APPLICATION OF LINEAR PROGRAMMING MODELS FOR NATIONAL AGRICULTURAL PLANNING IN SWITZERLAND

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INTRODUCTION

"Agricultural policies are made by governments for their own people." This expression in the newest agricultural economic paper of "The Atlantic Institute for International Affairs" is true also for Switzerland. Herein is also said how difficult the international agricultural policy is. Most of these efforts until today were unsuccessful.

Unstable international food prices and difficulties of supply in many developing countries are reasons for keeping high self-sufficiency degrees of food in many small Western European countries. The governments are doing that for their own people and not for stabilizing international agricultural prices.

Switzerland as well is in such a situation. The main agricultural policy goals are to keep up a long-run reasonable high degree of self-sufficiency of food, a corresponding number of farmers and the conservation of our cultivated area in order to expand our own production in times of no import possibilities. In order to achieve these goals we need many protectionistic measures as import restrictions, guaranteed producer prices, income payments and consumer subsidies.

Such a political framework is a favorable precondition for the application of mathematical programming methods. It is possible to calculate optimal factor allocations and outputs under given restraints by the agricultural policy. The unsecurities of the international markets are more or less suppressed, so that it is possible to calculate different policy alternatives with deterministic models.

For this reason, two linear programming models were built for dealing with agricultural problems. The first model is used for the planning of our self-sufficiency in times of no import possibilities. We shall call it APN-Model, i.e. Agriculture Production and Nutrition Model. The second one is a interregional competition model for the Swiss agriculture. We use it for calculating different agricultural alternatives for the next five to ten years.

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The APN-Model

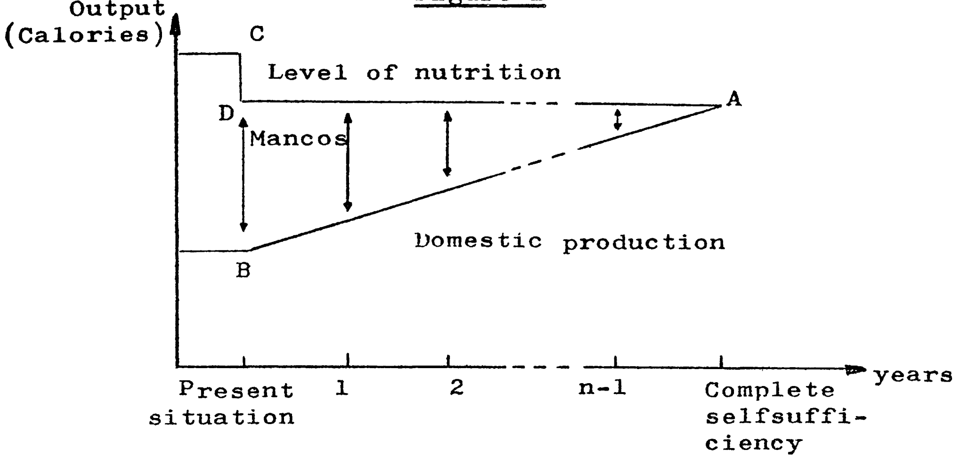
During the Second World War Switzerland was forced to expand her own food production very strongly. There was a need for rationing the distribution of food, too. These two measures made it possible to supply the Swiss population sufficiently with food. The experience of the war time led to a further production and nutrition planning in the fifties. The goal was and still is to be prepared for other shortages and crisis on the international markets.

Because of good relationship between the government administration and the university we started to study the self-sufficiency by building up a LP-Model. Since that time there was a good understanding in these affairs.

The APN-Model is based on the assumption that it can be possible that no food and agricultural inputs can be imported in our country. In contrast to the present situation, where about 60 percent of food and about 70 percent of feedgrains and all engines and fertilizers are imported it means a rather strong change in the domestic production. For calculating this change we use the APN-Model.

The comprehensive problem is explained by figure 1:

Figure 1



The problem can be divided into three steps. In the first step we ask whether and how far the Swiss agriculture after an adaption time can produce enough food for the population. This is point A in the figure 1. We get this point by solving the APN-Model by maximizing of calories. As restrictions are used diet requirements for the nutrition of the population and the technical and biological datas of our country. However, this point A has to be calculated permanently as regarding to population increases or changes of the available acreage.

After the production and nutrition level of the complete self-sufficiency (point A) is known, we ask in a second step how many years our agriculture needs for the adaptation process from the present situation (point B in figure 1) to point A. The number of years it needs depends of two items, namely of the number of hectares, which yearly can be changed from grassland to arable land and secondly of the absolute level where we are at the time of the beginning of the import stop situation (point B). The higher point B the fewer years the agriculture needs for the adaptation process for getting point A.

