabled beef', 'Cereal mountains', and 'Wine lakes' are used to emphasize this overproduction caused by the initial CAP which was heavily interventionist/protectionist rather than a free market approach. Levies remained as a barrier for imports, together with the support prices and incentives for exports, EU producers had a monopoly in Europe over non-EU producers. Agriculture became a subsidized and protected industry.

In the literature discussing the CAP reform, there is a consensus on the causes of the reform. The articles discuss which factors are more critical; e.g. Dughbjerg and Swinbank (2007) say that "*Analysts agree that GATT talks and budgetary concerns played a crucial role for CAP reform. However, they disagree on which was more important*". It is out of this paper's scope to indicate which factor is more critical but it is essential to construct the causal dynamics. The consensus among the academicians about the causes of the reforms helped us to construct the model structure confidently.

Table 1. Actions taken by EU CAP reforms

Events	**Actions**
Mansholt Plan	Modernization of agricultural holdings, encouragement to cease farming, and the training of farmers.
Milk Quotas	Milk quotas are introduced.
Stabilizers Reform	Production ceilings are set.
MacSharry *Reforms*	Greater transparency in costs of agricultural support, 'de-coupling' of income support from production, more free agricultural market, 'set-aside' payments to withdraw land from production, encouragement of retirement, reduction of 29% in the main arable crops support price.
Fischler Reforms	Single Farm Payment (Decoupling of direct-payments) which are subject to Cross Compliance was introduced.

The evolution of CAP has been described by Sandık (2005) who classified the CAP into three distinct stages, first self-sufficiency (1960-1985), second preserving producers' income (1986-2000) with the introduction of MacSharry reforms and third competitiveness and product quality with the Agenda 2000 and Single Payment Plan (2000 -). Table 1 lists the actions taken by corresponding CAP reforms.

As of 2007, aims of the CAP were defined by the EU as:

- To provide farmers with a reasonable standard of living;

- To provide consumers with quality food at fair prices; and

- To preserve EU's rural heritage.

EU (2007) suggests that "*the policy has evolved to meet society's changing needs, so that food safety, preservation of the environment, value for money and agriculture as a source of crops to convert to fuel have acquired steadily growing importance*".

Avery (1984) emphasizes CAP's being a central feature of the Community's activity and questions the reasons of CAP's occupying a large part of the Community's time and money despite decreasing farming's share of employment and economic output.

Knudsen (2006) argues that "*many observers are highly critical of the CAP, often because of their failure to understand why the policy exists*" and asserts that "*CAP should not be viewed from an economic angle, but from the perspective of the political purpose that it serves*". We agree with the author in the sense that the political perspective is important in understanding CAP, but we suggest to include the economic, social and technological perspectives to this analysis.

According to Leguen de Lacroix (2004) agriculture is important for Europe as "*Europe has a modern and competitive farming sector occupying a leading position on world markets, both as a major exporter and the world's largest importer of food, mainly from developing countries*". Since EU is a major exporter, subsidized exports due to CAP policy took attention and opposition from other exporting countries played an important role in international trade relations.

CAP has been comprised of two pillars. The first pillar comprises market price and income supports whereas pillar two includes rural development. One of the market price support measures is price supports, also called guaranteed price system. Target prices are the prices that EU hope farmers will receive on the open market. These are usually set above world prices and represent the ceiling price for farmers. Intervention prices are used to denote the price that authorities buy the agricultural products when market prices fall to this level, thus, representing guaranteed prices.

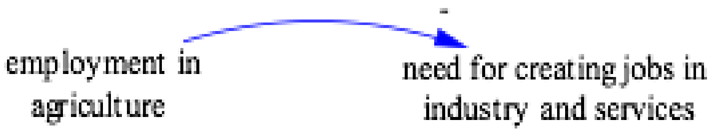
Another market price support measure is export subsidies, also called as restitutions or refunds. Exporters are supported and refunded the difference between the internal and export prices. Import levies exist to provide a barrier for non-EU agricultural producers to sell agricultural products with competitive prices. Entry prices are the minimum prices which an agricultural product can be imported for into the EU. Threshold prices are prices for imports from outside the EU at which levies are charged. After Uruguay round, threshold prices are not applied. Market price support was among the initial mechanisms of CAP support and the dominant scheme during 1960 through 1990. Due to MacSharry reforms in 1992 its percentage declined and income support mechanisms were introduced.

Income support comprises direct aids coupled to production first, then they are decoupled from production and in the final form, payments are done with compliance based on environmental, food safety and animal welfare concerns. With the introduction of the second pillar by Fischler, expenditure for rural development became the growing part of the CAP. Although, it is still much smaller than the first pillar, it is expected to increase gradually in the coming years.

2.2. Agricultural Dynamics

Employment in agriculture began to decline after industrial revolution; today the trend towards working in industry or services cause employment in agriculture to decline. As the employment in agriculture decreases, the need for creating new jobs in industry and services increases. This causal relationship has been confirmed also by the EU Progress Report for Turkey (2006) which indicates that "*the share of agriculture in employment decreased markedly during 2005, from 33% to 26% of total employment. Jobs were created in the industrial sector and its share in the total labor force rose from 18% to 26% in 2005. However, job creation in industry and services was not strong enough to fully compensate for the reduction in agricultural employment*". This causal relation is shown in Figure 1.

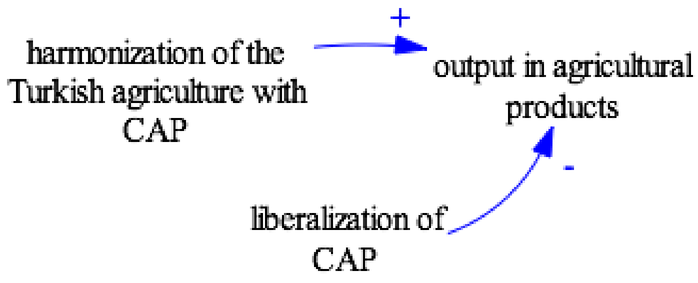
Figure 1. Need for creating jobs in industry and services



Source: EU (2006)

CAP of EU provided incentives for farmers to increase output in agricultural products. These incentives are expected to increase agricultural outputs in acceding countries. Çakmak and Kasnakoğlu (2002) calculated that the harmonization of the Turkish agriculture with CAP of EU creates an output increase in most of the agricultural products. Herok and Lotze (2000) found that the liberalization of CAP will lead to a decrease of agricultural output in Central and East European Countries. This causal relation is depicted in Figure 2.

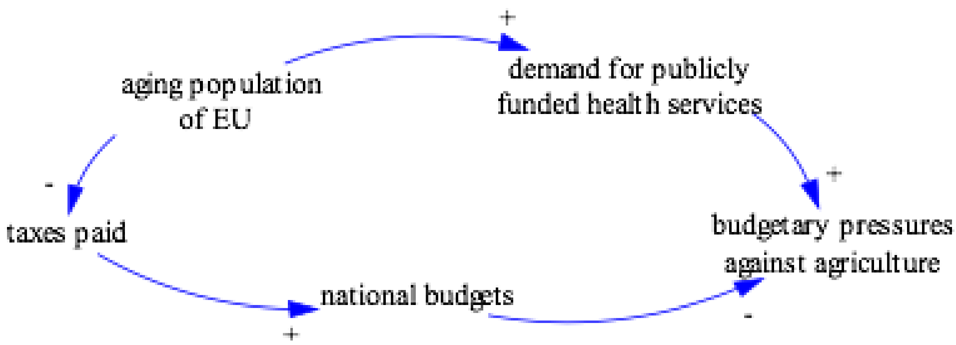
Figure 2. Harmonization of the Turkish agriculture with CAP



Source: Çakmak and Kasnakoğlu (2002) and Herok and Lotze (2000)

Effects of aging population of Europe is being emphasized by Roberts and Gunning-Trant (2007) who assert that "more old people mean fewer people earning and paying taxes and increasing demands for publicly funded health services, pensions and social security. These will squeeze national budgets." As the taxes paid decrease, national budgets decrease. The effects of decrease in national budgets and increasing demands for public health services increase budgetary pressures against other policies. This implies that budgetary pressures for agriculture which absorb most of the EU's budget, is expected to rise in parallel with the aging population of Europe. Causal relations are drawn in Figure 3.

Figure 3. Budgetary pressures against agriculture



Source: Roberts and Gunning-Trant (2007)

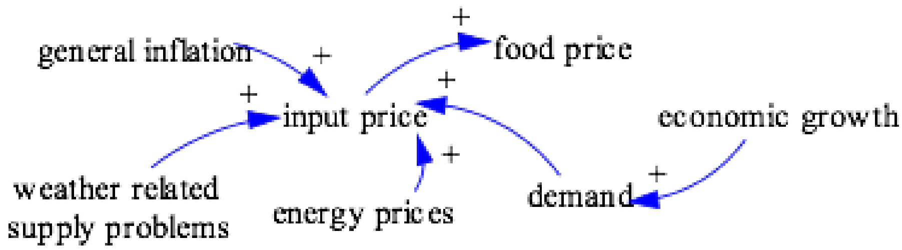
An SD model is developed to explore the potential long-term ecological, economic, institutional and social interactions of ecological agricultural development through a case study of Jinshan County in China by Shi and Gill (2005). They found that the diversification of land-use patterns, government low interest loans and government support for training are important measures for promoting the sustainable development of ecological agriculture. The causal relations which are also applicable to EU are depicted in Figure 4.

Figure 4. Sustainable development of ecological agriculture

Source: Shi and Gill (2005)

Factors that cause input prices in agriculture to increase are important. General inflation, weather related supply problems, increase in energy prices, and excess demand are among these factors (Lee, 2002). Demand is also positively affected by economic growth and input price has a positive relation with food price. The causal relation is shown in Figure 5.

