Welfare Economic Implications of Agricultural Biomass Production for Energy and Forest Products in the European Community

- Model Design for On Farm and Sector Level Evaluation -

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Preface

In 1983, Directorate-General VI of the Commission of the European Community initiated an agricultural research programme on "Energy in Agriculture". A working group was established dealing with the general theme "Macroeconomic Aspects of Biomass and Energy". This group has been composed of research staff from:

- Institut National de la Recherche Agronomique
  Station d'Economie de Grignon
  F-78850 Thiverval-Grignon
- Centre National du Machinisme Agricole du Génie Rural
  des Eaux et des Forêts
  F-92164 Antony Cedex
- Faculté des Sciences Économiques et Sociales
  Université Notre-Dame de la Paix
  B-5000 Namur
- Institute of Farm Economics
  Federal Agricultural Research Centre
  D-3000 Braunschweig

The Institute of Farm Economics took over the task to design models allowing welfare economic considerations on farm and sector level of the production of biomass from agricultural land for energy and forest products. Main emphasize concentrated on multiperiod model building to incorporate anticipated changes in the technical and economical environment favouring or hampering biomass production within the Common Agricultural Policy of the European Community.

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Contents

Tables

page

1. Introduction

In the 1960's and 1970's world wide economic development was rapid because of abundant energy availability from fossil fuel sources which required only modest production costs. The anticipated declining supply of fossil fuel has motivated research and political institutions to reinforce research activities in the field of renewable resources, with prospects that agriculture should become an energy producer and a supplier of raw materials for industrial utilization (Buchholz, 1987). The concern of agricultural policy in renewable resources has mainly been caused by the increasing surplus in traditional food production within the existing common agricultural policy (CAP) of the European Community (EC). In this regard, agricultural pressure groups demand still from the political-administrative system technological and institutional innovations favouring supply and demand of renewable resources supplied from the agricultural sector (LAB, 1989). Innovations are expected to stabilize or to increase producers' rents allowing the application of CAP market intervention instruments as well for non food products for raw material supply. In addition, those innovations will create pay-offs for different social groups (de Janvry, 1978, p. 301) participating actively in agricultural food and non food markets, in energy markets and in the provision of equipment for conversion of renewable resources.

This study deals with model building for economic evaluation of anticipated technical and institutional innovations for renewable resources on micro and macro level. The renewable resources considered are supposed to substitute fossil energy- and wood imports. The evaluation is done by applying within a multiperiod framework principles of dynamic welfare economics (Just, Hueth and Schmitz, 1982). The main purpose of the empirical applications is to show whether the production of renewable resources for energy substitution and the production of forest products could alleviate agricultural income-, surplus problems and financial constraints of the EC agricultural support policy. The economic analysis provides means of quantifying the effects of alternative production strategies for food products and for biomass, of different CAP support measures and of different technological production options. The evaluation of welfare economics of different production and agricultural support options requires knowledge about the opportunity costs of production factors and public financial support budget allocations. In a market economy designed. This allows the analysis of institutional change and of technical progress (yield increasing or cost saving) on the supply of renewable resources (ethanol, rapeseed oil or forest products), on the internal agricultural price for wheat within the EC, on the prices for renewable resources drawn from different feedstocks, on the distribution of an EC-support budget on export subsidies and on price supports for renewable resources. Furthermore, the effects of technical progress and institutional change on producers' and consumers' rent and the support budget are determined within the framework of a (discounted) multiperiod cost-benefit-analysis.

The study proceeds in the following stages and provides (1) a brief introduction towards the sectoral assessment of renewable resources including a summary of studies carried out in the Federal Republic of Germany, (2) a description of the supply and demand system for innovations in the field of renewable resources (3) projections about world market prices for agricultural-, forest products, and energy required for the evaluation, (4) microeconomic assessment of short rotation forestry in crop and dairy farms, (5) a summary of anticipated technical progress for renewable resources for energy substitution and (6) the presentation of a sectoral multiperiod simulation model for the macroeconomic evaluation of anticipated technological innovations and institutional change. Within the simulation model it is presumed that land resources are partly utilized for the production of energy substitutes either reducing fossil fuel imports or increasing wood supply. The model is applied on EC-level. The time horizon considered is 15 production periods.

With regard to agricultural policy main concern is given towards an alternative policy for the grain market of the EC. Pressure groups favouring biomass production with agricultural resources suggest that the support of biomass would reduce public support burden of CAP-grain policy, without reducing producers' income. Whether this will be true under anticipated world market conditions will be analyzed on micro and macro level.

