I FORECASTS FOR AUSTRIAN AGRICULTURE TO THE YEAR 2000

II THE FOOD AND AGRICULTURE MODEL FOR AUSTRIA

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FOREWORD

Understanding the policy options available to alleviate the food problem has been the focal point of the Food and Agriculture Program (FAP) of the International Institute for Applied Systems Analysis (IIASA) since the program began in 1977.

National agricultural systems are highly interdependent and yet major policy options exist at the national level. To explore these options, therefore, it is necessary both to develop policy models for national economies and to link them together by trade and by capital transfers. For greater realism the models in this scheme of analysis are kept descriptive rather than normative. Models of some 20 countries (where the CMEA and EC countries with common agricultural policies are counted as single units), which together account for nearly 80% of such important agricultural attributes as area, production, population, exports and imports, are linked together to constitute the basic linked system.

As a part of this system and to explore the agricultural policy options available to Austria in the context of its open economy, a policy analysis model was developed for Austria by Karl Michael Ortner of the Federal Institute of Agricultural Economics, Vienna, in collaboration with the FAP of IIASA.

In these two papers, the author presents the first version of the Food and Agriculture Model for Austria (FAMA-1), and forecasts for Austrian agriculture based on this model, respectively. These papers are English translations of articles originally published in German by Oldenbourg-Verlag, Munich, in a book consisting of two volumes entitled: *Österreich – Prognosen bis zum Jahr 2000*, and *Methoden und Modelle zu den Österreich – Prognosen bis zum Jahr 2000*, edited by Christoph Mandl (September 1982), and are reprinted with permission.

KIRIT S. PARIKH
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Food and Agriculture Program

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1 FORECASTS FOR AUSTRIAN AGRICULTURE TO THE YEAR 2000

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SUMMARY

In Austrian agriculture substantial technical progress has been achieved since World War II, and this has led to high self-sufficiency ratios for foods, decreasing relative prices for agricultural products, and increased migration of labor out of agriculture. As forecasts, three scenarios were assumed, which differ according to the level of production of agricultural goods desired by policy makers: (1) a continuation of past price trends; (2) a continuation of current self-sufficiency ratios; and (3) increased exports. It appears that developments observed in the past will continue into the future but with modifications that critically depnd on the targets of agricultural policies and the measures taken to pursue them. The results also demonstrate that the econometric policy analysis simulation model can provide valuable information and can – with some improvement – become a tool for evaluating agricultural policy alternatives and their outcomes.

1 INDICATORS OF AUSTRIAN AGRICULTURE

Within the Austrian economy agriculture plays a rather modest role, as measured by the value of its output. In 1980 agricultural output was worth 50.4 billion Austrian schillings (AS), which contributed 3.6% to the gross domestic product (GDP). Two-thirds of the value of agricultural production is made up by livestock products. Self-sufficiency ratios are usually close to 100%; it is highest for milk, and recently the ratios for grains and wine have come close to that of milk. On the other hand, with protein feeds and vegetable oils and fats, self-sufficiency ratios are particularly low, at less than 5%. These products are obtained from crops that could be grown in Austria, but at high costs.

Agricultural productivity in Austria has increased rapidly in recent decades. Improved breeding, feeding, and fertilization techniques, as well as mechanization, better education, more efficient farm sizes, production technologies, and transparent markets have contributed to this progress, and have made it possible to reduce significantly the labor input to food production. The agriculture and forestry sector employed 1 million people in 1950, but by 1980 this figure had been reduced to 298800, with increased output (for an estimate of labor employed in agriculture, see Puwein 1975).

In the past, Austrian agriculture was characterized by the fact that in most instances it was uneconomic to export agricultural products. Since domestic consumption reacts inelastically to price changes, increased output depresses farm prices, which then no longer cover (labor) costs so that some farmers decide to phase out production and look for employment elsewhere. The prices of most agricultural products have decreased in real terms and allowed Austrians to buy food more cheaply compared with other goods of the same quality and level of processing. According to a 1974 consumer survey, 26.5% of the expenditure of Austrian households was on food, compared with 34.3% ten years previously.

Despite the improvements in productivity already achieved, however, there is still considerable potential for further increases in efficiency. Bigger farms in suitable locations can produce at lower costs and at higher profit margins, but this usually leads to a disparity in incomes within the agricultural sector, which can be compensated for by off-agricultural employment. In 1979 in 62% of all farms this option was chosen; in that year for the first time the number of full-time farms (116565) was less than that of mountain farms. The average farm size was 8.3 hectares of reduced* agricultural land in 1979.

The aim of Austrian agricultural policy is to achieve self-sufficiency in food. This objective is being given high priority because of the large number of people employed in the agricultural sector, whose absorption into other sectors of the economy would entail social hardships that should be avoided as far as possible. Therefore, agricultural markets have to be protected from external shocks that might disturb the desired continuity and price levels. The most effective way of doing this is by imposing limits on exports and imports and/or on the time in which foreign trade is free. Furthermore, tariffs and levies can be imposed to make foreign produce more expensive, thus increasing the competitiveness of Austrian produce on the domestic market.

Production specifically for export is rarely successful in the agricultural sector. World market prices are more or less biased through the foreign trade regulations of various countries and vary widely because of fluctuating supplies resulting, for example, from unstable weather conditions. Only goods of high quality, to be sold through bilateral trade agreements if possible, are advisable for export production. Other goods should be offered at low prices, but these are usually a drain on the domestic economy.

*Marginal areas have been reduced by factors of up to 1:8.

2 THE FUTURE

The future of Austrian agriculture will depend on the determination and the room for action of policy makers, and the latter will be more important than the best wishes directed toward agriculture. The desire to improve agricultural incomes has increased recently with the prospect of introducing onto the market a new agricultural product – alcohol. If the government decides to ban lead additives to gas as a means of reducing atmospheric pollution, alcohol is an ideal substitute, and it can also serve as an anti-knock substance. However, it is likely that imported alcohol will be cheaper than that produced in Austria and, more importantly, crude oil is cheaper than alcohol. Thus drastic policy measures will have to be instituted to realize these hopes. Also, the hope of producing more protein feeds and oil crops seems to be unrealistic since the costs of domestic production are too high at present to be competitive with imports.

Thus the challenge for Austrian agriculture lies in exports, but will the prices of agricultural goods rise on the world market? Unfortunately, this is unlikely because developing countries import technological goods, and pay for them with exports of minerals and agricultural products. Only high-quality, processed agricultural goods can therefore be successful on international markets and fetch an adequate price. Generally, agricultural exports will only then make sense if Austria is able to decrease production costs to below those of its competitors and to increase the quality of goods for export in order to be able to charge higher prices.

3 FORECASTS FOR AGRICULTURE

From a forecast of the future of agriculture we are interested not only in the results, but also in the conditions that produce these results and in ways of influencing these conditions so that other, more desirable results evolve. In order to arrive at such forecasts, computer simulation models have been formulated and used. FAMA-1 is one such model, produced in cooperation with scientists of IIASA (Parikh and Rabar 1981). The model represents Austrian agriculture mathematically and can delineate probable paths of development.

The most important insights that can be gained from forecasts for agriculture are the development of incomes, employment, prices, regional and structural change, foreign trade, and the status of agriculture within the economy. FAMA-1, with the exception of regional and structural change, produces indicators of all the problems mentioned above, provided the conditions that accompany the development are specified thoroughly; whether a certain specification is realistic is open to subjective judgment. Thus it is advisable to run various alternatives, compare them, and in so doing to determine whether opportunities exist for agricultural policy makers to influence and control agricultural sector development. Conditions governing the calculation of forecasts in this particular study are agricultural policy targets and the way in which policy instruments are used to zero in on these targets.

The aspect now receiving most attention by agricultural policy makers is the improvement of agricultural incomes. In order to realize this, many measures can be taken, such as income transfer payments to mountain farmers, public investment into infrastructure, subsidized investment credits (see Ministry of Agriculture and Forestry), and foreign trade management aimed at raising the prices of agricultural goods.