When the situation of the import stop begins there is a gap on food of the difference between points C and B in figure 1. This gap can be closed in two ways. First by reducing the nutritional level by immediate rationing. Point C decreases hereby to point D. Secondly the gap can be closed by stock holding. But the stocks have to be filled up before the import stop begins and have to cover the nutrition gap between point D and B.

For this first year we now use the rationing model for optimizing the distribution of the available food to the different population groups. By the given level of nutrition (point D) we minimize the costs of stocks (difference between point D and B).

In the third step we now ask for the optimal adaptation process between point B and A. The model has to be solved for so many years as are needed for achieving point A.

The most restrictive yearly change hereby is the number of hectares which yearly can be brought from grassland into arable land. For these years the model is solved by minimizing costs of stock holding.

As results one gets the optimal adaptation policy for the production, the best combination of the stocks and the yearly available rationing quotas. The cumulative amounts of the yearly stocks have to be stored in advance.

As mentioned above our country imports today not only food but also huge amounts of the very important agricultural input factors as feed-grains, fertilizers and energy. Out of this situation it is necessary to store also input factors. The amounts of inputs to be stored are derived of the results of the yearly solutions of the APN-Model. So it will be possible to pursue a harmonic adaption process by decreasing the animal herds and by increasing the arable land. It is also possible to derive the numbers of farm workers needed for executing the calculated farm work.

The results of these solutions are yearly discussed in a common meeting between university and administration representatives. This is an essential condition that our results are really used and have an important influence on the agricultural decisionmaking process.

In the just described APN model no product prices and production costs are included. This is justified because its application is thought to be in times where free market competition would be replaced by a number of governmental regulations. In contrast to APN model lies the present situation where we want to keep a minimum inland production level (point B in figure 1), but where exists free production possibilities and free consumer choice. With this situation deals the following interregional competition model.

The interregional competition model for the Swiss agriculture

The problem:

The actual Swiss agricultural protectionism causes a lot of problems. The greatest problems are the surpluses of milk, potatoes, and other products where guaranteed producer prices are paid. These products can be sold only with high subsidies. On the other side the world market prices are normally much lower than the domestic prices so that the government is paying deficiency payments for products, where we produce only a part of our consumption. This is the case for wheat, sugar and butter. The huge import of relatively cheap feedgrains causes a great meat production. These imports are made more expensive by variable import taxes. This leads to more expensive meat production. This again leads to a decreasing meat demand of the consumers and we get periodically meat surpluses, too. All measures cost a lot of money to the taxpayer and consumers. The winners of the actual governmental agricultural price policy are the bigger and well situated farmers. They are able to steadily increase their production by using more and more yield increasing inputs. The small and mountain farmers receive additional direct payments but nevertheless they earn only about 60 to 70 percent of the incomes of the bigger plain farmers.

All these single problems are connected and represent one big complex of problems. Realistic and long-run solutions can only be found if methods are used which are able to deal with this complexity. So we started several years ago to build an interregional competition model for Swiss agriculture. It was our aim to build a problem specific model which really can be used for the problems we are permanently faced with.

In the following I shall show the main features and some results of it.

The model

The method we used is based on the theoretical works of Henrichsmeyer (1) and Onigkeit (2). It is an interregional linear

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(1) Henrichsmeyer, W.: Das sektorale und regionale Gleichgewicht der landwirtschaftlichen Produktion, Hamburg und Berlin 1966.

(2) Onigkeit, D.: Zur Anwendung der mathematischen Programmierung bei der Losung interregionaler Strukturprobleme der Landwirtschaft, Zurich 1967.

programming model and is solved with the OPTIMA program. Solutions can be found by maximizing the total farm income or by minimizing the total production cost by given minimal amounts of foodstuffs.

The structure of the model has to be adapted to the reality of our country. This led to formulate eight different representative farm types for eight agricultural zones with different technical and biological conditions. For simulating a realistic economic behavior of the single farmers each farm type is based on an acreage of 20 hectares. This means that fix costs and labor forces are coordinated to this size. The corresponding zone, divided by 20 hectares is the maximal number of units of a zone.

The next higher level of the model is the region. A region has a market where products of the farm types can be sold or where they can buy farm inputs as feedgrains, heifers and others. Some inputs must be dealed on a regional basis, others can be sent to the interregional market. The formulation of a regional market allows to avoid unrealistic transports within a country.

All salable goods go to the interregional market where they are sold to the dealers for the guaranteed prices. The own produced feedstuffs and imported inputs can be bought here by each farm type. All the governmental interventions such as variable levies, quotas, deficiency payments can be brought in at this section of the model. The more detailed the formulation the more measures can specifically be analyzed.