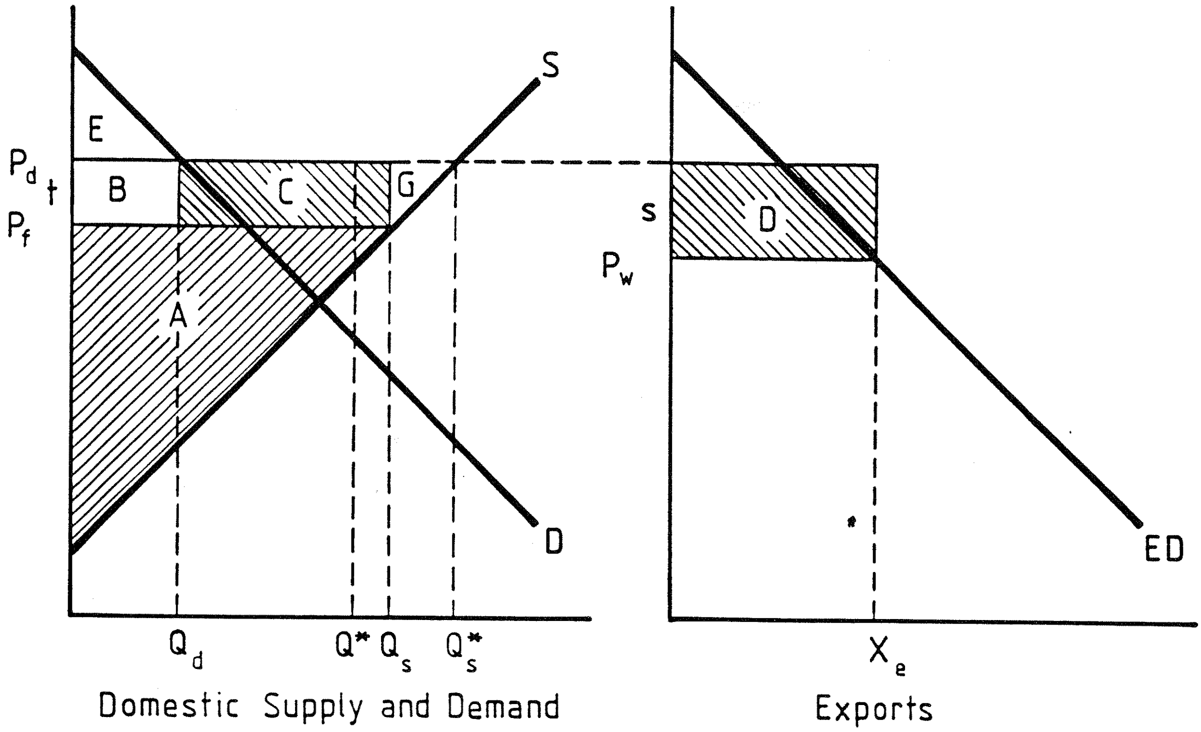


Figure 2.1 Price formation and trade with coresponsibility levy

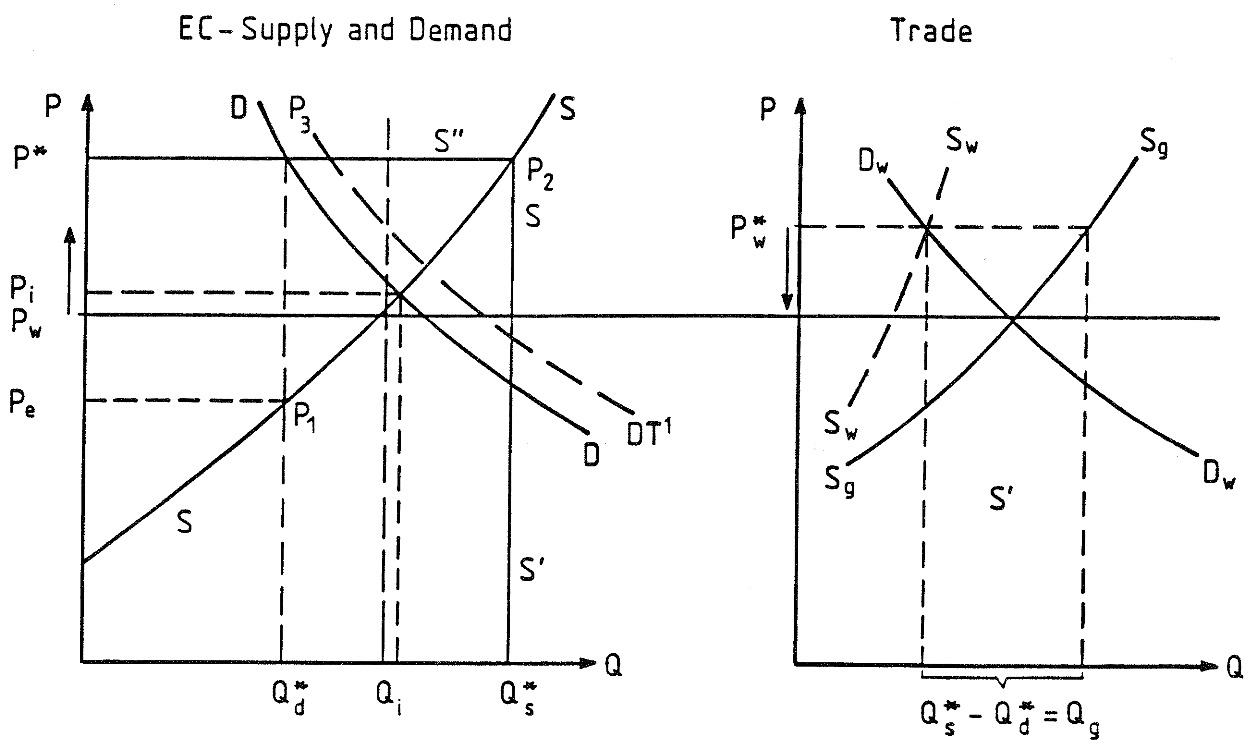


Figure 2.2 Comparative statics of EC-grain market policy interventions

2.2 Static welfare economics of prices support measures

In this chapter we will briefly describe the welfare economics of price support policies and the impact of deficiency payment in the comparative static context (Tolley, Thomas and Wong, 1982, pp 140). Market price support with interventions and export restitutions are the classical instruments of EC-grain policy. Producers within the EC receive not only the world market prices but the higher domestic target price. Assuming that simple constant elasticity supply functions and demand functions exist and that government is purchasing surplus Q_g than we can express percentage changes of supply EQ_s and of demand changes EQ_d as follows (Gardner, 1987, pp 39).

(2.1) $EQ_s = \varepsilon\ EP$ supply changes

(2.2) $EQ_d = \eta\ EP + EQ_g$ demand changes

and $EQ_s = EQ_d$

where ε is the supply price and η the demand price elasticity and EP are price changes. From (2.1) and (2.2) the relation between price changes and government interventions can be obtained:

(2.3) $$\frac{EP}{EQ_g} = \frac{1}{\varepsilon - \eta} \quad \text{or} \quad EQ_g = (\varepsilon - \eta)\ EP$$

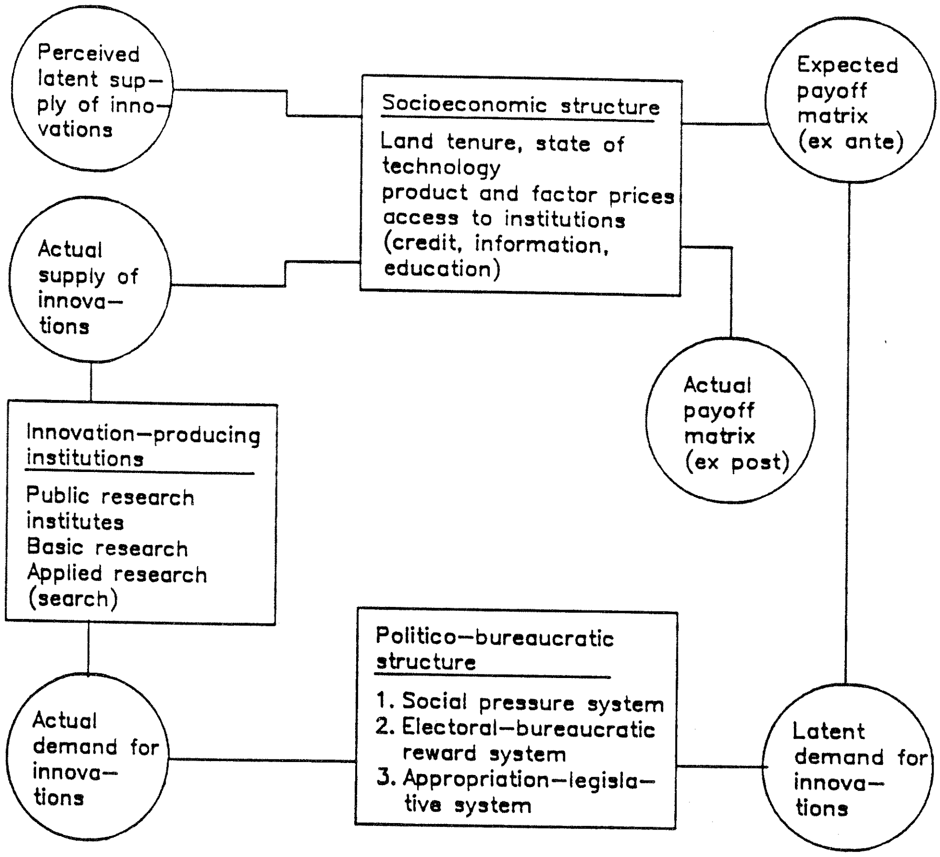