The success of price policies is limited, however, because higher prices encourage higher production and this may lead to surpluses whose control may become too expensive for the government. However, per capita agricultural incomes can also rise through the migration of workers to jobs in other sectors. If we now wish to choose a criterion that is closely connected with agricultural policy measures taken to control domestic prices, the improvement of incomes does not seem to be a particularly good choice, since it depends too much on the size of the labor force engaged in agriculture and forestry.

Let us now consider the development of prices, which to a large extent determines levels of income. What price movements are probable? The simplest answer is clearly that prices will continue to move as they have done in the past. But relative prices change and so does the composition of agricultural production: more profitable goods will be favored by producers (e.g., industrial-commercial goods), while others will be neglected. However, there is a chance in this case that either the objective of secure food supplies or avoiding surplus production will not be met in the case of some commodities. Thus prices cannot rise in the future as they have done in the past if these aims are to be achieved. At a certain point in time price ratios must change, mainly when the self-sufficiency target of a product is critically low or in the process of reaching an upper limit. Price changes are thus the consequence of the violation of certain self-sufficiency targets, and these targets can be used to define the conditions that will govern the future development of the agricultural sector.

4 SPECIFICATION OF SCENARIOS

The scenario variants given below differ firstly in the assumed development of prices during the initial years of the forecast, and secondly in the lower and upper limits of self-sufficiency ratios accepted by agricultural policy makers and the resulting adjustments of prices. The self-sufficiency ratios themselves stay within these limits because producer prices will be changed over time such that production is guided accordingly. By imposing quotas on imports and exports it is possible, if necessary, to influence consumption and consumer prices too.

4.1 Variant S – Standard

The prices of all goods increase linearly until 1985 as they did on average from 1970 to 1980, and increase proportionally thereafter (with the comsumer price index). These prices are protected against world market fluctuations through tariffs, levies, and export subsidies. Food security and the avoidance of surpluses are defined such that the self-sufficiency ratio of an agricultural product may change from its current value by 20% at the most; these targets become fully effective in 1990 and thereafter.

4.2 Variant E – Export-Oriented Agricultural Policy

In this scenario agricultural prices gradually approach world market levels, but are higher than in variant S and thus encourage excess output. The prices of "other food" (vegetables, fruits, wine, sugar, potatoes, fats and oils, and coffee) are particularly high, in contrast with the low price of "bovine and ovine meat". Acceptable self-sufficiency ratios are then the same as in variant S, but are effective from 1985 onwards in determining price ratios.

4.3 Variant D –Domestic-Oriented Agricultural Policy

As in variant E, the relative prices of agricltural products gradually approach world market levels, and these prices favor agricultural expansion. The self-sufficiency ratios that prevailed around 1979 must again be achieved from 1985 onwards but should not exceed their current levels by more than 5 percentage points.

From a brief comparison of the three variants, the following picture emerges: In variant S there are attempts to continue previous price structures into the future through agricultural policy. In variant E prices change – contrary to observation – in favor of agriculture and exports are supported and admissible to a greater extent than in variant D. In the latter, prices change such that domestic consumption is covered by production, as has been observed, but additional exports are generally limited. Both alternatives to variant S assume high prices for "other food" (energy crops?).

5 RESULTS OF FORECASTS FOR THE YEAR 2000

5.1 Agricultural Prices

Since price policy is important in guiding agricultural production and, since price policy depends on production, the actual development of prices in the alternative variants is of primary interest. The ratio of agricultural prices to the general price level (the GDP deflator), gives an overview of that, as shown in Figure 1. In variant S, relative agricultural prices decrease until 1987, increase again until 1990, and fall slightly thereafter. The unexpected upturn in prices occurs because for some products it becomes necessary to increase prices in order to motivate farmers toward higher production to reduce the amount of imports required. Since these prices are not subsequently adjusted downwards, self-sufficiency ratios increase and the real prices of the corresponding goods have to be reduced later so that exports do not rise above the set limits.

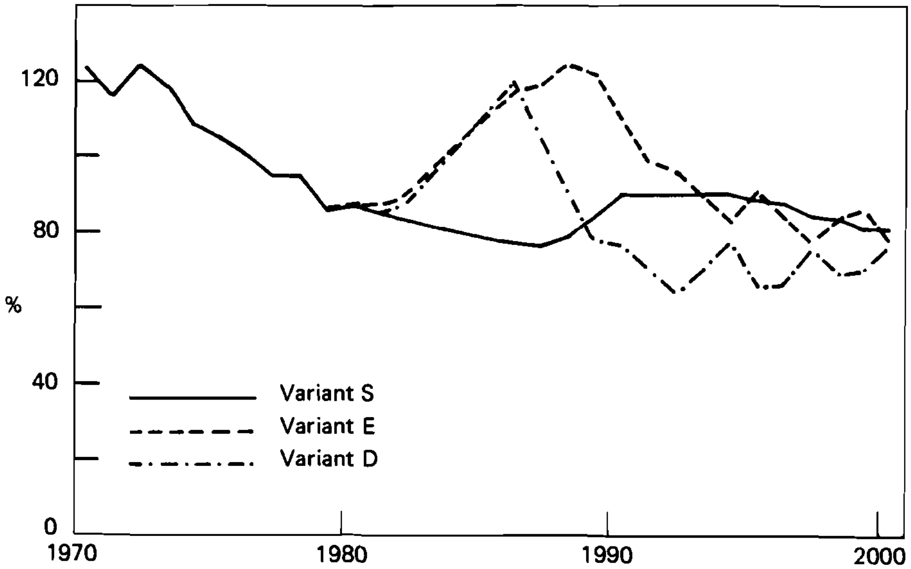

FIGURE 1 Index of agricultural prices as a percentage of the overall price index (1976 = 100).

In variants E and D agricultural prices increase rapidly in the early 1980s, partly to take advantage of the export opportunities offered in this case, and partly to secure the self-sufficiency targets of those products which, in the process of restructuring agriculture, would otherwise be neglected. Higher prices induce farmers to invest, expand livestock herds, increase production capacities, and eventually to produce so much that the upper bound for financing surpluses is reached. Exports are constrained, domestic prices fall rapidly and bring about a contraction phase. In the 1990s price movements gradually level off.

5.2 Gross Domestic Product of Agriculture

The real gross domestic product of agriculture measures the quantity of food produced. At the relatively low real prices of agricultural goods during the 1980s in variant S it is not surprising that production grows least (see Figure 2). A remarkable, smooth growth occurs only in the 1990s, during which time those prices that have been raised in the late 1980s in order to maintain domestic food supplies above critical levels come into effect.

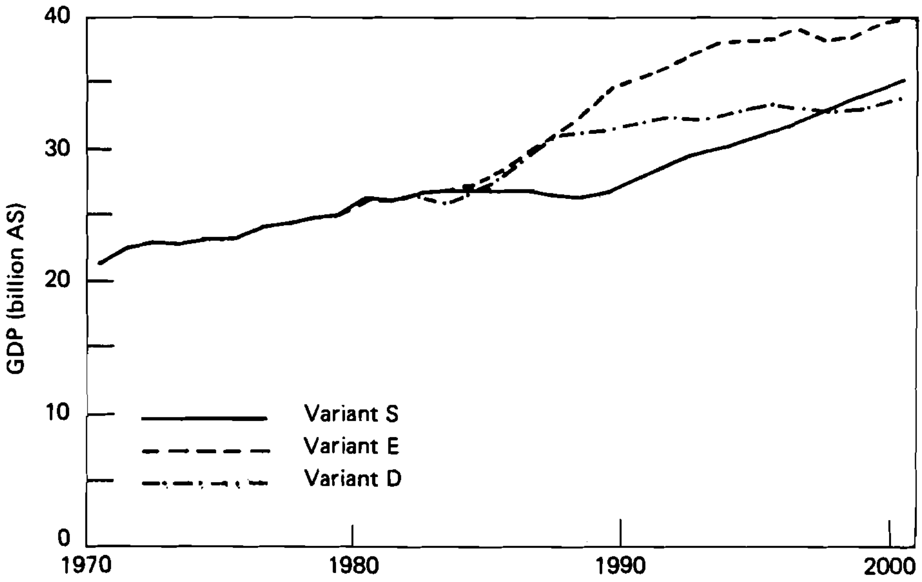

FIGURE 2 Gross domestic product of agriculture in billion Austrian schillings (1976).