The interregional competition model needs region and time specific datas. As technological and biological data we use so-called norms. These are not averages of today's agriculture but figures which will be averages in five to ten years. By doing so we give the model a planning time for which we want to receive results. Such datas can be found by analyzing the upper half of today's farms and by using correspondent research results. By changing this data it is always possible to change the wanted planning time.

As economical datas as prices and costs we at times choose a basic year. The changes of prices and costs then can be interpreted as relative changes corresponding to the basic year.

Some selected results

The selection of the following few results shall give answers to two questions, namely:

(a) which are the supply reactions of the Swiss agriculture to different producer price changes and direct payments and,

(b) which is the influence of different payment systems to the income distribution within the Swiss agriculture?

For answering this question the influence of the following measures are investigated:

-- An increase of all producer prices by 5 percent resp. 10 percent

-- Direct payments of SFr. 450.--per hectar

The amount of SFr. 450.-- per hectar is used because with that the agriculture as a whole gets about the same increase on income as by a price increase of 10 percent.

Because the milk and meat production has an outmost important position, we focus the following table mainly to these important products.

Table 1: Influence of price increases and direct payments to the most important products (basic year = 100)

Product	Basis year	Prices increases of 5 %	Prices increases of 10%	Acreage payment of SFr. 450/ha
Milk (excluding milk for feeding)	100	109	134	121
Meat of Calves, Beef and cows	100	116	129	118
Wheat	100	100	109	100

Table 1 shows that higher producer prices lead to a strong increase in milk production, that means to a more intensive agricultural production. But direct payments lead to an increase in milk production, too. The later increase is caused by the additional area in the mountain region which will be cultivated if acreage payments are given. If the farmers would produce the lower amount of milk, the milk surplus utilization costs could be reduced by more than the additional direct payment costs. 1/

1/ This calculation is made and published by P. Rieder: Varianten zur heutigen Milchpolitik. Agrarwirtschaftliche Studien, No. 9, ETH Zurich, 1975.

Similar differences appear for the meat and wheat production. The meat production corresponds strongly to the milk production because of our dual purpose cows. The wheat production would not increase if acreage payments are given. By going into further details we could explain the different reactions by analyzing the reactions in each of our eight zones. For the wheat production doesn't exist a great flexibility, whereby there is a much greater flexibility in the milk and meat production. Analyses of supply in the last 15 years confirm these reactions of our model. 2/ That means that the economical behavior of the Swiss agriculture does not differ much from the reaction of the representative farm types we build up in the model.

After this experience with the interregional competition model we shall describe some results which answers the second above mentioned questions, namely what influence have different agricultural policy measures on the income distribution within the Swiss agriculture.

The agricultural area of Switzerland is represented by eight farm types which differ in their natural conditions. In the practice as well as in our model exist quite great differences in incomes between the agricultural zones.

The figure 2 now illustrates the situation by using three solutions of the model.

By using the Lorenz curve in figure 2 we show that the different measures lead to great differences in the income distribution curve.

-- The lowest 20 percent of all farm types receive

1.5 percent of the whole net income in the basis solution
4.0 percent of the whole net income if prices are raised by 10 percent
10.0 percent of the whole net income if acreage payments are given

or

-- The lower half of all farm types receive

17 percent of the whole net income in the basic solution
23 percent of the whole net income if prices are raised by 10 percent
32 percent of the whole net income if acreage payments are given.

2/ P. Rieder: Angebotsreaktionen auf Preise und Flachenbeitrage in der schweizerischen Landwirtschaft. In Schweizerische Landwirtschaftl. Monatshefte, 53,325-336 (1975).