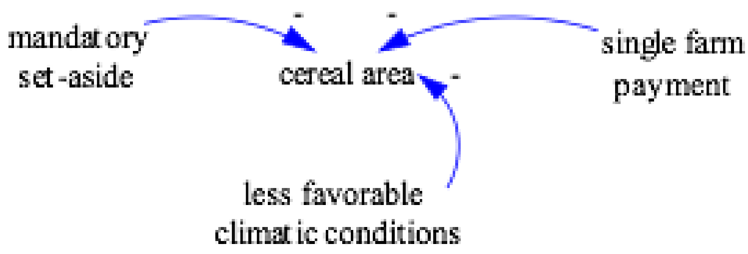
Figure 5. Input price



Source: Lee (2002)

Lee’s (2002) empirical study is supported by the data on agricultural statistics in EU, provided by the 2005 Report of European Commission where it is stated that “input prices were substantially higher in 2005 in most Member States.“ The main reason for the increase of input prices were “increased prices for energy and fertilizers”. Moreover “EU-25 cereal area is estimated to have declined by 1.6% to about 51.2 million hectare in 2005”. This decline is mainly due to a “10% mandatory set-aside and less favorable climatic conditions in some EU regions and the first implementation of the single farm payment”. The mandatory set-aside and the single farm payment are introduced in CAP reforms. The causal diagram is depicted in Figure 6.

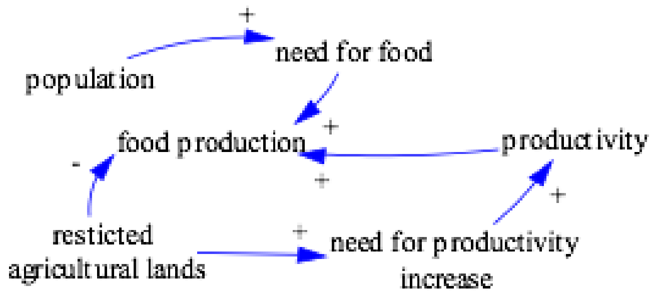
Figure 6. Mandatory set-aside payments



Source: European Commission Report (2005)

Güryay et al. (2005) suggest that “because of restricted agricultural lands, necessity of getting more output with the same amount of input has been going out. In this way, scientific and technological studies try to find out to produce more goods with high quality, in the same restricted agricultural lands”. Figure 7 shows the relationship among productivity, land restriction, population and food production.

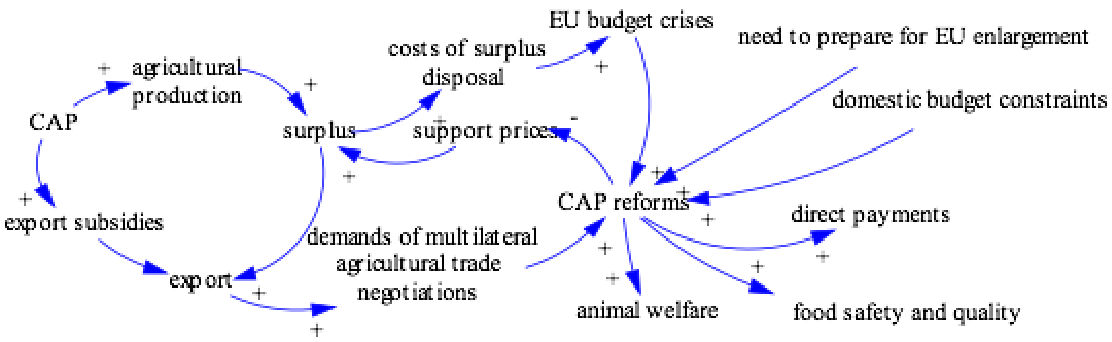
Figure 7. Relationship among productivity, land restriction, population and food production



Source: Güryay et al. (2005)

Kelch and Normile (2004) examine the CAP reform of 2003 providing important causal relations about the CAP and CAP reform. CAP’s effect on increasing production, surpluses, and agricultural exports due to export subsidies results in an increase in costs of surplus disposal. This triggered EU budget crises and created demands of multilateral agricultural trade negotiations for a CAP reform. The need to prepare for EU Enlargement also created a need for a CAP reform. The CAP reform, which is designed to decrease support price, initiate direct payment, increase however concern for animal welfare, food safety and security. The relations are depicted in Figure 8.

Figure 8. CAP reforms



Source: Kelch and Normile (2004)

Henke and Storti (2004) indicate that the 2003 CAP reform causes reorienting support from market policies to rural policies because of the modulation of direct payments. This relation is given in Figure 9.

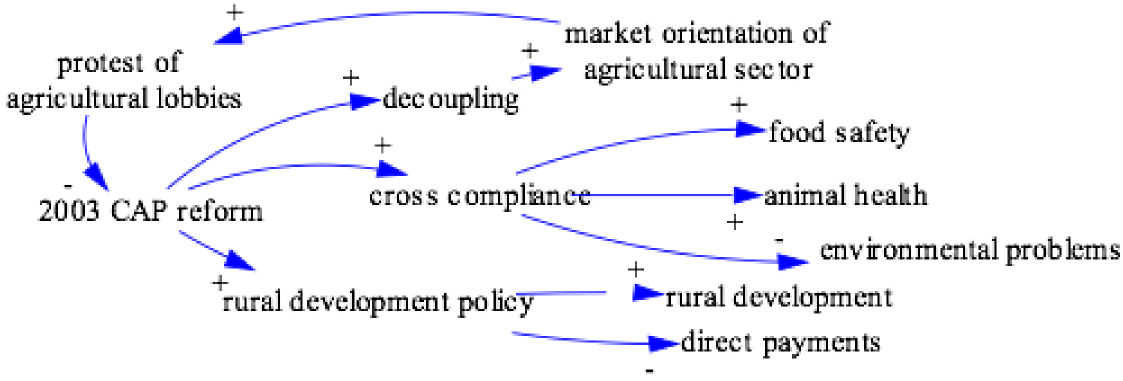
Figure 9. Reorienting support from market policies to rural policies

Source: Henke and Storti (2004)

Ahner (2004) considers single payment scheme as the most important element of this reform and reminds that "the new payment will no longer be linked to what a farmer produces but will be decoupled" and suggests that "de-coupling should contribute to improve the market orientation of the sector". Ahner (2004) emphasizes other elements of the CAP reform as cross-compliance and rural development policy.

Cross-compliance considers food safety, animal health and environmental effects. Rural development policy transfers the funds from direct payments to rural development activities. The protest of agricultural lobbies due to market orientation of agricultural sector which may aim to decrease the effects of CAP reform is added to the causal relations of Ahner (2004) as shown in Figure 10.

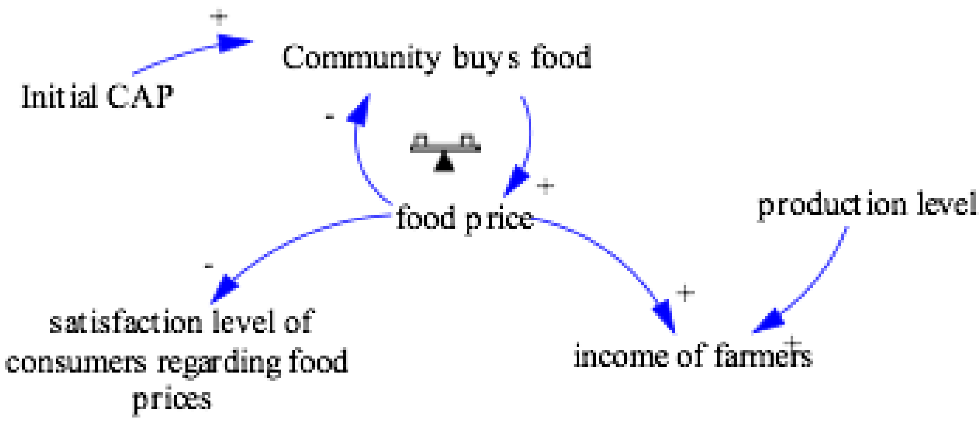
Figure 10. 2003 CAP reform



Source: Ahner (2004)

Keskin (2008) exposes the initial objectives of CAP and emphasizes the balance between producers and consumers. The balance of food price is being guaranteed with the CAP. As the food price decreases to intervention price level, EU intervenes and buys food which increases food price. Since food price is subsidized by price support, direct income support for farmers' income is also stabilized. The causal relation is depicted in Figure 11.

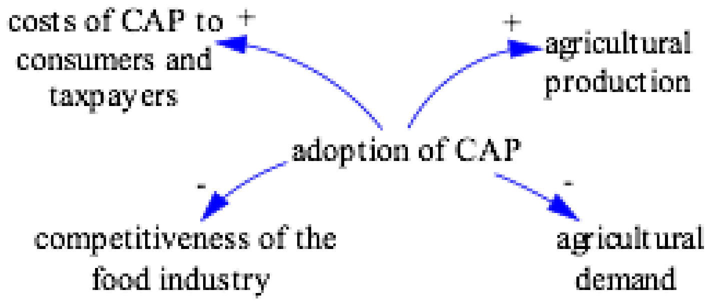
Figure 11. Interventions



Source: Keskin (2008)

Mergos et al. (2001) assert that the "adoption of the CAP will stimulate production, decrease demand and have strong adverse effects on consumers and taxpayers, and negative effects on the competitiveness of the food industry". The causal relation proposed by Mergos et al. is given in Figure 12.

Figure 12. Adoption of CAP



Source: Mergos et al. (2001)

3. Methodology

Many articles in the literature discuss simulation in general, system dynamics modeling in particular in order either to start discussion on possible scenarios and/or to predict the future. Simulation gaming can help bring to attention a rich and varied range of possible specific changes that may occur in an existing or imaginary scenario, and explore what repercussions might result in.