In variant E the increase in production is highest. The opportunities to export dairy products and to substitute imports of "other food" are fully utilized. In variant D these opportunities are smaller because they are limited to the current self-sufficiency ratios plus 5%. Agricultural production then rises, as in variant E, but only for as long as is allowed for by the diminishing inclination of the government to finance exports.

The growth of agricultural production until the year 2000 is between 1.3 and 2.3% annually, depending on the price and trade policies then being pursued. The share of agriculture in the GDP shown in Figure 3 demonstrates once again the effects of the different agricultural policy targets in variants S, E, and D. The observed decrease of this share from 1970 to 1980 essentially disappears by the year 2000. In the variants with higher self-sufficiency ratios for agricultural products it rises to 4%, although it eventually levels out to between 1.8 and 2.6%. How closely the share of agriculture in the GDP is related to the movements of agricultural prices can be seen by comparing Figures 1 and 3.

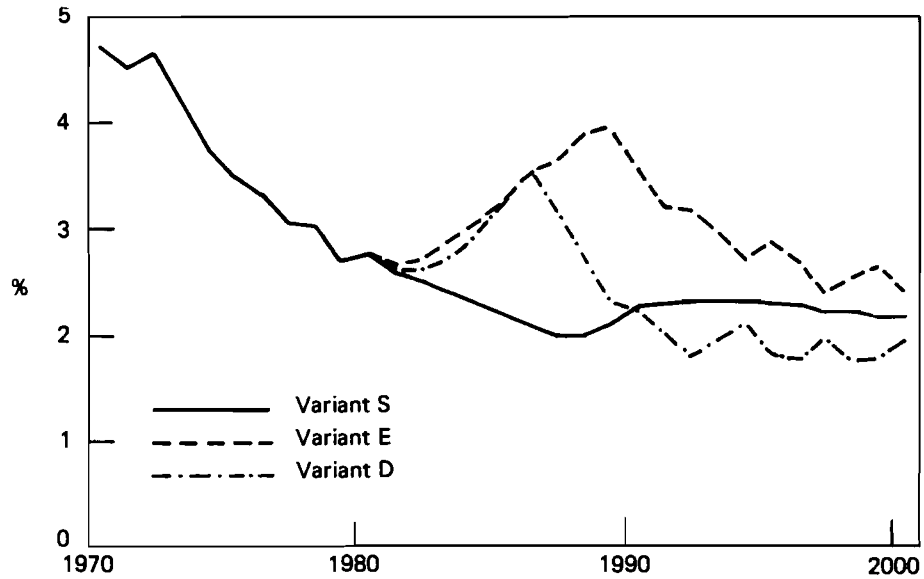

FIGURE 3 GDP of agriculture as a percentage of GDP.

In the model FAMA-1 the GDP for 1980 was overestimated by AS 13 billion (base 1976) because the recessions of 1975 and 1978 were not taken into account. Until the year 2000, the growth rate of the GDP is estimated to be 2.3% per annum in variant S. The highest growth rate is predicted in variant D, where agricultural production is constrained according to domestic demand, thus freeing labor for use in other sectors of the economy.

5.3 Employment in Agriculture

As a result of the unfavorable development of agricultural prices in variant S, labor migration out of agriculture increases dramaticaly until 1990. Only from then on do policies aimed at maintaining certain self-sufficiency targets for foods start to be effective because of rising agricultural prices in real terms and improvements in agricultural incomes. Out-migration virtually halts, and the flow even reverses slightly (see Figure 4). The minimum number of persons required in agriculture and forestry is 190000, which is approached on the same development path in the forecast of the Institute of Economic Research (Schneider 1978).

Out-migration until 1983 is high, and is virtually the same in all variants, although in variants E and D agriculture experiences massive price increases during that period. The reason is the slow economic growth at the end of the 1970s, which held back mobile labor in agriculture but was disregarded by the model. The immobility of the labor force during that period is compensated for by the model in the first years of the forecast through increased out-

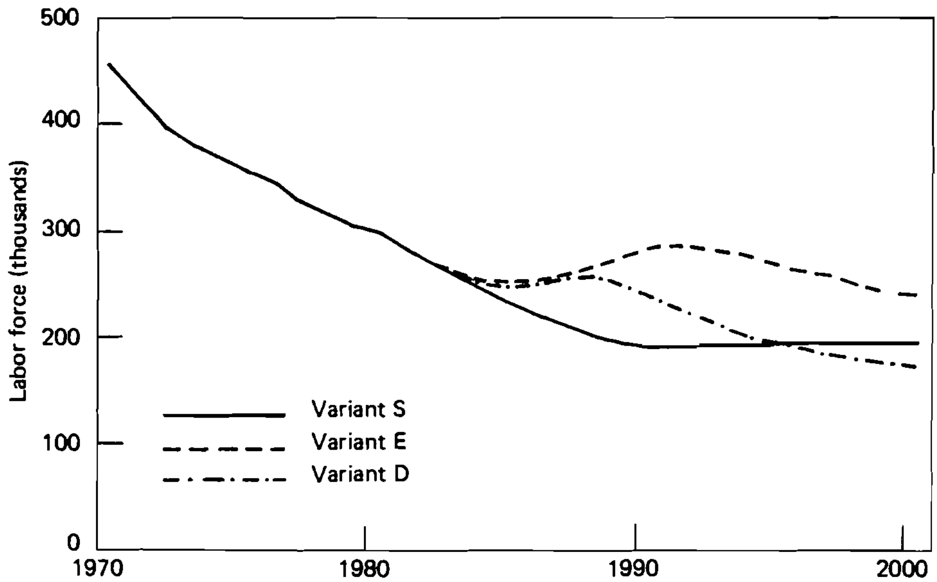

FIGURE 4 Labor employed in agriculture and forestry (in thousands).

migration. In 1986, however, that trend reverses and agriculture starts to attract more labor, which soon results in an undesirable surplus of agricultural products, the imposition of export quotas, and a severe slump in farm prices. Workers move out of agriculture, leaving only 170 000 by the year 2000 in variant D.

In variant E the favorable development of agricultural prices and the maximal utilization of the world market for the export of dairy goods, pork, and grains, accompanied by high production of "other food" (fruits, wine, sugar, etc.) have a serious effect on employment. Only after 1990 are additional food supplies not exported any more, and thus have a depressing effect on domestic prices so that the number employed in agriculture and forestry decreases to 240 000 by the year 2000. The production of these workers is so high that only protein crops and beef do not reach the upper admissible limits of self-sufficiency ratios.

5.4 Coarse Grains

The model results on the individual sectors of agriculture are certainly interesting, but are not reported here in full for reasons of space and clarity. However, one example will be described: the sector of coarse grains (excluding wheat and rice), i.e., barley, rye, oats, mixed grains, and corn, was chosen because it is the most important crop sector in Austria.

Wheat is excluded because it is treated as a separate sector in the model and is subject to stricter controls by the grains marketing board. The forecasts for wheat eventually turn out to be little different from those for coarse grains, which are mainly used for livestock feed. The prices of these grains determine profitability, feed consumption, total domestic consumption, the self-sufficiency ratio, and even foreign trade policy because export quotas are determined as a function of domestic consumption. The model results account for all these effects and it is therefore difficult to find simple explanations for the changes that occur from year to year.

Let us first look at the development of real prices, as illustrated in Figure 5. Up to 1985 variant S prices follow earlier trends, but in 1986 production increases unexpectedly, and further decreases in real prices become necessary in order to constrain exports to desired levels. By 1989 that has been accomplished and prices remain constant in real terms. Livestock production increases, feed consumption goes up, coarse grain output rises to meet the demand, and in 1996 reaches a level at which exports are so high that downward adjustments in real prices have to be made in order to discourage further increases in coarse grain production. The corresponding development of production is displayed in Figure 6.