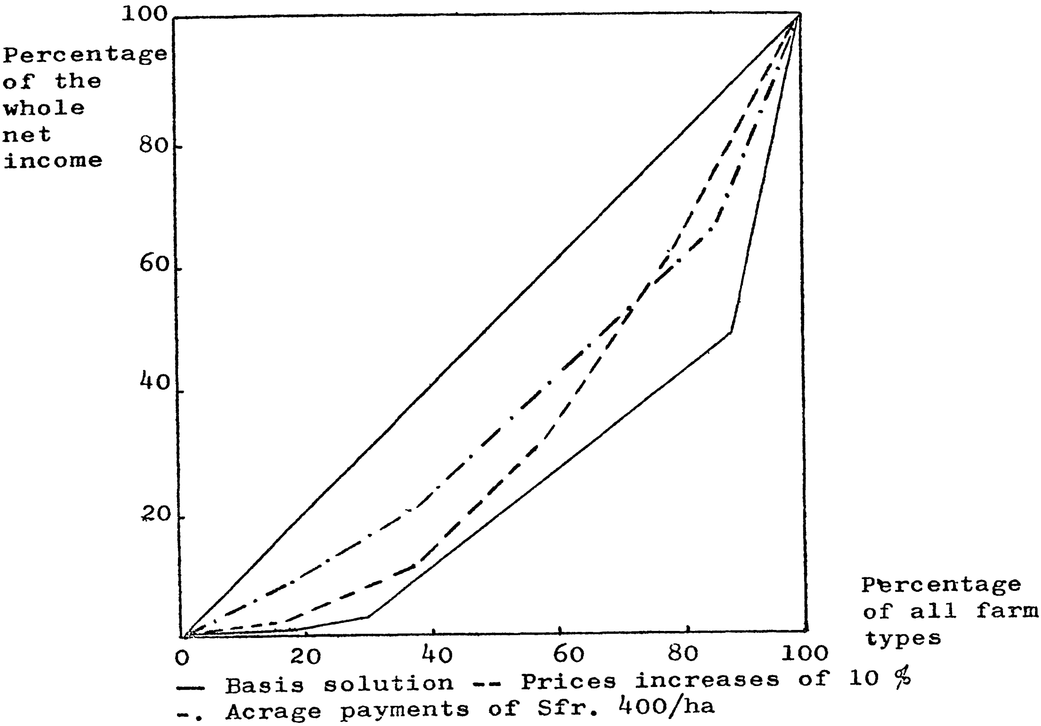

Figure 2

Few remarks should explain the differences resulting of the three solutions. The basic solution has a bad income distribution because the guaranteed prices for crops are relatively high. Farms with a high percentage of crops are in the climatic most favored zones of our country. If prices are raised by 10 percent the milk and meat production increases more than the wheat production because of its greater production flexibility. This leads to a relatively better situation of the milk and meat producing farm types in the foddercrop zones. This alternative is consequently better than the basic solution.

The alternative with acreage payments is the best one for the low income farm types in the most unfavorable zones. The payments are not proportional to the production but to the cultivated area per farm type. The lower the production the greater is the percentage of the income which the farmer gets by acreage payments. From this point of view governments should introduce direct payments.

Mathematical models and agricultural policy goals

The different agricultural interventions cause changes in agricultural supply and income distribution within the agriculture. A just income distribution is one of the policy goals. But there are other agricultural policy goals such as keeping up a minimum domestic production, minimization of the state expenses and low consumer prices for the basic foodstuffs. These goals are interdependent and part of a hierarchical goals system. On the other side there exists in the developed Western economics a number of different measures. Consequently we have a very complex goal-measure system.

For the application of models described in this paper we may draw the following conclusion:

-- Models are justified if they bring additional knowledge compared with the simpler techniques of analysis,

-- Models are justified if they are able to deal with the complexity of the reality. They must be able to treat specific problems,

-- Models should have the quality of an instrument in order to use it for different questions within the same complex goals-measures systems.

The first of our three claims is for both of our models fulfilled. Without applying computer techniques it would not be possible to solve the problems mentioned above. The second claim is fulfilled only partly in the APN model because it does not contain the corresponding costs and prices and the important interactions between agriculture in normal times and crises times. The interregional competition model on the other side deals with the problem of self-sufficiency only in a very simple and aggregate form. The food demand is calculated separately and treated as exogenous variables. The costs of stock holding are not in the model. For both models the third important claim is fulfilled in a satisfactory manner. The future efforts will be to expand the interregional competition model by introducing the neglected problems of the costs of the minimum self-sufficiency. Afterwards it should be possible to compare simultaneously the cost of today's agricultural protection with the cost of an expanded stock holding on food and input factors.

Summary

The paper contains a description of two LP models which were built in order to solve Swiss agricultural policy problems. The agricultural production and nutrition model (APN) deals with the problems which exist, if Switzerland would be curtailed of the import possibilities of foodstuff and agriculture input factors. It is a part of our emergency planning. Under such conditions our agriculture will have to be changed very strongly and the distribution of food will be done by rationing. The solution of the APN-model gives answers to the questions (a) which nutrition level we could achieve when our agriculture would maximize the calories production and how we had to organize the production, (b) how long would the adaptation time be and how big stocks we would need for the survival of our population. Results of this model are used for the policy decision process of today.

The second model is an interregional competition model. With this model we try to answer a lot of today's agricultural market and policy questions. In this paper is shown how the agriculture could react in supply to different measures such as price increases and acreage payments. Simultaneously we showed how the same measures change the income distribution within agriculture.

By evaluating our models we came to the solution that such models are useful instruments if they are formulated specifically enough for treating the complexity of the real conditions.