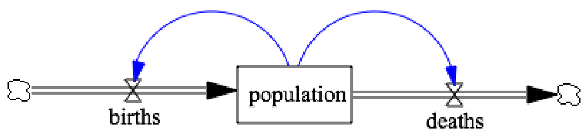
SD modeling provides a common language which can be communicated through stock and flow diagrams (SFD). This increases the readability of the arguments without sacrificing the holistic view and it is an appropriate way to show multi-dimensional and complex relations in diagrams. SD modeling is based on systems thinking (Senge, 1999). Systems thinking has a holistic view and can be used to solve complex, interrelated, and multi-disciplinary problems. It is a concept that enables to grasp the whole picture in any kind of problem and analyze the impacts of the system by having a thorough understanding about the components and their interactions within the system. Senge (1999) suggests that the discipline of systems thinking lies in a shift of mind: "*Seeing interrelationships rather than linear cause-effect chains and seeing processes of change rather than snapshots*."

In order to develop an SD model, one needs to know the causal relationships between variables and to be able to indicate feedbacks to draw causal-loop diagrams (CLD). The most important features of a CLD are negative and positive feedbacks. Martin (1997) suggests that "*the two types of feedback, positive and negative, combine to create all of the behavior observed in complex systems. Positive feedback drives growth and change while negative feedback negates change and stabilizes systems. Negative feedback exhibits goal-seeking behavior.*" If one cannot figure out the feedbacks then the model is not an SD model because the dynamic movement of the system is caused only by feedback loops.

After developing the CLD, the SFD should be developed. SFD is drawn with the help of rates (flows) and stocks (levels). "Stocks" represent variables that accumulate during the selected time interval. They increase and decrease only with low (rate) variables. A causal loop diagram is shown in Figure 13 and an example of a stock and flow diagram is shown in Figure 14.

Figure 13. Causal Loop Diagram

Figure 14. Stock and Flow Diagram



Based on the SFD, mathematical relationships and equations are defined and the model is ready for a computer simulation. Simulations provide the opportunity to run sensitivity analysis and "what if" simulations in order to depict how variables interact with each other and how the overall system changes.

4. Proposed dynamic model

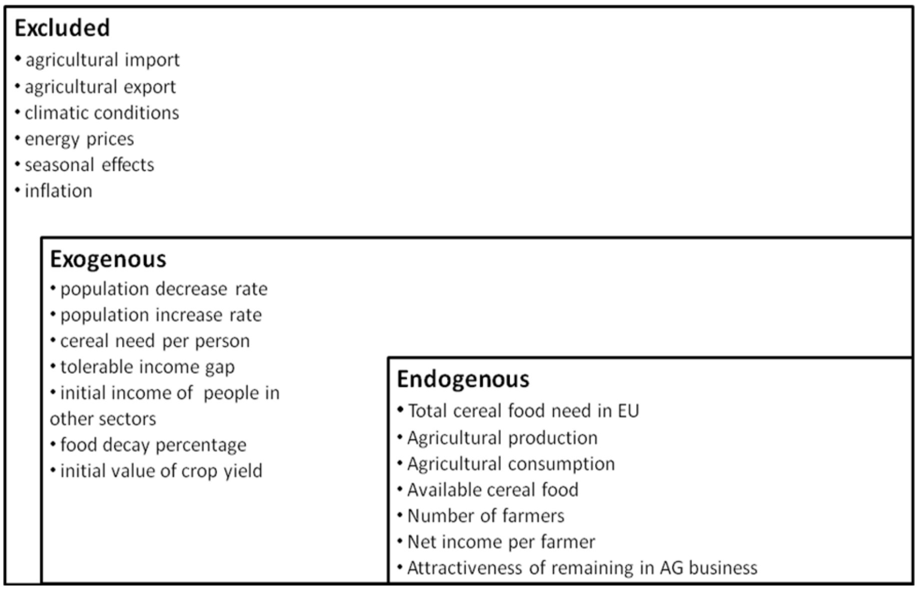
In this chapter SD models are constructed and simulated. Two SD models are constructed:

1. Agricultural Model: illustrates the dynamics of the agricultural industry in a closed economy.
2. CAP Model: shows the dynamics of initial CAP of EU.

The issues that are important to the model are treated endogenously, issues that are of secondary importance are inserted into the model as exogenous variables, and variables that are irrelevant with the problem are excluded.

The model boundary chart for Agricultural Model is shown in Figure 15. Agricultural import and export are excluded from the agricultural dynamics of the model. Probabilistic conditions such as climatic conditions are excluded. Since the time step is chosen to be one year, seasonal effects are excluded. Energy prices is neglected, however it can be included in an extended model which includes the economic area.

Figure 15. Model boundary chart for Agricultural Model



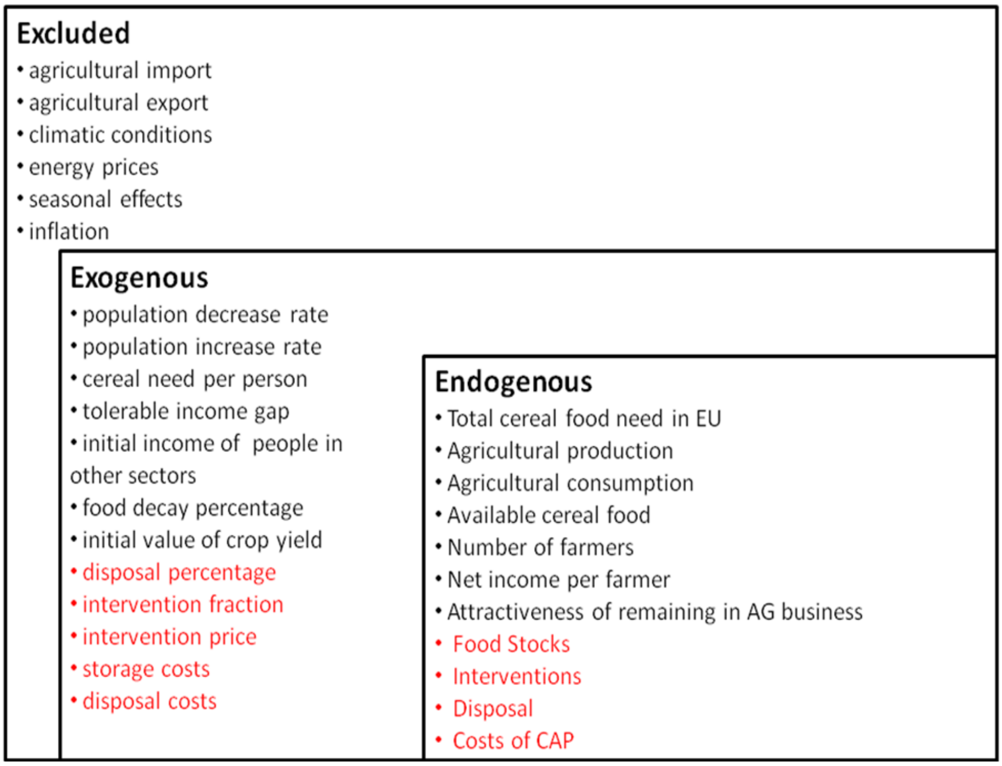
Population increase and decrease rates are exogenous variables whose data are extracted from Eurostat. They are selected as exogenous as the internal structure of population dynamics is not important in this model. However, the output of population data is important for calculating the total cereal food need in EU. Thus, its output which is congruent with the real data is used in the model. Cereal need per person is selected as exogenous as it is not expected to change significantly over time.

Tolerable income gap is assumed to be constant and is calculated from the real data observed. Initial income of people in other sectors is set from the real statistics in the beginning of the simulation in 1960. Food decay percentage is assumed to be constant during the simulation time. Initial value of crop yield is included into the model as setting an initial value to the crop yield which is expected to change by modernization in the agricultural industry.

Since total cereal food need in EU, agricultural production, agricultural consumption, available cereal food, number of farmers, net income per farmer and attractiveness of remaining in agricultural business are the factors relevant to the purpose they are selected as endogenous variables in the Agricultural Model.

The model boundary chart for the CAP Model is based on the Agricultural Model and is shown in Figure 16. Additions to Agricultural Model are designated in red color. Disposal percentage, intervention fraction, intervention price, storage and disposal costs are selected to be exogenous whereas food stocks (surpluses), interventions, disposal of surplus food, and costs of CAP to EU are selected as endogenous variables.

Figure 16. Model boundary chart for CAP Model

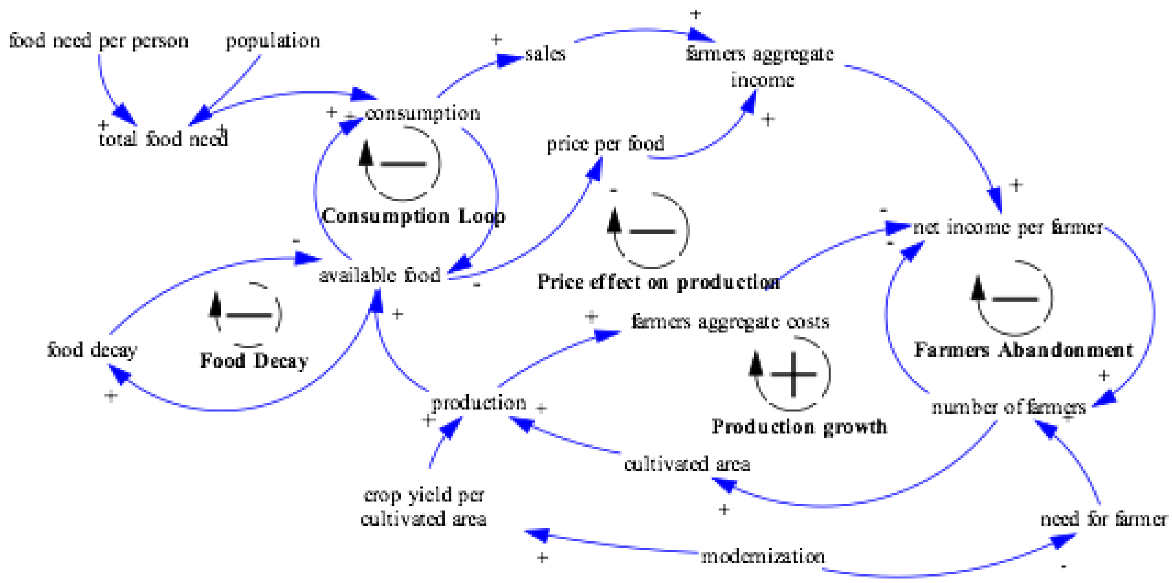


4.1. Agricultural Model: Dynamics of Agricultural Area in a Closed-Economy

Agricultural model in a closed-economy (import/export variables are excluded) includes agricultural production, number of farmers, food prices, food supplies, farmers profitability and agricultural spending factors. These factors seem to be of decisive importance in determining the agricultural dynamics.