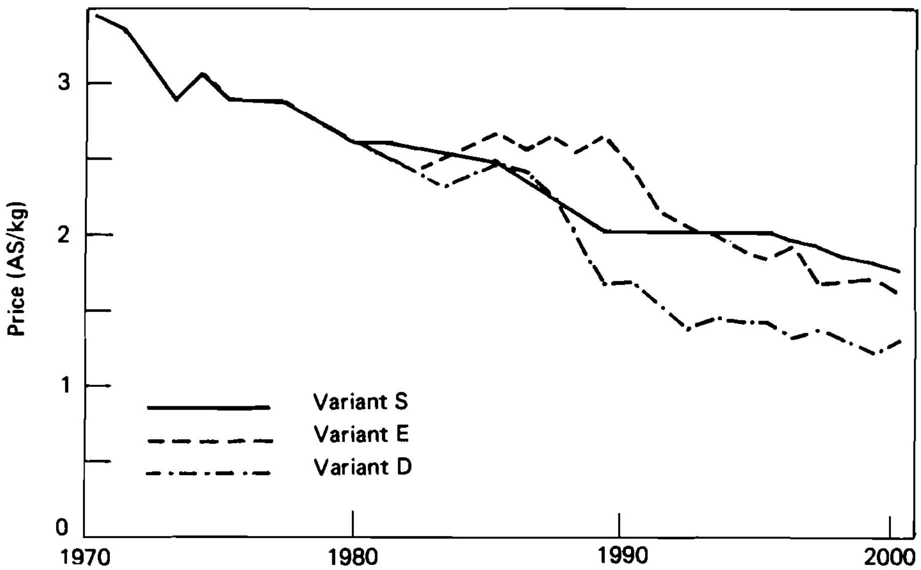

FIGURE 5 Real producer prices of coarse grains in AS/kg (base year 1976).

In variant E real prices increase until 1985 and then fluctuate at about the same level while production expands. In order to halt further production increases and to re-establish competitiveness with wheat, grain prices have to fall steeply in real terms in the following years. In the 1990s in variant E exports continue at about 900 000 tonnes per annum, while in variant D 250 000 tonnes is the admissible maximum. That not only depresses the real price of

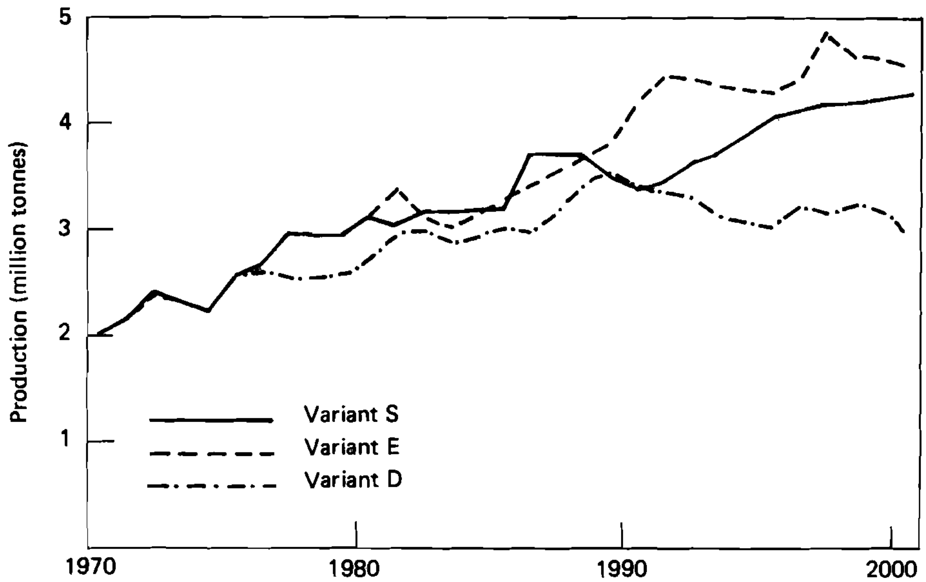

FIGURE 6 Production of coarse grains.

grain but also those of all other agricultural goods, mainly because livestock feed becomes cheaper. Out-migration from agriculture increases and farmers invest less in their businesses. In variant D structural change occurs until 1993 and agriculture is carried on much less intensively. In the year 2000 coarse grain production is 4.3 million tonnes, whereas in variant E it is 6.3 million tonnes (on almost the same agricultural area). The higher production costs in variant E are of course only acceptable at higher prices for products.

5.5 Other Agricultural Products

If prices of agricultural products lag as far behind those of other goods and services as they do in variant S it is not surprising that agricultural production stagnates or even falls. The highest falls occur in the categories bovine and ovine meat, milk, and "other food", whereas grains and "other meat and eggs" production increases. The drop in milk output is remarkable because it is not the consequence of individual farm quotas (introduced in 1978), but of the price policy assumed in this scenario. In the late 1980s agricultural prices have to rise, with the effect that production increases steadily after 1987 without reaching the upper limits of admissible exports. The upper limits of self-sufficiency ratios are only reached by grains and "other meat".

In the export-oriented variant E the real prices of "other food" increase until 1989, to almost double those in variant S. For that reason the production of "other food" is expanded by some 50% until 1990. Since these products are labor- and capital-intensive many persons and investment goods are employed at the expense of the production of other agricultural commodities. To maintain their competitiveness, the price of this "other food" therefore also has to be raised in both variants E and D during the 1980s.

Prices are changed in order to ensure that the self-sufficiency ratio of a commodity group stays within admissible limits. The price of "other food" in variant E increases toward world market levels only until 1989, when self-sufficiency ratios approach the admissible maximum, as shown in Figure 7. In variant D this happens earier and in variant S even the lower limit is violated and is only reached again in 1990, as required in that scenario.

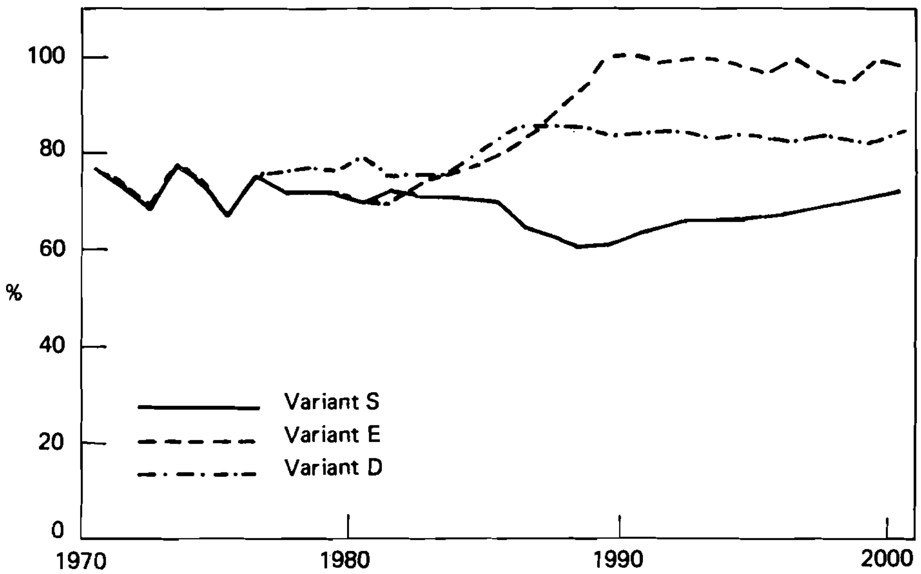

FIGURE 7 Self-sufficiency ratios of "other food".

In the period of high prices during the 1980s the agricultural sector expands and in variant E the upper limits of self-sufficiency are not met only by the commodities "bovine and ovine meat" and protein crops. For bovine and ovine meat the target prices are particularly low. In variant D self-sufficiency ratios are constrained within narrow ranges and sometimes even fluctuate between them. Otherwise, the trends follow closely those of variant E except that the process of expansion is followed by a contraction at an earlier point in time and the contraction is more radical.