Under EC-grain policy, domestic target prices have been the main policy instrument. Considering the fact that $(\varepsilon - \eta)$ is always positive incremental price increases augment government intervention purchases EQ_g.
This fact can be simply correlated with table 2.1 where figures about the EC support budget are given. Having no possibility to sell the government intervention quantity Q_g within the EC, Q_g has been offered on the world market granting export subsidies.

The comparative statics of EC grain market policy are given in figure 2.2. Without intervention the EC farmers are supposed to produce the quantity Q_i and receive the equilibrium price P_i. Consumer rent would be equal the area under the demand curve DD and above the price P_i. If the domestic target price is fixed to be P*, supply increases from Q_i to Q^*_s, demand declines from Q_i to Q^*_d. Depending on the shape of the supply and demand curve producer rent increases and consumer rent declines. The difference between Q^*_s and Q^*_d equals Q_g and is offered on the world market. Government intervention cost are $(Q^*_s - Q^*_d) \cdot (P^* - P_w)$. Supposing that without EC trade world trade supply curve is S_wS_w, EC-trade shifts this curve to the right depending on the amount of Q_g to S_gS_g. The consequence would be declining world market prices and increasing intervention and consumers' costs of grain support policy. Export subsidies are mainly a function of the domestic target price and the world market price both depend on the shape of domestic and world market demand and supply curves.