The remainder of the section will present the causal structure and indicate how the interaction of these factors creates dynamic effects. Agricultural Model is developed as it forms the basic dynamics involved in CAP. In this section, the model is constructed considering these relations presented in Figure 17.

Figure 17. Agricultural model



4.1.1. Production Growth Loop

As the production increases, available food in the market rises. When there is available food, it is consumed, (indicating sales) and farmers aggregate income increases and thus, net income per farmer increases. As the net income per farmer increases more people enter into the agricultural business, there are fewer retirements, and less people leave farms, indicating a growth in the number of farmers. As the number of farmers grows, the cultivated area and then production increases.

The clock-wise circle with a plus sign indicates a positive (reinforcing) feedback loop and it is named as production growth. According to this loop any increase in the production variable ends up in an even higher production (virtuous cycle) or any decrease in production causes a further decrease in production (vicious cycle).

Modernization entailing new technologies and production techniques decreases the need for farmer and increases the crop yield per cultivated area. Modernization is assumed to increase each year.

4.1.2. Food Decay Loop

As the available food in EU increases, people consume more food. However, the food that is not consumed is either disposed or stocked. Naturally a fraction of the food in these stocks is expected to decay. In order to consider the effects of food decay (both decay and disposal), the balancing loop is added to the Agricultural Model.

4.1.3. Consumption Loop

As consumption increases, the available food in the market decreases. When there is less available food in the market, consumption decreases creating a negative feedback loop.

4.1.4. Price Effect on Production Loop

The price per food is affected by available food in the market. If there is a surplus of available food then the price per food will decrease, or if there is a food shortage then the price per food will increase. As the price per food increases, farmers' aggregate income increases too. As the farmers' aggregate income increases so does the net income per farmer. As the net income per farmer increases, the number of farmers increases in parallel. When the number of farmers increases, cultivated area also increases. An increase in cultivated area increases production and more production means availability of food increases. Any increase in the available food in the market ends up in a decrease in available food due to price effect.

4.1.5. Farmers' Abandonment Loop

As the net income per farmer increases, an increase in the number of farmers is expected. As suggested in the "Common Agriculture Policy Explained" report of the EU Commission (2004), "if farming is not profitable then existing farmers will cease their activities, and young people may not be attracted into agriculture". As the number of farmers increases, net income per farmer decreases.

4.2. CAP Model: Dynamics of Initial EU Common Agricultural Policy

Dynamics of initial EU CAP is constructed in this section which is based on the literature review of CAP in section 2.

4.2.1. Price Supports Loop

When market prices (price per food) fall down to the level of intervention price, intervention authorities buy the agricultural products. As the interventions increase, available food in the market decreases (food in stocks increase). Hence, price per food increases due to market dynamics. EU enlargements increase the EU population and the number of farmers. This effect is seen in the upper right-hand side of Figure 18 where each EU enlargement increases EU population, and middle right where enlargement increases the number of farmers.

Figure 18. CAP Model: Price supports loop

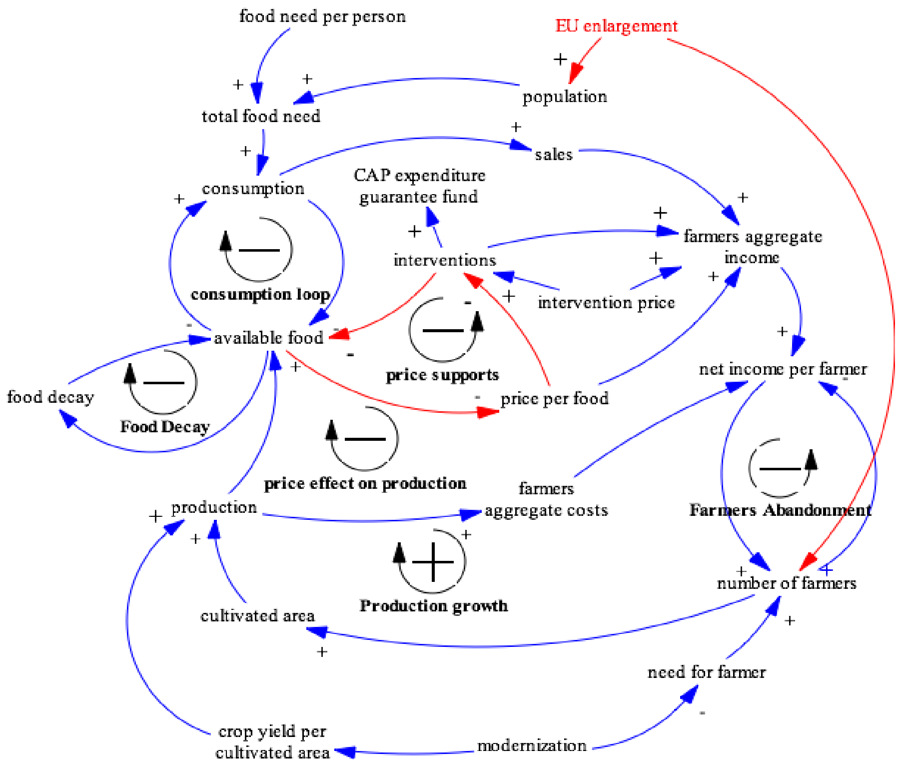
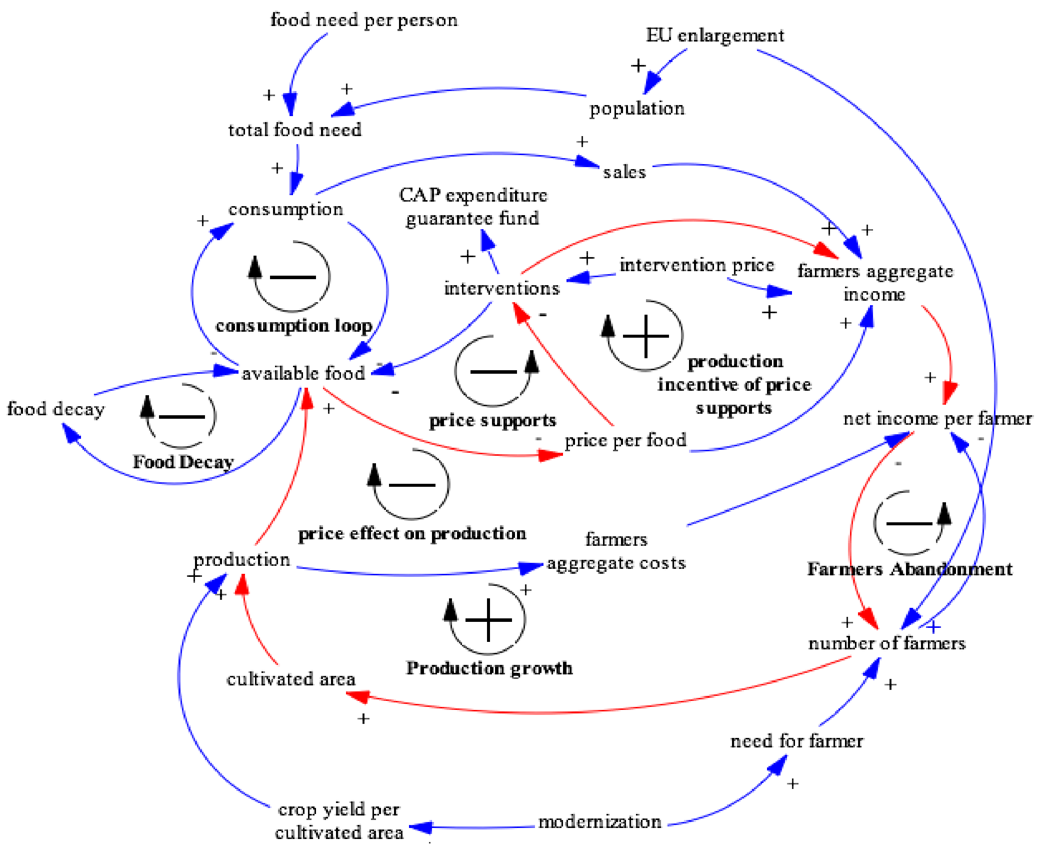