6 SUMMARY AND CONCLUSIONS

The results of the model runs are clearly somewhat different from what one would ideally wish and expect from forecasts. Agricultural development in the alternative scenarios vary widely, particularly during the years 1980–90. The standard and the other two variants differ from one another substantially. Only in the 1990s does a somewhat parallel development occur among all variants after agriculture has adjusted to the new economic conditions.

Obviously the conditions assumed in the alterative scenarios are important: agricultural policy is one aspect of these conditions; the position of domestic agriculture in relation to foreign countries is another. Both are interconnected, for just the political determination to set up an export-oriented agricultural system is not sufficient. There must also be support from the farmers to supply products cheaply so that they are competitive on foreign markets. The dilemma is that at low domestic prices the agricultural sector shrinks and produces less that can be exported, and at high prices the competiveness that is so urgently needed for exports disappears.

The art of agricultural policy making, keeping overall economic efficiency in mind, is to find a way out of this dilemma, and that way is greatly determined by the development of world market prices. This is shown by variants E and D, particularly in the 1980s, when agriculture deviates from its previously quite smooth development, when prices are favorable and exports financed by the government. However, one has to ask whether such radical changes such as, for instance, the increases in consumer food prices (see Figure 1) would be readily accepted. That is improbable, and the agricultural sector is unlikely to have to face the price rises and slumps forecast by variants E and D for the 1980s. Nonetheless, it is reasonable to assume that these variants delimit the range of conditions within which agriculture will operate during the 1990s.

In addition, the variant S forecast for the 1990s is not completely realistic. Agricultural prices fall too far, for to long a time, too many people migrate from employment in agriculture too quickly, and the original agricultural policy has to be suspended eventually. But since, once changed, prices remain at a higher level, there is a phase when agriculture starts to expand from the lower to the upper limits of self-sufficiency. In reality, this expansion would be controlled in an attempt to regulate production according to domestic consumption, as is done in variant D. The future development of agriculture is thus likely to be between variants S and D: in the 1980s closer to variant S, and in the 1990s closer to variant D. Variant E should be considered as an upper limit of that development begun in variant D towards production for export, but stopped early.

This study has shown that the future of Austrian agriculture depends crucially on the conditions that evolve around the rest of the domestic economy and foreign trade. Furthermore, agricultural policy will guide its development to a large extent by deciding on domestic supply targets, and on the measures that should be taken to attain these targets. However, these policy decisions are also subject to the prevailing conditions and thus policy makers only participate in an overall development that is hard to predict if one wishes to take interdependencies into account. The forecasts of this report to a considerable degree do just that, and are thus useful in providing further insights into the funtioning of the Austrian economic system. However, better insights and more accurate forecasts and prescriptions are only possible if the task of shedding light on the complexities of the agricultural sector through mathematical abstraction is continued and intensified. This may then lead to a model that can be used to help analyze present and pressing agricultural policy problems.

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II THE FOOD AND AGRICULTURE MODEL FOR AUSTRIA

Karl Michael Ortner

SUMMARY

The Food and Agriculture Program of IIASA is analyzing the world food situation and the problems encountered. In order to make it possible to evaluate the outcomes of particular policies, dynamically recursive econometric models for the economies of individual countries and country groups have been developed and linked together by the imposition of general equilibrium conditions. Among these efforts a first version of the Food and Agriculture Model for Austria (FAMA-1) was set up and is described in this paper. It distinguishes nine agricultural commodities and the rest of the economy, and is used to simulate economic development over a medium-term time horizon. Exogenous to the model are policy targets and decisions, in particular prices and foreign trade quotas.

1 INTRODUCTION

The simulation model for Austrian agriculture presented here evolved from the Food and Agriculture Program (FAP) of IIASA. The aims of the FAP are (Parikh and Rabar 1981, Rabar, 1981, Ortner, 1981).

- to evaluate the world food situation and its dimensions;
- to identify the causes of problems in it; and
- to analyze and suggest policy actions towards their solution.

The world food problem is a problem of individual countries, and the policy actions for its solution are decided upon at the national level. World market conditions influence these actions, and the actions of individual countries in turn influence the world markets. It follows that a global model is necessary for an analysis of how the world food problem can be disposed of, and that national governments are the actors in this model and decide upon measures to be taken.

The global model of the FAP consists of a linkage algorithm and national models that have certain common features: a descriptive type of model; a common commodity classification at the international exchange level; annual time increments; a dynamically recursive linkage of supply and demand; a time horizon of 15–20 years, and linear homogeneity in prices. These features have been incorporated in order to ensure that national models can be linked and so that a general equilibrium can be attained in all national and international commodity markets.

A national model is supposed in particular to serve as a tool in the process of arriving at economic policy decisions by showing

- how domestic economic development depends on events that occur in foreign countries;
- what results can be expected from various proposed or implemented economic policy measures;
- to what extent political instruments are consistent with the targets towards which they are directed; and
- which policy measures are necessary or advisable in order to avoid undesirable developments and to bring about desired ones.

The work of producing national models was partly carried out by researchers at IIASA and partly delegated to national collaborating institutions. At IIASA a databank was set up with the support of the FAO, essentially covering the food balances of most countries, and this was used to set up models for the so-called basic linked system (BLS). The BLS is the first version of a global model representing roughly 80% of the world's population, agricultural production, and foreign trade by individual national models.

In order to come up with the BLS in a short time, the models for a set of countries organized as market economies were constructed using a common scheme. The data for their construction are available at IIASA and were supplemented with data from national and international statistical sources. In this way the model of the Austrian economy presented here evolved as part of the work devoted to the development of the BLS. Of those persons who contributed significantly to the Austrian model I should like to acknowledge Fischer and Frohberg (1980) who undertook many of the tasks of estimating, programming, conceptualizing, and formulating the model. The original concept of the study was outlined by De Haen (1978).

The work on the food and agriculture model for Austria (FAMA) is still in its early stages. We intend to produce a model that depicts the agricultural economy in as much detail as possible, its relations to other sectors of the economy, and its dependence on the prevalent economic structure and agricultural policy. In particular, we hope that the model will be used by the Austrian Federal Ministry of Agriculture and Forestry as a means of simulating and forecasting the effects of alternative agricultural policy measures and to help ensure that decisions towards the realization of agricultural policy targets can be taken with more confidence.

Since the cost of producing models increases exponentially as they become more complex, various intermediate versions of FAMA can be developed. One of these is presented here and applied in order to generate discussion, give critical advice a chance to influence the model, and possibly to encourage the involvement of other interested parties. At the same time, we wish to demonstrate – with currently rather confined means – the types of uses we anticipate for the model. In any case the reader is asked to keep in mind that the version presented here is that of May 1981 and does not exploit all possibilities since offered by the algorithm (FAMA-1).

2 MODEL STRUCTURE

Generally speaking, FAMA consists of a supply component, a demand component, and a policy component. The latter defines the conditions that guide production and demand over time and which are determined by policy measures and decisions. The connection between supply and demand is not simultaneous but recursive, i.e., production takes place before goods are traded. When domestic supply enters the market, quantities are fixed, and the prices determine domestic demand and foreign trade. At this point agricultural policies are crucial.

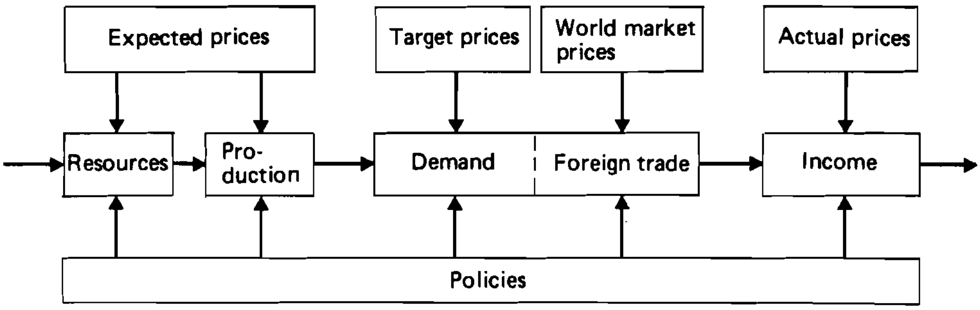

FIGURE 1 Structure of the model FAMA.