Actual EC agricultural policy discussions concentrate on reducing producer prices with the instrument of Maximum Guaranteed Quantity depending price reductions, acreage control measures and the utilization of part of the quantity Q_g for the supply of renewable resources.

The target prices depending on Maximum Guaranteed Quantities reduce the price P*. The consequences are declining producer rents, because quantities supplied and prices decline. Consumer surplus will not be affected but part of the government support budget will be recovered by taxing producers (see chapter 2.1). Acreage control is supposed to increase producer rent or surplus. This would be possible only if internal target prices could be augmented to such an amount that with a set-aside programme income transfers are paid which are higher than the triangle P_1 P_2 P_3 in figure 2.2. If a unique set-aside premium would be paid, government expenditure would be $(Q^*_s - Q^*_d)$ $(P^* - P_e)$ which would be higher than the amount given to export restitutions $(Q^*_s - Q^*_d)$ $(P^* - P_w)$. If a deficiency payment system for energy import substitution should be favourable for tax payers the expenditures for such institutional change must be less than the minimum support expenditures for alternative measures leaving consumer and producer rents unchanged. Whether this could happen under prevailing domestic and world market conditions will be analyzed in chapter 5 for the wheat market of the EC. The comparison of institutional and technological changes of the introduction of renewable resources focusses on three criteria: producer surplus, consumer surplus and government expenditures. The empirical exercise will include an assessment of EC agricultural policy changes anticipated to be introduced after the actual GATT negociations.

totality of these gains (or losses) constitutes the payoff matrix of technical and institutional change for renewable resources from agriculture.



Source: De Janvry (1978)

Figure 2.3 Supply and demand for technological and institutional innovations

By means of illustration, De Janvry (1978) has constructed a scheme of the process of inducement and diffusion of innovations (figure 2.3). This scheme has the advantage of "socializing" the phenomenon of technical change. That is to say, not only does it reveal the many different interests involved, it also contains an alternative for unilinear cause-and-effect treatments of the subject; thus, demand and supply are interrelated, as are - indirectly - the socio-economic and politico-bureaucratic structure. For reason of clarity we should add that the payoffs are determined by the material and economic effects of innovations concerned and their rate and extent of diffusion.
However, with the above presented scheme in mind, de Janvry argues that the question as to whom captures the benefits is crucial in understanding the causative elements of technical and institutional change. So far it is

utilization (OECD, 1984). Under present knowledge in production and conversion technologies, actual world market and EC-prices in energy and food, profitability of non food production is low or negative compared with the supported food production systems (Becker, Kleinhanß and Kögl, 1988). If public authorities in the EC consider to favour the utilization of agricultural resources for biomass production, they have to decide, to what extent private profitability can be ensured through public intervention. Public intervention is possible in two ways: First through incentives given to public or private research institutions, with the expectation that they will produce technical progress allowing the diffusion of renewable production technologies within the actual socioeconomic structure. Second through the direct supply of institutional change in the fields of agricultural, structural and energy policy to increase competitiveness of biomass production compared to food supply within the EC. Member states of the EC reinforced their research mainly through the provision of public funds for research activities with the purpose that

- yield and quality of renewable resources could be enhanced
- technology of production and processing of renewable resources would be improved.

Both should allow declining unit costs for renewable resources. With regard to institutional incentives EC-market regulations were changed. Deficiency payments provided for industrial utilized starch, sugar and vegetable oils allow the procurement of these renewable resources by industries paying world market prices. The latter should provide incentives towards private research in the domain of renewable resources. But private investment in non food production research will take place only, if the expected economic rent of research within these systems will be equal or higher than in food production.

2.5 Applied methods for the economic assessment of renewable resources

Methods applied to analyse the economic effects of renewable resources are mainly input-output calculations, linear programming approaches and simulation studies. Simulation studies and linear programming approaches are based on input-output calculations. Most of the studies are carried out in a static framework.

production costs and market potentials ethanol production would not reach competitiveness.

The different input-output calculations show that this instrument allows the evaluation of production costs on different production and conversion stages. Further this approach helps to identify supply prices in a static environment. The prevailing constraint for this approach is that interactions between different factor utilizations for different products are not considered.

2.5.2 Linear programming approaches

As indicated by Hazell and Norton (1986) aggregated linear programming models analysing policy changes should contain the following five elements:

1. A description of producers' economic behaviour. In all mentioned models (see the following page) the main decision rule applied was profit maximization. But none of the models made reference towards risk and uncertainty.
2. A description of the production functions, and technology for the production and conversion of raw materials.
3. A definition of the resource capacities held by different groups within the sector. This could be done on a sectoral level or differentiated by regions and farm types.
4. A specification of the market environment in which producers of raw materials and owners of conversion plants operate. For farmers this includes demand functions for traditional food crops and for raw materials; for operators of conversion plants this has to include functions for final products.
5. A specification of the policy environment of the sector to identify subsidies given towards inputs and outputs. The option to produce renewable resources is broadly compared with other agricultural support measures: direct income payments, set-aside programmes and free market conditions.