Figure 19. CAP Model: Production incentive of price supports



4.2.2. Production Incentive of Price Supports

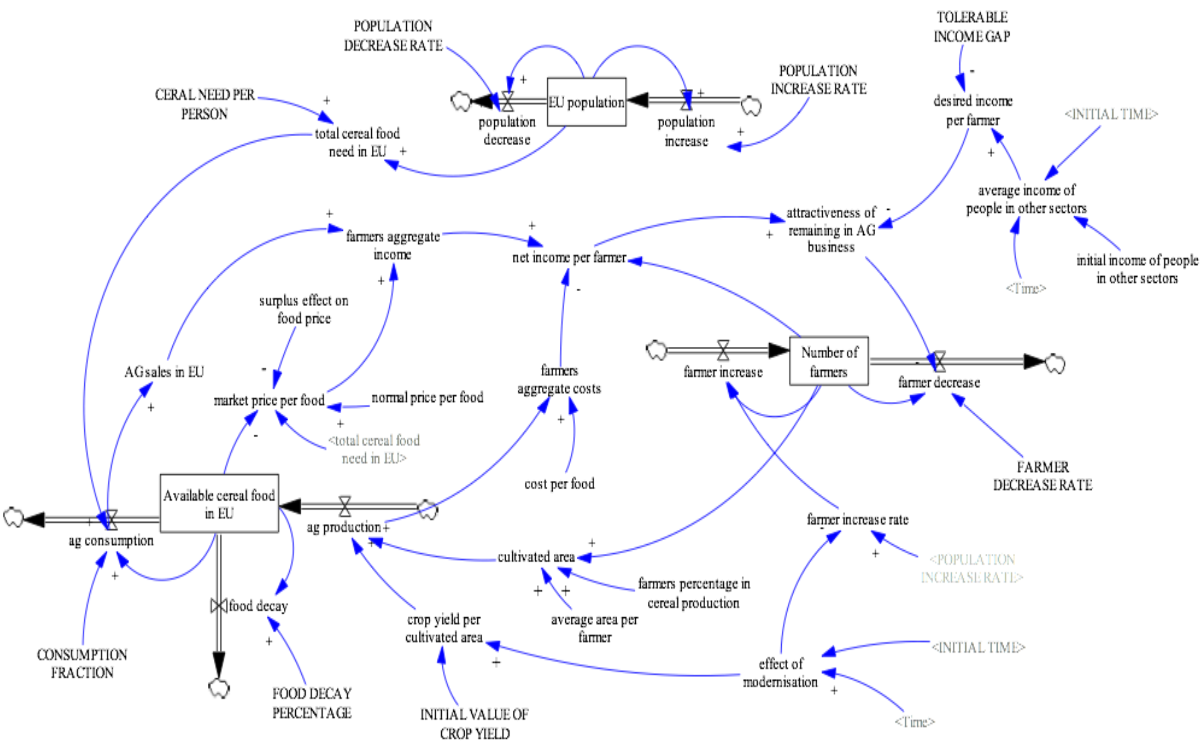
Figure 19 shows the effects of price supports on production. As the interventions increase, farmers' aggregate income, net income per farmer and number of farmers increase. As a consequence the cultivated area and production raise leading to an increase in available food. As the available food increases, price for food decreases and thus another intervention is expected. This causal relation emphasizes the self-addictive character of the intervention policy rather than the original idea of supporting farmers. This is a counterintuitive effect which can only be seen from a holistic, systemic approach. This loop shows how price supports results in overproduction leading to 'Cereal Mountains' that occurred in EU due to the CAP.

5. Results

5.1. Simulation Results for Agricultural Model

In System Dynamics, after identifying the problem, the first step is to find out the causal relationships among critical variables creating the problem. This is done by using causal loop diagrams. Following the causal loop diagrams, SFD and the underlying equations, parameters and mathematical equations are entered. In order to run the simulation, data are needed.

Figure 20. SFD of Agricultural Model



The Agricultural Model is more an operational model than an abstract one. Thus, real data is collected and used during the simulation. The initial values of the exogenous and constant parameters in the simulated model are set in congruent with the actual data of EU-6. The actual data is gathered from Eurostat, FAOSTAT, ENA, and official EU reports.

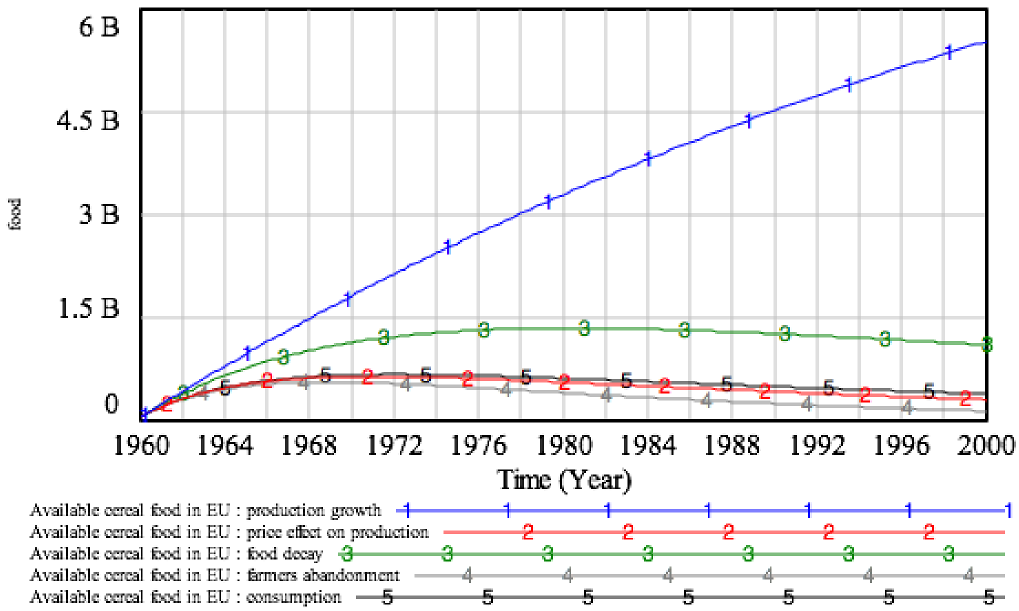
The cereal which is the most produced item in agriculture (14.3% in 2002) is selected to represent the agricultural output in the model. When the word food is used in the model it represents cereal. The EU population average growth rate is calculated to be 0.39% during 1960-2006.

The parameters used during the simulations are given in the Appendix I.

5.1.1. Changes in Available Cereal Food in EU

The simulation results for the loops production growth, food decay, consumption, price effect on production, and farmers abandonment are shown in Figure 21 and 22.

Figure 21. Availability of food



In the production growth loop, the available cereal food in the market increases due to the existence of only one loop which is a reinforcing one. This increase is expected due to the structure of the model. The growth is not exponential as the modernization increases linearly during the simulation of the model, leading to a decrease of the number of farmers as seen in Figure 22.

After the food decay is added to the model the available food first grows and then stabilizes during years 1972-1988 and begins to decline from 1988 to 2000 (Figure 21).

the peak is reached at 1.5 billion tons.

After the consumption loop is added, the available food further decreased to 650 million tons. This result was predictable as in the previous models the consumption was not defined to decrease the available food stock. Consumption is changed to be a rate variable rather than an auxiliary variable.

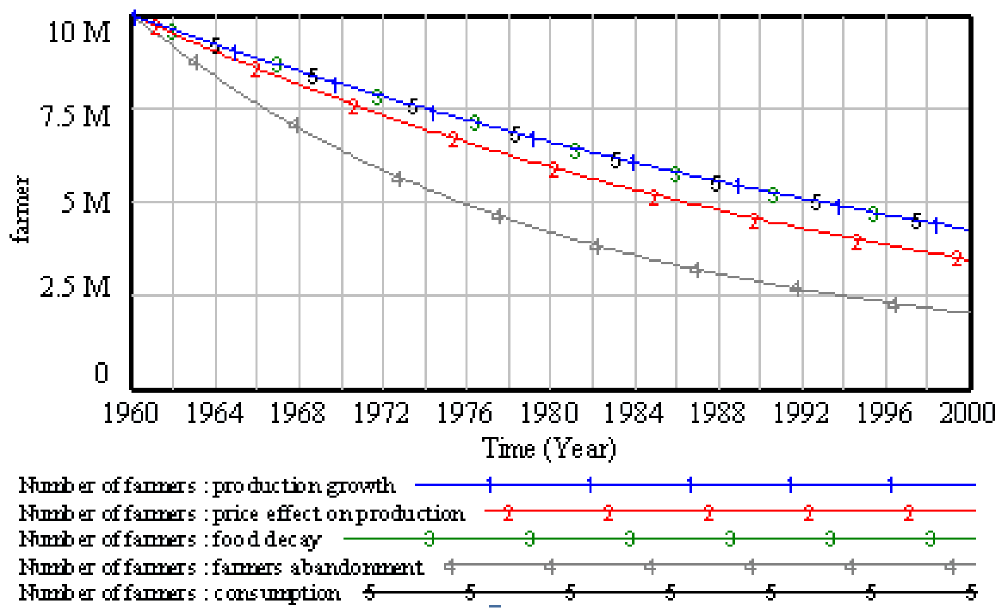
The patterns observed after the price effect on production is added to model is similar with the previous run, both in available food and in the number of farmers. A slightly greater decline in available food especially in the end of the simulation has to be noticed in comparison to the previous run.

When the farmers' abandonment loop is added to the model, the available cereal in the market first increased due to the dominance of the reinforcing loop (production growth), then began to decrease and collapsed as the balancing loops (consumption loop and price effect on production) started to dominate the system. This behavior is called "growth then collapse". The Figure 20 indicates the inability of farmers to produce sufficient food without the governmental support. This explains the choice of governments to support farmers.

5.1.2. Changes in the Number of Farmers

For production growth, food decay, consumption the number of farmers is constant. When the price effect is added to the model the number of farmers is influenced like the available food showing a slightly higher decline than in the previous runs. However the general pattern and behavior is not influenced.