Figure 1 depicts the model structure in somewhat more detail and also reveals the series of decisions taken by producers, consumers, and the government that set the agricultural system in motion. We start at the point when the economic agents in the various sectors have earned some income, which pays for their contribution of factors of production and thus provides some indication of how these factors should be allocated in the future. Further indicators are the prices that are expected to prevail for products and factors of production, which depend on the economic performance of the previous period. The input supply component specifies, according to actual wages, the quantities of individual factors that will be employed in the various economic sectors during the current period. The factor allocation model specifies the uses of factors of production in the production of various goods within an economic sector. Factor allocation is governed by expected prices and technology and determines, at given production functions and possibly within politically decreed constraints, the quantities of various commodities that will be produced in a sector. The intermediate inputs required per unit of production are of course accounted for in the allocation decision. Finally, the supply component calculates in the form of domestically produced goods the endowments of actors available for exchange on the market.

In addition to the endowments of economic actors there are their demands for goods and services. These demands are primarily determined by the prices of final goods and by the incomes of consumers. The latter vary according to the economic sector in which they are employed. Demand can be met partly by domestic and partly by foreign products, but foreign trade is subject to certain conditions with which the public sector has to comply. Differing prices on domestic and foreign markets are possible only if there are trade restrictions, levies, tariffs, or export subsidies, and foreign trade has to close with a certain balance.

The results of running the exchange component of the model are domestic prices and net trade quantities (exports minus imports) of the various commodity aggregates. In addition, the financial drain on the national budget by the corresponding export subsidies (minus import revenues) is determined. Since production prices and external drains on the national budget are known, it is then possible to calculate the GDP and the incomes of economic agents.

A national model can be run independently of the global model; the only requirement is that world market prices are given exogenously and do not depend on specific national decisions. Austria is hardly likely to influence world market prices through its trade policy, so this precondition can reasonably be assumed to hold. Thus simulation runs for the Austrian economy can be made for any kind of scenarios concerning the world market without having to apply the global model.

The public sector is able to influence and control economic development at any level: at the level of factor supply through the management of interest rates and the willingness to save; at the factor allocation level through credit policies and supply quotas; and at the demand level through fiscal and foreign trade policies. These are only some of the most important measures and indicate those areas in which alternative policy instruments primarily operate.

With these instruments the course of the economy is guided towards the overall social optimum for the population, and our interest concentrates on analyzing the effects of certain measures. These measures, or the rules according to which policy instruments are set, are thus more or less exogenous to the model and provide the background against which the model simulates economic development in a particular application.

In the following sections I present the components of the FAMA-I used to calculate the results reported in the preceding paper. Some of these components have not yet passed the entire validation stage of model building and will be replaced by better ones as time allows and know-how and data become available. I thus deliberately abstain from critical comments and rather just present the approach chosen for discussion.

3 COMMODITY CLASSIFICATION

FAMA-1 differentiates seven primary products, 20 intermediate goods, and ten final (consumer) goods, as listed in Table 1. Data on area harvested yield per hectare, production, imports, changes in stocks, exports, feed, seed, industrial consumption, and waste, were obtained from the FAO on magnetic tape. They covered the years 1961–76 and some 500 agricultural products, classified according to the Standard International Commodity Classification (SITC). These products were aggregated into some 250 goods and further to the commodity groups listed, using content coefficients or average world market prices in the years 1969–71 as weights.

Domestic producer prices were taken from *Paritätsspiegel* and exclude value-added tax. The prices of consumer goods are obtained from these prices by the addition of the value of nonagricultural services that transform the raw product to the consumer good.

TABLE 1 Commodity classification in the food and agriculture model FAMA.

Unit	Aggregate	Y^a	Q^b	X^c
1000 t	Wheat	1	1	1
	Rice	(2)	2	2
	Coarse grains	3	3	3
PE[d]	Ruminant protein	7	17	
1000 t	Bovine and ovine meat		4	4
	Milk		5	5
PE[d]	Other meat, eggs and fish	8	6	6
	Protein feed			7
	Protein crops	4	7	
	Meat meal		13	
	Fish meal		14	
Million US$ (1970)	Other food		8	8
	Nonoil[e]	5	19	
FE[f]	Oils and fats		20	
	oils of Q_7		18	
	fats of Q_4		11	
	fats of Q_6		12	
Million US$ (1970)	Nonfood agriculture			9
	Industrial crops (hops, tobacco)	6	9	
	Wool and hides of ruminants		15	
	Hides of other animals		16	
	Nonagricultural goods and services	10	10	10

[a] At production level.
[b] Products and byproducts.
[c] At trade level.
[d] Protein equivalent = 1000 t crude protein.
[e] Sugar, potatoes, fruits, vegetables, wine, beverages.
[f] Fat equivalent = 1000 t pure fat.

4 RESOURCE SUPPLY

In the following equations, capital letters designate time series variables, and other characters represent parameters estimated econometrically or otherwise. Superscripts relate to commodity groups (see Table 1) and subscripts are used to differentiate goods or economic sectors. Variables without subscripts depict in this case the sum over subscripted variables; however, in definitions they represent any one of them. A post- and subscript -1 indicates a variable relating to the previous year.

In the first round of decisions taken by producers three variable factors of production can be identifed: human labor, capital stock, and fertilizer utilized. The size of the labor force is given by

$$L = b\ POP$$

$$b = b(T),$$

where

L = number of persons employed and self-employed
POP = population (exogenous)
b = participation rate of the population in employment
T = time trend.

The labor force is divided into two sectors, agriculture (A) and nonagriculture (N, the rest of the economy), depending on the capacity of agriculture to release or absorb labor:

$$L_A = 1.177(V_A / V_N)^{0.177}(L_A)_{-1}$$

$$L_N = L - L_A$$

$$V = G / L$$

where

L_A = labor force in agriculture
L_N = labor force in nonagriculture
V = value of gross production per person employed
G = gross domestic product.

Capital stock in the two sectors is calculated from initial capital, gross investment (which is split between the sectors), and depreciation rates:

$$\overline{I} = 0.312(\overline{G} + \overline{B})_{-1} + 0.207(\overline{G}_{-1} - \overline{G}_{-2}) - 13.222$$

$$\overline{I} = I / D,$$

where

I = gross investment
D = GDP deflator (Divisia index)
$-$ = sign for real values (base year 1970)
B = balance of trade.

$$\overline{I}_A = 0.579(D_A / D_N)_{-1}^{0.595}(\overline{V}_A / \overline{V}_N)^{0.586}\overline{I}$$
$$\overline{I}_N = \overline{I} - \overline{I}_A$$
$$\overline{K}_A = (\overline{K}_A)_{-1}(1-k_A)+\overline{I}_A$$
$$\overline{K}_N = (\overline{K}_N)_{-1}(1-k_N)+\overline{I}_N,$$

where

$\overline{K}$ = capital stock
k = depreciation rate of capital.

The application of fertilizer depends on its real price and on the previous year's production of crops:

$$M = c_1(\overline{G}_C / \overline{P}_M)_{-1}^{0.725}$$
$$\overline{P}_M = c_2\overline{P}_N$$
$$c = c(T)$$

where

M = (nitrogen) mineral fertilizer comsumption
$\overline{G}_C$ = real value of crop production
$\overline{P}_M$ = real price of fertilizer
$\overline{P}_N$ = real price of the nonagricultural (the nth) goods
c = proportionality coefficients.

5 PRODUCTION

5.1 Production of Agricultural Goods

The decision rule of agricultural producers is assumed to be the principle of profit maximization. The factors of production in agriculture will be allocated to the various commodities such that the value of goods will be as high as possible. The measure for this value is the expected net revenue of goods to be produced. In addition, the production decision is governed by technical factors (the technology), which can be represented by linear or neoclassical production functions. The advantage of the latter is that they allow for continuous substitution between factors of production and thus need far fewer parameters to represent technology. The amount of data would even suffice for statistical estimation of these parameters.