The linear programming (sector) models reviewed (Bühner and Kögl, 1981, Kögl, 1986, Janetschek, 1986, Haimböck, 1985, Hansson, 1985) were mainly designed to provide supply response functions for raw material production. The models contain alternative techniques of production both in the field of traditional food crops and for raw materials. The costs are divided into two components:

The static "Landkreis" level results allow an aggregation towards a sectoral supply response function including an analysis of regional comparative advantages of raw material production.
The decision rule applied is that the above mentioned low income crops: spring barley, oats and rye will be substituted by energy crops like fodder beets, sugar beets, potatoes, maize and rapeseed if these crops gain higher gross margins. Depending on regional yield levels, variable costs and the opportunity costs supply prices for different raw materials are given.

2.5.4 Quantitative statements about welfare implications of biomass production

Market orientated economists have always indicated that social costs would increase if biomass production with agricultural production factors was supposed to solve agricultural income problems, to reduce agricultural surplus and to substitute fossil fuel imports (OECD, 1984).

The most detailed welfare assessment of renewable resource production (ethanol) is available in Hofreither, Schneider and Weiß (1987) for the Austrian economy. Their approach is supply orientated. The authors assume that technical progress, price policy and structural change will increase surplus production in the fields of traditional food crops and they investigate the social costs of the supplementary ethanol production. The authors assess the support needed for the competitive supply of ethanol in 1985 and 1995. Single estimation equations are used to explain and project: Austrian petrol demand, Austrian petrol prices, yield and land use development, and Austrian food demand, Austrian prices for agricultural product. As within the linear programming models the authors compare an ethanol production policy with export subsidies for cereals.

In the Federal Republic of Germany the Federal Ministry for Research and Technology initiated an evaluation of research activities in the field of renewable resources from agricultural resources. Two reports, one on bioethanol (Grosskopf, Henze, Kloos, 1988) and the other on wood (Gerstenkorn and Thoroe, 1988) are available.

The report on research activities about bioethanol production (Grosskopf, Henze and Kloos, 1988) applies the procedures of scoring models. The authors do not reflect the usefulness of other approaches. A scoring model produces an

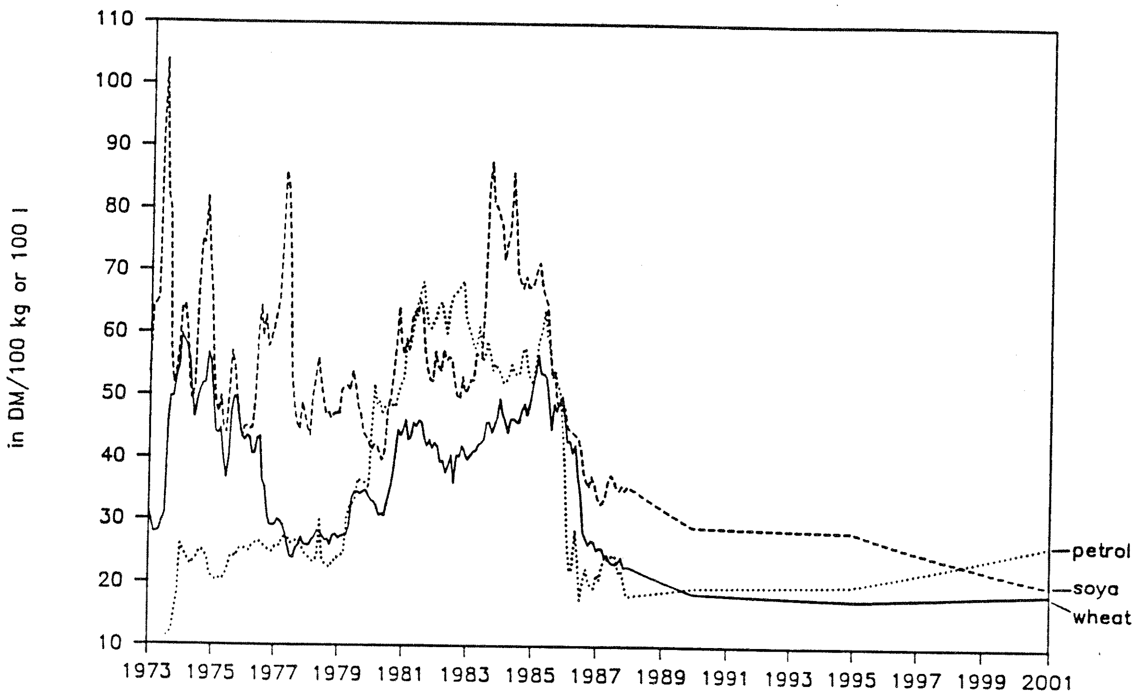
The authors apply scenario design, activity analysis to maximize agricultural income, input-output models for conversion and a separate analysis of environmental impacts. The economic model of the production of renewable resources determines supply prices for renewable resources for predetermined quantities. These prices are than compared with assumed market prices and price support is specified. Supply prices depend on assumption about production activities and the opportunity costs for fixed factors. In general the approach is biased towards supply. Main emphasize is on agricultural income and the agricultural support budget. The main model, maximization of agricultural income within linear activity analysis, does not allow investigations of changed food prices and food demand structures. The comparative static optimization approach does not provide an impact analysis of dynamic aspects: mainly structural change.