Figure 22. Number of farmers

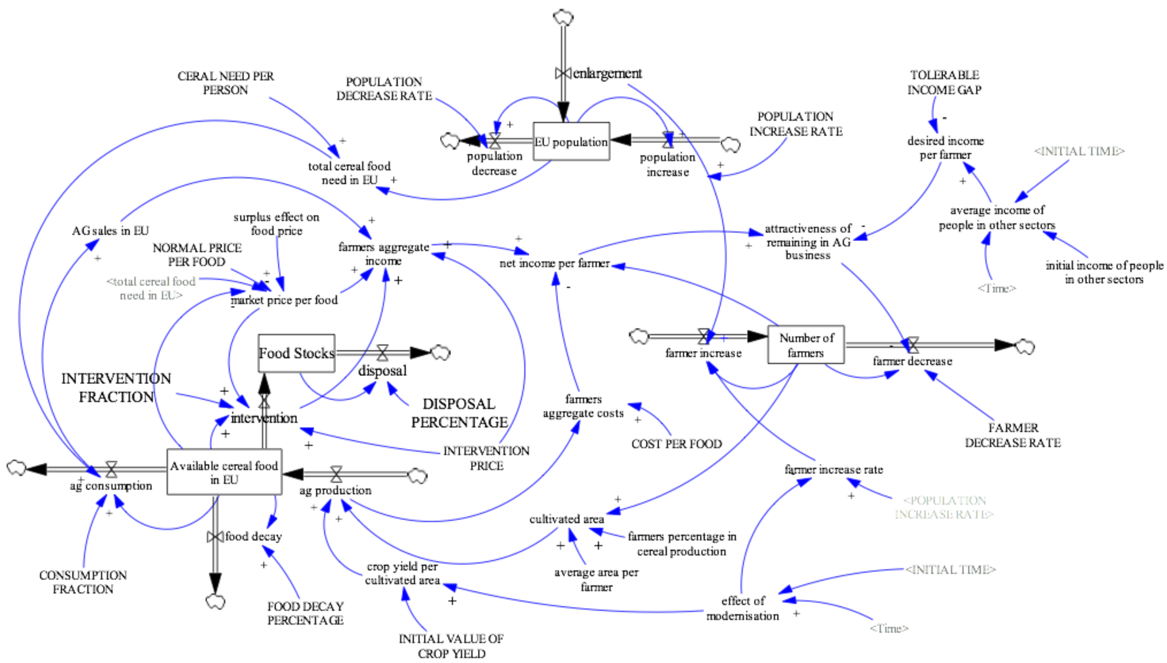


In the last run (farmers' abandonment) the number of farmers decreased during the period 1960-2000. Although the population has a net growth rate of 0.39% (EU-6 statistics during 1960-2005), the number of farmers decreased due to an increase in modernization. This is the exogenous effect. However, the more important endogenous effect is the decrease of profitability because of increased stocks of available food (excess supply) and their negative effect on food price.

5.2. Simulation Results for CAP Model

The parameters used during the simulations of the CAP Model for price supports are given in Appendix II. The simulation period is from 1960 to 1992 as CAP dynamics are constructed before the CAP reforms were established. In order to analyze the effects of CAP if there were no reforms, the model is also simulated from 1960 to 2100. SFD of the model is given in Figure 23.

Figure 23. SFD of CAP Model (Enlargement effects are included)



5.2.1. CAP Effects

Two versions of the CAP model are simulated (enlargement effects excluded Figure 24 and 25; enlargement effects included Figure 26 and 27). When comparing the versions a sudden perturbation after each enlargement can be seen. However, the general pattern of the system did not change. It seems more meaningful for EU leaders to discuss the effects of EU policies in the long run, rather than overemphasizing enlargement effects which have short-term effects. Enlargements could not generate the momentum to change the pattern of the system in the long run.

Simulation results both reproduced the successful consequences and problems of EU CAP during the 1960-1992 period. The successful consequences of CAP are increased individual earnings for labor working in agriculture (Figure 26) and ensuring availability of supplies (Figure 27). The counterintuitive effect which was not expected when EU leaders formulated the CAP is cost burden on EU budget and overproduction causing food stocks. These effects are reproduced in the CAP model as indicated in Figure 26. According to the simulation results the number of farmers has a tendency to decline, which is also congruent with the real life situation.

The only difference in the two simulation runs, is that in the first run, where enlargement effects are excluded market price of food first decreases and then increases (fixes that fail type of behavior) whereas in the second run where enlargement effects are included market price converges earlier and stabilizes in the balanced price.

When the model is simulated with the initial CAP with a wider time span the following results occur. Figure 25 and 27 show what would have happened in the following years (from 1992 to 2100) according to the SD model of CAP, if the CAP reforms of 1992 (and following reforms) had not been implemented. According to this assumption EU agricultural industry would have produced an oscillatory and chaotic type of behavior in the net income of farmers during 2023 and 2030 (Figure 25) and during 2044 (Figure 27) and then the system would have begun to collapse (abnormal increase in agricultural food prices due to unavailability of food and farmer). This result explains the correct timing of first CAP reform in 1992 when the costs of CAP and food stocks seemed to reach to peak values.

Figure 24. Simulation results for CAP effects of Price supports, Enlargement effects <u>excluded</u> (1960-1992)

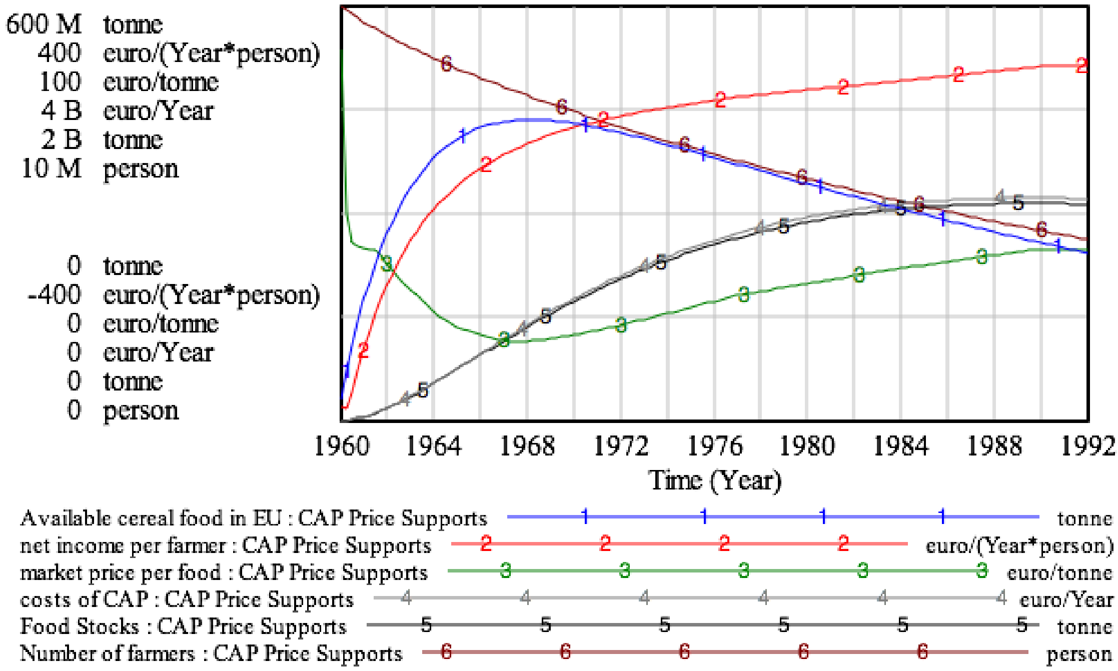


Figure 25. Simulation results for CAP in a wider time span, Enlargement effects <u>excluded</u> (1960-2100)

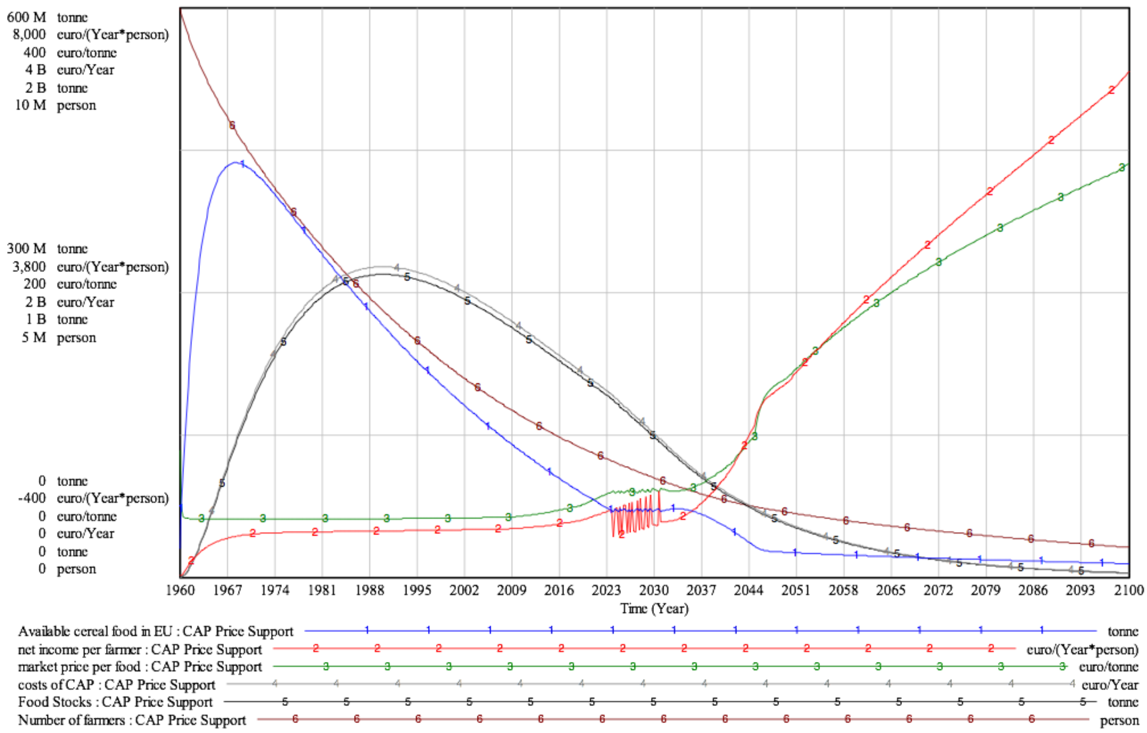


Figure 26. Simulation results for CAP effects of Price supports, Enlargement effects <u>included</u> (1960-1992)