Unfortunately, for the allocation of factors of production to individual agricultural sectors no historical data exist, so if we still wish to produce an econometric model, both the allocation and the parameters of the production functions have to be determined simultaneously. This creates considerable methodological problems, but they can be solved through the development of an appropriate iterative estimation procedure. Agricultural technology is represented by a system of particular Cobb–Douglas production functions, which incorporate the property that returns to scale diminish if the distribution of factors of production to the various goods changes. The production function for the agricultural sector as a whole is linearly homogeneous. The available factors are diverted for the production of goods according to an objective function with expected net returns. A naive price expectation scheme is assumed.

Agricultural producers maximize with a given technology the following objective function:

$$z = \sum_{i=1}^{3} P_i^y Y_i + (P_4^y + b_{18,7} P_{18}^q) Y_4 + P_5^y Y_5 + P_6^y Y_6$$

$$+ \left[P_7^y + \sum_{j \in J} b_{j,7} P_j^q - \sum_{k \in K} a_{k,7} P_k^q \right] Y_7 + \left[P_8^y + \sum_{m \in M} b_{m,8} P_m^q - \sum_{k \in K} a_{k,8} P_k^q \right] Y_8$$

where

J = (11, 13, 15)

M = (12, 14, 16)

K = (1, 2, 3, 5, 7, 8, 13, 14)

a = $a(P_K^q, T)$

P^y, P^q = expected prices (for explanation of superscripts see Table 1)

$a_{i,j}$ = feed requirements of commodity Q_i per unit of production of commodity Y_j (see Section 2)

$b_{i,j}$ = quantity of commodity Q_i produced per unit of production of commodity Y_j (byproduct i of j)

J, M = set of indices of Q designating byproducts of bovine and ovine meat, and other animals, respectively

K = set of indices of Q designating commodities that are partly used as feeds.

The expected prices of the disaggregated products and byproducts depend on the prices of traded goods in the previous year through the use of fixed-value shares of particular goods, namely protein feeds, "oils and fats", and "other food". The prices of "oils and fats" and "rest of other food" stay in constant proportion. A time dependence of these shares, proportionality coefficients, feed requirements, and byproduct coefficients was only allowed for in the reference period 1961–76. The prices of feeds (P_K) are slightly lower than their market prices in order to account for quality deficiencies and the lack of marketing costs.

Maximization of the objective function is subject to the technical and organizational level attained in the agricultural sector, which is represented in the model by a system of nonlinear equations. The system is linearly homogeneous for the agricultural sector as a whole and has diminishing returns to scale for individual commodities as their share in the factors of production increases. Substitution between factors is possible and is characterized by an elasticity of substitution of unity. Technical progress is represented in the following production functions through time-dependent production elasticities (ε, μ) (embodied technical progress):

$$Y_i = c_{i1}(K_A)^{\varepsilon_i}(L_A)^{\mu_i}(M)^{1-\varepsilon_i-\mu_i}\left[\frac{K_i}{K_A}\right]^{\beta_i}\left[\frac{L_i}{L_A}\right]^{\gamma_i}\left[\frac{M_i}{M}\right]^{\delta_i} + u_i$$

$$\sum_i K_i = K_A \, , \ \sum_i L_i = L_A \, , \ \sum_i M_i = M$$

$$\varepsilon_i = (1 + e^{c_{i2}T})c_{i3}c_{i4}$$

$$\mu_i 0 = c_{i4} - (1 + e^{c_{i2}T})$$

where

c_i = constant
K_i = capital used in the production of commodity i
L_i = labor used in the production of commodity i
M_i = fertilizer used in the production of commodity i
u_i = stochastic disturbance.

In the production functions for meat (Y_7 and Y_8) the variables concerning fertilizer are disregarded. Fertilizer used for meadows and pastures is determined before simultaneous allocation of the remaining fertilizer on the basis of expected production of bovine and ovine protein. Since the distribution of factors to the various production activities has not been observed, the estimation of production function parameters starts at the most probable allocation of factors, judging from normative experience. That allocation in all years of the reference period satisfies the condition

$$\sum_i R_i \leq R \quad \text{for} \quad R = \left\{K_A, L_A, M\right\}.$$

The objective of the estimation of parameters representing technology is the minimization of

$$\varphi = \sum_T \sum_i \left\{(\hat{Y}_i - Y_i)/Y_i\right\}^2 + \sum_R w_r \sum_T \sum_i \left\{(\hat{R}_i - R_i)/R_i\right\}^2$$

$$(T = 1962, \cdots, 1976)$$

where w_r (= 0.1) is a weighting factor for resource R (capital, labor, fertilizer). The estimation is made through an iterative procedure, beginning with assumed initial estimates for the parameters and by trying to minimize φ (by changing the parameters) assuming that the disturbance term is independently normally distributed. A program for nonlinear least-squares estimation developed by Günther Fischer (IIASA) was used. This allows for simultaneous estimation of the parameters of any system of equations at inequality constraints for the domain of parameters. The estimates of parameters of the production functions were subject to the following inequality constraints:

$$0.5 \leq \beta_i + \gamma_i + \delta_i \leq 0.95.$$

Additional constraints, i.e., that some parameters have to be greater than zero or less than or equal to one, follow from the Cobb–Douglas specification. Since the estimation leads to either a local or a global minimum of φ, the constraints for the parameter estimates are important. In order to downgrade their importance, an additional parameter was added to the system of equations, namely a constant ρ by which the parameters β, γ, and δ of the production functions are multiplied. Furthermore, ρ serves as an exponent of the expected net revenues in the objective function and, since it was estimated at 0.784, decreases the price elasticity of production. The scale elasticity of the sector (the sum of the exponents of K_A, L_A and M) remains unchanged at unity.

5.2 Feed Requirements

Feed requirements of the two livestock categories are covered by feed commodities Q from the index set K. Considering that some substitution between feeds is possible, the following allocation rule was assumed: Farmers minimize feed costs Z_l subject to the conditon that Y_l units of livestock commodity $l(l = 7,8)$ can be produced:

$$Z_l = \sum_{k \in K} P_k^q F_k\, l$$

$$Y_l = f_l \prod_{k \in K} (F_{kl})^{f_{kl}}$$

$$\sum_{k \in K} f_{kl} = 1$$

$$f_l = f_l(T) \qquad a_{k,l} = F_{kl} / Y_l$$

where

P_k^q = expected price of feed k
F_{kl} = use of feed k by livestock l
f_{kl} = production elasticity of feed k for livestock l.

The feed requirement coefficients a_{kl} are the solutions to this minimization problem and are needed and used in the objective function of agricultural producers (see Section 5.1).

5.3 Nonagricultural Production

Technology is represented by a linearly homogeneous Cobb–Douglas production function with changing factor shares. Nonagricultural production is thus:

$$Y_{10} = 60.7(K_N)^{\varepsilon_N}(L_N)^{1-\varepsilon_N}$$

$$\varepsilon_N = 0.378/\,(1 + e^{-0.147T}).$$

6 COMMODITY SUPPLY

Not all primary products are available for trade because parts of them may be consumed as feeds, inputs to nonagricultural production, and used as intermediate inputs in the production of agricultural commodities. Seed and waste are accounted for by defining production as the amount in excess of these uses.

Feed consumption relates to the vector of goods Q, which is calculated from production goods via fixed or time-dependent byproduct coefficients (b). From livestock production and feed requirement coefficients per animal (a), one obtains feed consumption, which is later also reported at the final (trade) commodity aggregation level.

At the final commodity level we can directly determine the industrial use ("other utilization") of agricultural commodities. This is done with coefficients, g, that define the real value of industrial consumption relative to the real value of nonagricultural production:

$$g_i = \frac{\bar{P}_i^T O_i}{\bar{P}_N Y_N} \qquad \text{for } i = (1, \cdots, 9),$$

where

O_i = other utilization of commodity i
$\bar{P}_i^T$ = producer price (raw product) of commodity i in 1970 (at trade level).