The use of renewable resources depends heavily upon price developments of fossil substitutes, agricultural prices, technical progress in conversion and production technologies of industrial utilizers and institutional change, yield and cost saving technical progress in the domain of the agricultural production of renewable resources, and in the possibilities to change the agricultural support policy. Therefore macro-economic assessment of biomass production must include methods dealing with these interactions and which allow projections in an uncertain and risky environment both in technical and economic terms. The sector model used in chapter 5 for evaluation will be based on long term techno-economic evaluations including the most important alternatives of biomass production for energy and wood, under conditions of alternative price scenarios and alternative support policies.

3. Anticipated market evolutions for agricultural products and energy

Opportunity costs for agricultural biomass for energy substitution for the evaluation of biomass policies and projects have to be world market prices. For our activity to evaluate biomass projects, land opportunity costs and feed stock opportunity costs have to be assessed. Biomass lines considered are ethanol, rapeseed oil and forest products. The following prices have to be considered: wheat, maize, soya for the assessment of feedstock and land opportunity costs; different world markets for natural oils which compete with the EC-internal rapeseed (and sunflower) production, forest products to

Figure 3.1 World market prices for petrol, wheat and soya



projections based on constant $ (Deflator US GNP)
Source: Stat. Bundesamt and World Bank

TABLE 3.1 WHEAT - PRODUCTION, CONSUMPTION, EXPORTS AND IMPORTS IN MAJOR PRODUCTION AREAS

	Actual (1 000 Tons)				Projected					Growth Rates A/ (% per Annum)		
Countries/Economies	1969-71	1979-81	1986	1987/B	1988	1989	1990	1995	2000	1961-86	1970-86	1987-2000
Production												
North America	53.941	86.607	88.312	83.503	66.267	102.260	111.090	129.217	165.062	3.1	4.2	5.4
United States	40.040	66.225	57.072	57.178	48.053	72.993	77.835	97.134	125.422	2.1	2.8	6.2
Canada	13.901	20.382	31.240	26.325	18.214	29.267	33.256	32.083	39.640	5.8	8.1	3.2
EEC-10	41.358	54.592	67.705	67.715	68.990	66.751	69.872	78.570	94.469	3.3	3.5	2.6
Australia	9.014	14.472	16.272	12.103	17.428	19.046	20.512	22.929	27.811	3.6	4.6	6.6
Argentina	5.873	8.060	8.925	9.996	9.797	11.296	13.251	21.667	26.138	1.8	3.8	7.7
World	324.867	438.493	525.220	503.190	509.413	544.820	572.750	647.796	738.430	3.5	3.3	3.0
Consumption												
North America	26.392	27.126	38.700	35.900	39.915	40.696	41.405	47.419	52.644	2.4	2.3	3.0
United States	21.721	21.891	32.500	29.300	33.842	34.487	35.148	40.777	45.402	2.6	2.5	3.4
Canada	4.671	5.235	6.200	6.600	6.074	6.209	6.257	6.642	7.242	1.7	1.5	0.7
EEC-10	45.516	46.783	47.200	48.541	53.001	51.896	51.827	56.462	60.284	0.7	0.2	1.7
Australia	2.688	3.101	2.768	2.857	3.183	3.187	3.291	3.618	3.913	2.7	2.3	2.4
Argentina	4.393	4.090	4.334	4.417	4.541	4.653	4.755	5.378	5.965	0.8	0.4	2.3
World	334.678	440.902	513.075	524.111	545.614	553.201	567.209	635.000	733.022	3.2	2.7	2.5
Exports												
North America	29.292	59.139	49.252	64.733	62.326	65.613	65.679	80.476	108.868	2.2	2.9	4.1
United States	17.630	42.275	28.490	43.591	44.115	43.691	41.826	54.039	77.726	1.5	2.2	4.5
Canada	11.662	16.864	20.762	23.600	18.211	21.921	23.853	26.436	31.142	3.4	4.1	2.2
EEC-10	7.944	19.525	28.673	32.016	28.988	29.140	30.061	36.240	47.014	9.0	10.8	3.0
Australia	8.327	11.293	14.838	10.942	12.835	14.873	16.159	19.711	23.763	3.6	1.7	6.1
Argentina	1.640	4.079	4.647	5.696	5.297	6.481	8.142	16.296	20.168	2.2	10.3	10.2
World	56.119	99.358	105.184	122.703	117.598	124.446	128.603	162.469	210.952	3.2	3.9	4.3
Imports												
EEC-10	11.695	11.023	11.038	11.026	11.046	11.110	11.157	11.321	11.503	-0.4	-0.7	0.3
World	54.569	96.527	104.651	122.115	117.598	124.446	128.603	162.469	210.952	3.3	4.0	4.3