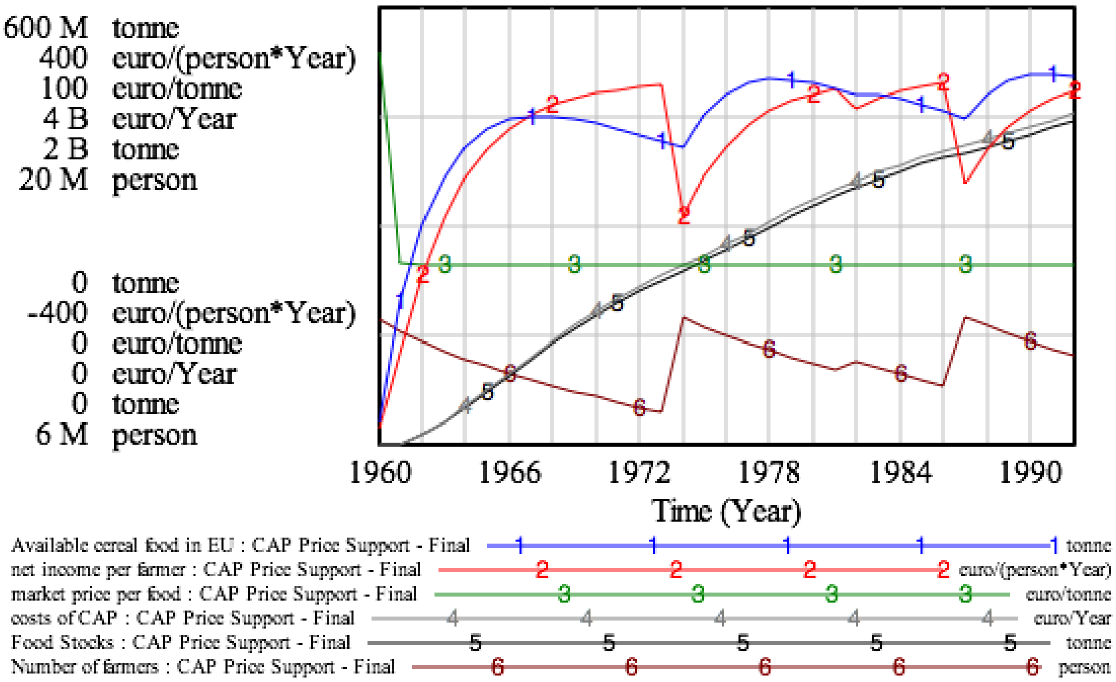
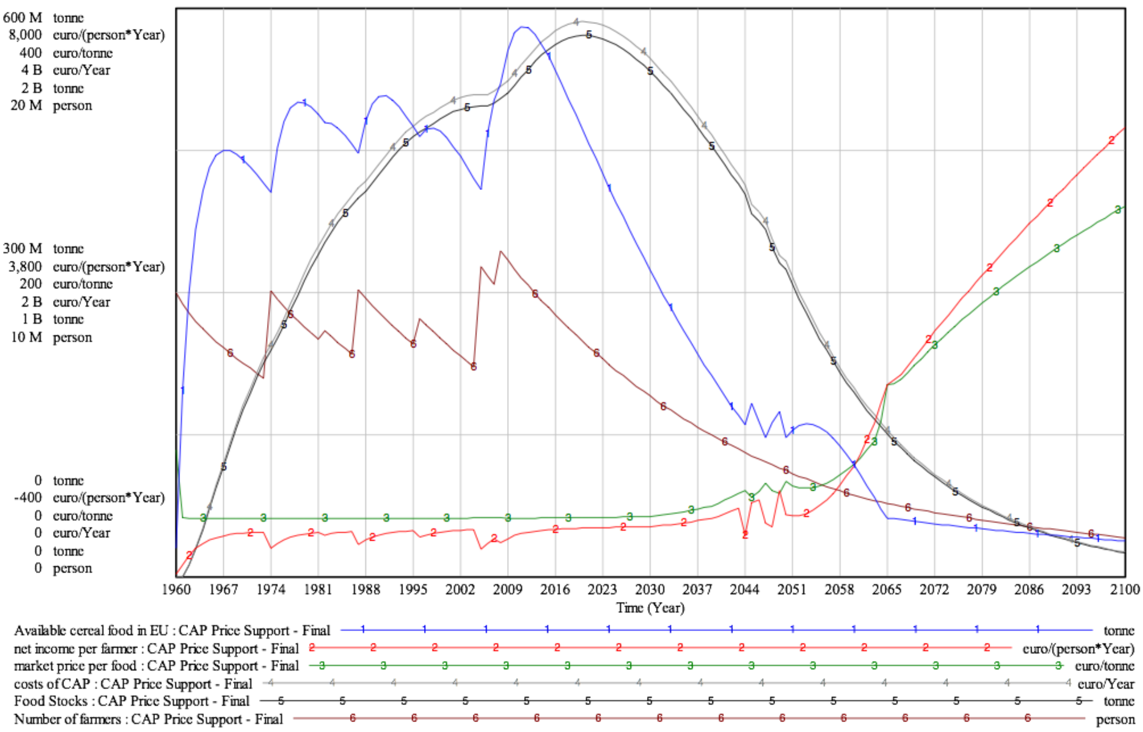


Figure 27. Simulation results for CAP in a wider time span, Enlargement effects <u>included</u> (1960-2100)



6. Discussion

Sensitivity analysis of SD is a good tool to analyze "what if" scenarios and also to create further discussions. By means of sensitivity analysis scenarios are created and time behavior graphs of variables are analyzed. Sensitivity analysis is done for four different cases of the agricultural model, moreover the effects of intervention price on food stocks were analyzed as part of the CAD model.

6.1. Agricultural Model: Effect of Tolerable Income Gap on the Number of Farmers

The value of the tolerable income gap parameter is 0.57. When the average income of people in other sectors is 100, farmers are contented when their income is more or equal to 57, and continue to farm. After running the sensitivity test by setting this parameter to change between 0.17 and 0.97 the following graph occurs:

Figure 28. Sensitivity analysis: Effect of tolerable income gap on the number of farmers

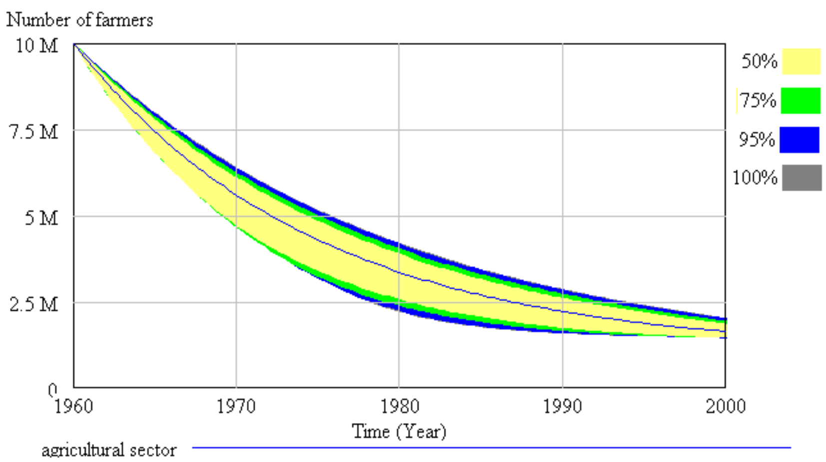
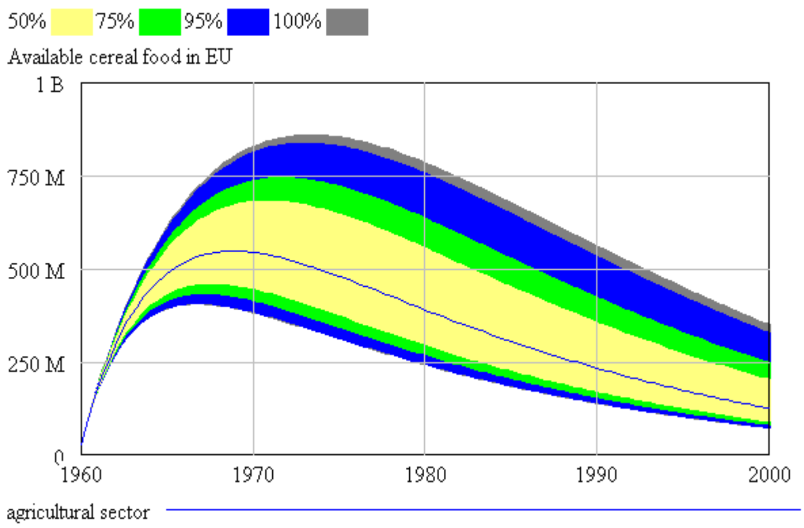


Figure 28 suggests that there is a numerical sensitivity until the end of the simulation. In 2000, the differences tend to diminish indicating a stability of the pattern. Although there is a numerical difference, in 2000, the number of farmers lies between 1.5 to 2.0 million. When the tolerable income gap decreases by 0.4 points, the number of farmers decreases from 1.64 to 1.51 million, however when the tolerable income gap increases by 0.4 points, the number of farmers increases from 1.64 to 2.02 million. The asymmetry of the system in terms of tolerable income is clearly visible. This explains why governments face difficulties when planning to reduce the number of farmers. In doing so, they need to provide attractive incentives to quit farming as farmers remain in agriculture business even if they earn much less than the average income of people in other industries. This structure also signals a warning to policymakers to consider the sudden rise in the number of farmers before defining incentives for farmers.

6.2. Agricultural Model: Effect of Food Decay Percentage on the Available Cereal Food in EU

The parameter food decay percentage is set as 0.1. After running the sensitivity test by setting this parameter to change between 0.05 to 0.15 we get the following graph. Figure 29 indicates that when the food decay percentage increases, available cereal food decreases more rapidly than it would decrease if the decay percentage was lower. This shows a numerical sensitivity and explains why EU placed a great emphasis to export subsidies in its CAP policy and why it draw the protest of other exporting countries. It seems logical, natural and purely rational to provide incentives for exports when the countries production exceeds the demand. The costs of storing, disposing and decay of food is much higher than the subsidy they provide for exports.