For nonagricultural goods consumed in the agricultural sector (excluding fertilizers) there is a similar ratio with respect to the real value of agricultural production net of feed costs:

$$g_N = \frac{\bar{P}_N O_N}{\sum_{i=1}^{9} \bar{P}_i^T Y_i^x} - \frac{\bar{P}_M M}{\bar{P}_N}$$

where

O_N = consumption of nonagricultural inputs by agriculture (excluding fertilizers)
$\bar{P}_i^T$ = price of commodity i in 1970
Y_i^x = net production of commodity i (excluding feed, seed, and waste).

Endowments of the agricultural sector are at the outset produced commodities (excluding seed and waste). They will be used as feeds, industrial inputs, and goods for human consumption, and the quantity of the latter depends on prices realized and foreign trade. When prices have been realized at the supply and demand intersection, the agricultural GDP can be calculated from the value of agricultural production less the value of feed and intermediate consumption, which the cost of fertilizer is calculated separately.

The nonagricultural sector is endowed with goods produced by it, including some agricultural goods (other utilization). Its contribution to the GDP consists of the value of production minus the value of raw products taken from agriculture.

The total supply of goods in the economy is defined as the total production, including goods used during production (industrial consumption of agricultural products and inputs to agriculture), feed consumption, and excluding seed and waste. Feed consumption and intermediately consumed products are added to supply and human consumer demand, so that supply can never be negative. That is required by the algorithm to calculate domestic and international equilibrium prices, and also ensures that the quantities used for feeding livestock are considered marketable and thus influence market prices.

7 TRADE

7.1 The Demand System

The demand for consumer goods is determined in two steps. The first step distributes consumer expenditure between food and other commodities. A linear expenditure system with habit formation is used for this purpose:

$$A_l = P_l C_l + d_l \sum_{j=A}^{N} (A_j - P_j C_j) \quad \text{for } l = \{A, N\}$$

$$P_l C_l = d_{0l} + d_{1l}(A_l)_{-1}$$

$$A_A + A_N = \sum_i P_i^x X_i$$

where

A	=	consumer expenditure
C	=	price-independent consumption
P_l	=	price index for food and nonfood expenditure
d	=	constant
P^x	=	consumer price (at retail level)
X	=	human consumption (demand).

The price elasticity of food expenditure is estimated to be −0.125 (in 1962) and −0.204 (in 1976), and income elasticity increases from an estimated 0.283 to 0.479. The elasticities of expenditure on nonagricultural goods are close to (absolute) unity.

When consumer expenditures on agricultural and other goods are known, the former can be distributed among food commodities. For that purpose, we now determine the preliminary demand for each good as a function of its price and food expenditure, or solely as a function of real food expenditure. Logarithmic, semilogarithmic, and log-inverse functions were estimated, and the one with best fit and most plausible elasticity estimates was chosen.

Actual demand deviates from the estimate because a desired calorie consumption, which depends on real consumer expenditure, is calculated and considered. Actual demand is determined through minimization of weighted sums-of-squares of deviations between estimated and actual demand for goods and calories, subject to budget constraints. The idea of this demand system was introduced by G. Fischer (IIASA) and was estimated by him using a non-linear least-squares estimator and 1961–76 data.

7.2 Foreign Trade

The demand system proposed above determines consumer demand at given expenditure levels from the prices of goods. Yet in the context of the whole model, consumer expenditure is not at all exogenous but is connected with consumer incomes through the relation:

$$\sum_i P_i^x X_i = \sum_i P_i^x Y_i^x + E + B,$$

where E = tariff receipts. This relation says that the expenditure on consumer goods must be covered by revenues from domestically produced and supplied goods, the balance of trade deficit, and tariff receipts. The latter accrue as the difference between revenues from levies (or tariffs) and outlays for export subsidies, both of which help to protect domestic prices against world market price levels:

$$E = \sum_i (P_i^x - P_i^w)(Y_i^x - X_i),$$

where P^w is the world market price (in national currency).

The balance of trade deficit depends on demand and world market prices by definition, given that domestic supply has already been determined (and fixed):

$$B = \sum_i P_i^w (X_i - Y_i^x).$$

The equilibrium exchange condition between revenue and expenditure set out above can thus also take the form:

$$\sum_i P_i^w X_i = \sum_i P_i^w Y_i^x + B$$

$$\sum_i P_i^x X_i = \Phi \sum_i P_i^x Y_i^x + B.$$

The difference between the values of demanded and supplied goods, at world market prices, is given by the balance of trade (surplus or deficit). At domestic prices, the two values differ by the factor Φ, which reveals that the government earns revenues or spends money as it approaches the trade equilibrium at B. In the current version of the model it is assumed that the government modifies taxation in such a way that a certain exogenously given trade balance will be realized. Such (positive or negative) taxes include only those that serve to balance the exchange condition.

The government aims not only at a certain trade balance, but also at a certain degree of self-sufficiency in food products, which it only partly achieves with the help of tariffs and export subsidies. Other instruments include import and export quotas and stockholding activities (market intervention). Only the former are considered in model FAMA-1. Food self-sufficiency targets are supplied to the model via upper bounds on export and import levels.

One of the most important policy instruments in the model are prices. It is assumed that the political decision process leads to clear-cut decisions about the ratios in which prices of the various commodities should stand in relation to each other. The government tries to reach these desired prices by applying the usual foreign trade policy instruments of tariffs and levies. Only if the self-sufficiency targets cannot be met by these means, the effect of trade quotas will be that realized prices will differ from those desired. The algorithm computing general equilibrium iterates on taxes (and possibly on certain prices) until demand meets the condition(s) of the balance of trade deficit (and foreign trade quotas) (see Keyzer 1980).

7.3 Raw Materials and Final Products

The demand for food commodities can be interpreted as the sum of the demand for agricultural raw materials and the demand for processing and marketing services contained in the final products:

$$X_i = X_i^r + m_i X_N.$$

where

$X i$ = final (retail) commodity
$X_i r$ = raw (farm gate) commodity i
m_i = processing and marketing profit margin per unit of final commodity i.

The processing and marketing margin can be calculated from the difference between retail and producer prices. Retail prices were determined from data on consumer expenditure for various products as reported by the 1974 consumer survey by the Austrian Statistical Office. The corresponding consumption of raw materials was evaluated at producer prices and taken from food balance data; m defines the relation between producer and retail prices in physical terms, and is assumed to be constant over time.

8 POLICY MEASURES AND SIMULATION RUNS

The simulation runs of the model vary according to the assumptions concerning policy measures or the criteria upon which the management of policy instruments depend. Decisive instruments in the model are prices and foreign trade quotas, and the two are closely interrelated because desired prices on the domestic market can only be realized if the corresponding imports or exports can take place. Domestic price policy affects both demand and production and thus the self-sufficiency ratios of the various commodities.

Apart from price policy, the other policy instruments available in the model are of secondary significance. At the level of factor supply one could, for instance, think of different capacity utilization of capital stock, different participation rates of the population in employment, or an increase in the price of fertilizers following an energy price rise. At the production level the government could announce higher prices or price subsidies, or could introduce some kind of production quota. Furthermore, weather variables could be used to disturb production.

Desired retail prices certainly depend on the income distribution between agriculture and the rest of the economy and on the levels of exports, which are determined by world market prices. An income distribution policy would influence the income situation in the two sectors, but not total demand. The latter could only be increased in the short term by a balance of trade deficit. Influencing the propensity to invest and the mobility of labor are policy instruments that could also be used.

Since the database that supported the estimation of model parameters ended in 1976, the model starts after that year to turn out *ex post* forecasts and, beginning in 1981, *ex ante* forecasts. The *ex post* forecasting period is supported by supplying producer prices, gross investments, the labor force in agriculture and forestry, and fertilizer use exogenously to the model rather than using the forecast values.

World market prices are available only up to 1980, and assumptions concerning their future movements are part of the definition of scenarios for simulation runs.

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