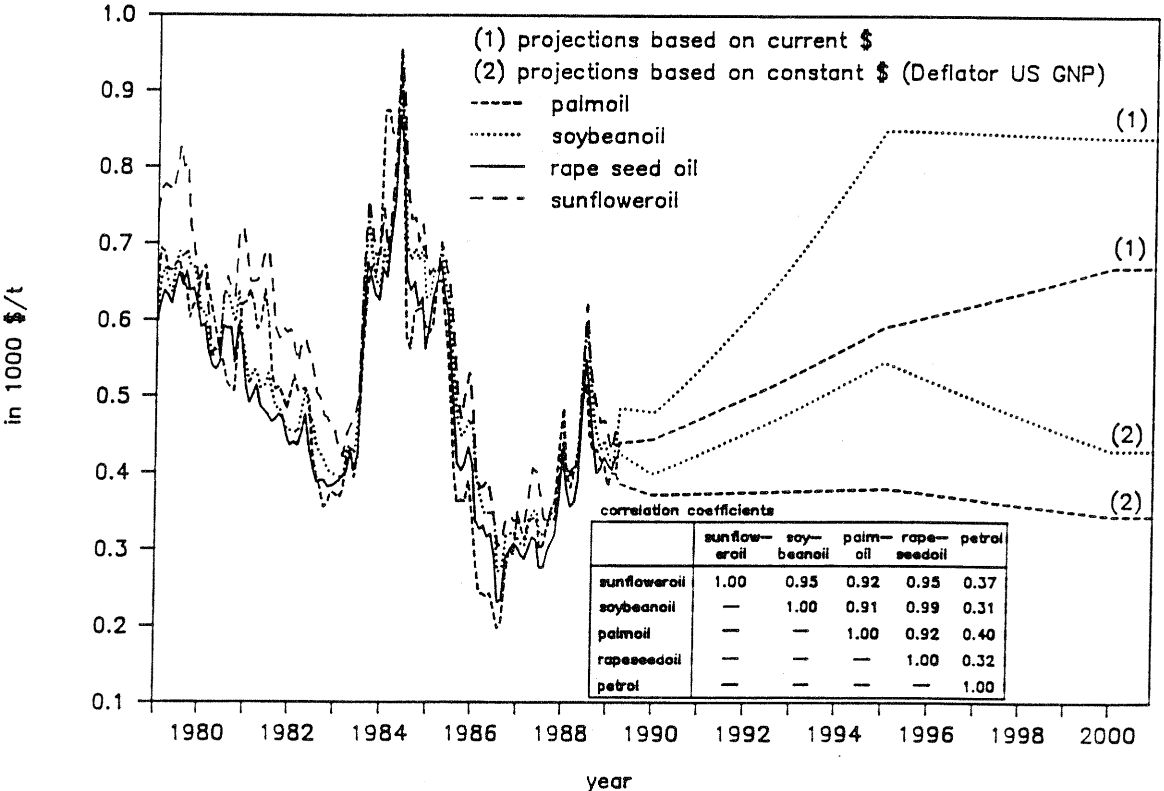
A/ Least Squares Trend for Historical Periods (1961-86); End-Point for Projected Periods (1987-2000).
B/ Estimate.
Source: The World Bank, Price Prospects for Major Primary Commodities. Volume II, 1989

TABLE 3.2 ACTUAL AND PROJECTED WORLD MARKET PRICES FOR WHEAT AND MAIZE FROM 1980 TO 2000 per ton

	US Wheat 1)	Canadian Wheat 2)	Maize 3)	US Wheat 1)	Canadian Wheat 2)	Maize 3)
	Nominal Prices			Prices in Constant US $ Deflated by US GNP Deflator		
Actual						
1980	168.3	190.8	125.3	219.6	249.0	163.5
1981	154.6	196.4	130.8	184.1	233.8	155.7
1982	132.6	166.5	109.3	148.3	186.2	122.3
1983	137.3	169.5	136.0	147.9	182.6	146.5
1984	140.2	165.4	135.9	145.4	171.5	141.0
1985	128.7	173.3	112.2	128.7	173.3	112.2
1986	118.4	160.6	87.6	116.1	157.5	85.9
1987	112.1	133.5	75.7	106.8	127.2	72.1
Projected						
1988	135.4	176.1	107.8	124.0	161.3	98.8
1989	138.9	186.7	109.5	121.7	163.6	95.9
1990	126.7	156.5	98.4	105.6	130.5	82.0
1995	155.8	192.3	123.1	100.0	123.9	79.0
2000	217.2	255.8	166.0	111.2	130.9	85.0

1) US No. 1 Soft Red Winter, export price Gulf.
2) Canadian No. 1 Western Red Spring in store, Thunder Bay.
3) US No. 2 Yellow, f.o.b. Gulf ports.
Source: The World Bank (1989), Price Prospects for Major Primary Commodities 1988-2000. Volume II. Washington DC.