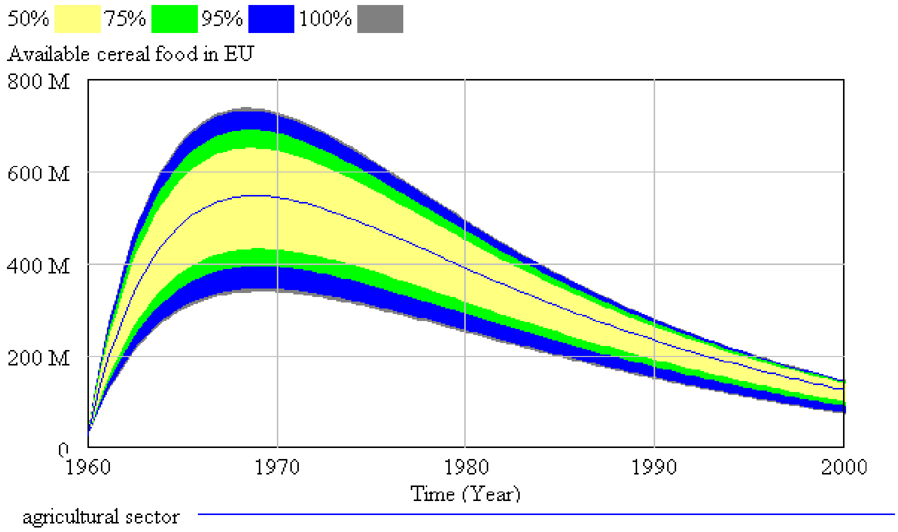
Figure 29. Sensitivity analysis: Effect of food decay percentage on the available cereal food in EU



6.3. Agricultural Model: Effect of Initial Crop Yield on the Available Cereal Food in EU

The parameter initial crop yield is set as 5.6. After running the sensitivity test by setting this parameter to change between 3.6 to 7.6 we get the Figure 30. The pattern does not change when the initial crop yield changes and the changes are symmetric as expected.

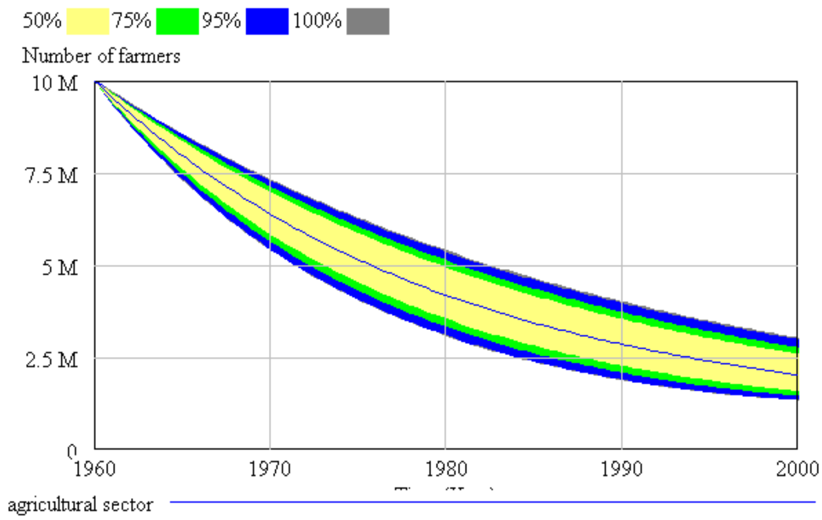
Figure 30. Sensitivity analysis: Effect of initial crop yield on the available cereal food in EU



6.4. Agricultural Model: Effect of Cost per Food on the Number of Farmers

The parameter cost per food is set as 30. After running the sensitivity test by setting this parameter to change between 10 to 50 we see the pattern shown in Figure 31. Cost per food is an important factor determining the profitability of farmers. The sensitivity analysis produced a change in a narrow band.

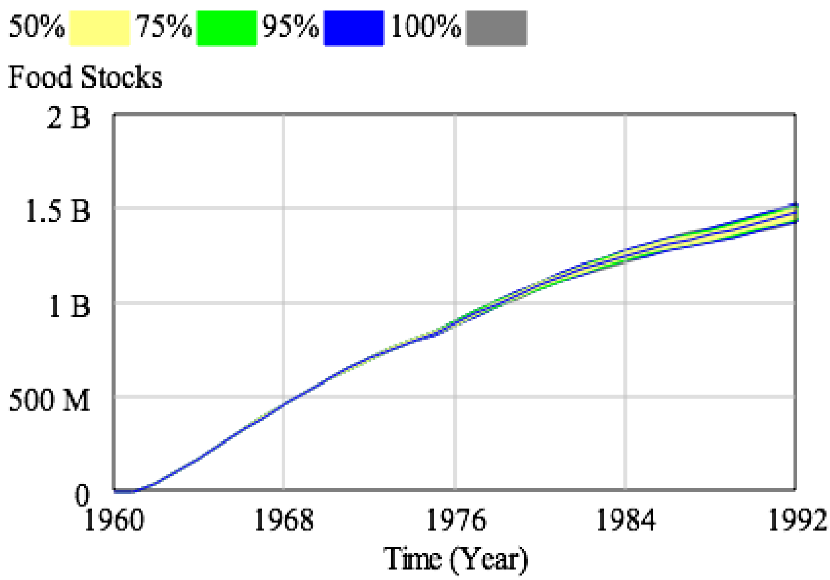
Figure 31. Sensitivity analysis: Effect of cost per food on the number of farmers



6.5. CAP Model: Effect of Intervention Price on Food Stocks

The sensitivity analysis for CAP model (enlargement effects included) is done to analyze the effect of intervention price on food stocks. It is expected that as the intervention price increases, government buys more food and the food stocks increase. As the intervention price decreases, government buys less or even no food resulting in a decline of food stocks. The sensitivity analysis is done after setting the intervention price to change between 50 and 70 and the results provided the expected behavior as seen in Figure 32.

Figure 32. Sensitivity analysis: Effect of intervention price on food stocks



7. Conclusion

The general contribution of this paper is the holistic and systematic approach taken while analyzing complex, interrelated, and dynamic issues. In this research, EU Agricultural Dynamics and Common Agricultural Policy of EU are analyzed using System Dynamic Modeling.

Simulation results of Agricultural Model indicate that agricultural dynamics justify the three initial policies of CAP. First, in the absence of government intervention, the production decreases sharply by experiencing a "growth then collapse" pattern. Thus, this fact justifies the EU's decision to provide incentives for production. Second, it is seen in sensitivity analysis that the number of farmers is not declining when their incomes are less than average income of other people in other sectors. This shows the accuracy of Mansholt's (1968) plan in which he suggested "encouragement to cease farming" in 1968. Third, when the agricultural production increases, supply exceed demand and overproduction causes surpluses. This places a great burden on the governments and justifies the export incentives offered by EU.

The two versions of CAP Model were simulated. The first model excluded the direct effects of enlargement (population and farmer increase) while the second model included effects of enlargement. Although during the enlargement period perturbations emerge, in the long run the pattern is the same. This fact indicates that the effects of EU policies on EU are more important in the long run than the short-term effects of enlargement on the agricultural sector.

As a general contribution of this study we recommend leaders to use SD in formulating strategies and policies. SD can also be used effectively as a monitoring tool for strategies. In this study we developed an SD for agricultural industry and then extended this model with CAP including EU enlargements. This method enables managers to see the future patterns, develop consistent scenarios and formulate their strategies accordingly. It enables to create the ability to act proactively and avoid major problems, at the same time, the ability to scan the environment and formulate relevant and effective strategies. When the model is appropriate and shows causal relations objectively and quantified with data, the simulation results are self-evident, and SD provides a common language as suggested by Richmond (2001).

We also recommend EU leaders to take this suggestion into consideration while formulating reforms for EU policies. Our SD results showed that problems of initial CAP could be anticipated and avoided if the model we developed in this study was used to analyze this complex issue. The models we proposed shall be examined and extended by vigorous researchers who adopt systems thinking approach and use SD methodology in analyzing complex problems in social sciences.

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Appendix I

Parameters used during the simulations of Agricultural Model

Variable	**Initial Value**
Simulation Period	1960-2000
Available cereal food in EU	30.000.000 ton
Number of farmers	10.000.000 person
cereal need per person	0.12 ton / year
EU population	193.000.000 person
initial value for average area per farmer	6.9 hectar / person
initial income of people in other sectors	2400 Euro / person
Food decay percentage	0.1 percent
Consumption	MIN(available cereal food in EU, total cereal food need in EU)
surplus effect on food price	Table loop up with [(0,0) - (10,10)], (0,5), (0.366972,2.85088), (0.795107,1.40351), (1,1), (1.55963,0.8), (2.35474,0.6), (3.08869,0.5), (4,0.45), (5,0.42), (10,0.41)
Normal price per food	100 euro per one tone of cereal
Cost per food	30 euro per one tone of cereal
Income per farmer	(farmers aggregate income-farmers aggregate costs)/number of farmers

Appendix II

Parameters used during the simulations of CAP Model

Variable	**Initial Value**
Simulation Period	1960-1992
Extended Simulation Period	1960-2100
Available cereal food in EU	30.000.000 ton
Number of farmers	10.000.000 person
cereal need per person	0.12 tone / year
EU population (initial stock value)	193.000.000 person
Enlargement	64.300.000 in 1973, 97.300.000 in 1981, 48.568.000 in 1986, 21.883.000 in 1995, 74.120.000 in 2004, 29.300.000 in 2007
initial value for average area per farmer	6.9 hectar / person
initial income of people in other sectors	2400 Euro / person
Food decay percentage	0.1 percent
Consumption	MIN(available cereal food in EU, total cereal food need in EU)
surplus effect on food price	Table loop up with [(0,0)-(10,10)],(0,5),(0.366972,2.85088),(0.795107,1.40351),(1,1),(1.55963,0.8),(2.35474,0.6),(3.08869,0.5), (4,0.45), (5,0.42), (10,0.41) (15,0.3), (18,0.2), (20,0.1)
Normal price per food	100 euro per one tone of cereal
Cost per food	30 euro per one tone of cereal
Income per farmer	(farmers aggregate income-farmers aggregate costs)/number of farmers
Disposal Percentage	0.05 percent
Intervention Price	60 euro per one tone of cereal
Intervention Fraction	0.2 percent