Figure 3.2 World Market Prices for Natural Oils



Source: Stat. Bundesamt and World Bank (1989)

TABLE 3.3 PRODUCTION OF OILSEEDS IN THE EC 1)
in 1000 t

Production \ Year	1982	1983	1984	1985	1986	1987
Rape-seed	2 679	2 492	3 477	3 725	3 683	5 951
Sunflower	745	985	1 202	1 760	3 193	4 048
Soybean	31	89	149	343	906	1 808
Lin	44	34	44	49	34	47
Total Oilseeds 2)	3 694	3 845	5 172	6 163	8 328	12 315

1) From 1986 incl. Spain and Portugal
2) Incl. mustard, poppy, sesame and cotton
Source: Götzke, H.: Preisbildung und Verwendung einheimischer Ölsaaten als Nahrungs- und Industriegrundstoffe, Braunschweig, 1989

TABLE 3.4 WORLD CONSUMPTION OF NATURAL OILS AND FATS
(Mio. t)

Production \ Year	1979 /80	1980 /81	1981 /82	1982 /83	1983 /84	1984 /85	1985 /86	1986 /87	1987 /88	1988 /89 1)
Soybean oil	12.4	12.7	13.0	13.7	13.0	13.7	13.9	15.0	15.4	15.5
Palm oil	4.5	4.9	5.3	5.9	5.9	6.4	7.3	7.7	8.4	9.1
Sunflower oil	4.7	4.5	5.2	5.5	5.6	6.4	7.0	7.3	7.6	8.0
Rape-seed oil	3.3	4.0	4.6	5.2	4.8	5.6	6.3	7.3	7.7	7.8
Cotton seed oil	3.1	3.3	3.4	3.3	3.1	3.8	3.7	3.3	3.5	3.7
Groundnut-oil	3.2	3.0	3.7	3.0	3.0	3.5	3.3	3.4	3.1	3.7
Coconut oil	2.6	3.0	2.8	2.6	2.4	2.3	3.0	3.0	2.9	2.9
Olive oil	1.7	1.7	1.6	1.6	1.8	1.7	1.7	1.8	1.9	1.9
Palm kernel oil	0.6	0.6	0.7	0.8	0.7	0.8	1.0	1.0	1.1	1.2
Linseed oil	0.6	0.7	0.6	0.6	0.7	0.8	0.8	0.8	0.8	0.8
Castor oil 2)	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Total vegetable oils	37.1	38.8	41.3	42.6	41.4	45.4	48.4	51.0	52.8	55.0
Tallow 2)	6.0	6.0	6.0	6.1	6.3	6.4	6.5	6.4	6.6	6.6
Butter	6.3	6.3	6.4	6.6	6.7	6.3	6.4	6.5	6.6	6.4
Lard 2)	4.7	4.7	4.7	4.6	4.6	4.9	5.0	5.1	5.2	5.2
Fish oil	1.1	1.1	1.2	1.2	1.4	1.6	1.6	1.5	1.5	1.5
Total animal oils and fats	18.1	18.1	18.3	18.5	19.0	19.2	19.5	19.5	19.9	19.7
Total all oils and fats	55.2	56.9	59.6	61.1	60.4	64.6	67.9	70.5	72.7	74.7

1) Estimate
2) From 1979/80 to 1983/84 production equal consumption
Source: Götzke H.: Preisbildung und Verwendung einheimischer Ölsaaten als Nahrungs- und Industriegrundstoffe, Braunschweig, 1989

maize or it has to be left idle. The impact of the corn programme will be that soybean acreage in the United States remains on the 1987 level, the substitution of corn through soybeans has been hampered by US farm support policy.

The most important palm oil and palm kernel producing countries are Malaysia and Indonesia. The production in these two countries is expected to grow rapidly until 1995. Malaysian palm oil production doubled over the period 1962 to 1967. It doubled again by 1970, 1973, 1977 and 1982. By 1995 production will double once more. As well Indonesia will continue to increase considerably production because of already completed plantings. The price drop from over $ 730/ton in 1984 to only $ 260/ton in 1986/87 induced fertilizer application reductions with lower yields. Increased world oil market prices will reverse this impact, fertilizer application will increase and yields will turn up.

When investigating northern hemisphere oilseed production competitiveness it must be born in mind that for well-managed palm oil plantations in Malaysia and Indonesia the amount of oil from one hectare has been increased from about 1.5/tons to more than 5 tons in recent 10 years.

The World Bank price (1989, p. 155) projection based on an interregional market model for oilseeds are given in table 3.5. Following three years of depressed prices (see figure 3.2) from 1985 to 1987, prices increased strongly in 1988 due to soybean production reduction in the United States. Over the past ten years structural changes have occured in the vegetable oil market mainly caused by agricultural policy changes within the EC and the US. These are 1) the EC became a major producer of oilseeds and protein meals, 2) the increasing oilseed productivity in South-West Asia, and 3) the potential of expanding soybean production in South America. These structural changes have increased competitiveness in world market and might be reflected in a downward trend in real prices over the long run (see table 3.5, contains price forecasts for soybeans, soybean oil, soybean meal, palmoil and coconut oil in nominal and real terms in US$).

3.2 Market outlook for energy

Table 3.6 provides a World Bank (1988) summary of the expected developments in the shares of major fuel groups in energy consumption in the main economic regions. The World Bank projections presume that in the industrial countries the share of solid fuels and natural gas in total energy demand remains stable at about 20 % over the forecast period until 2000. The industrial countries' commitment to reduce their dependence on imported oil, should reduce the oil share in total energy consumption from about 44 % in 1986 to about 40 % in 2000.

Since 1986, the low international prices of oil have slowed down the substitution of oil use in industrial production. To avoid a policy with reduced fossil fuel substitution incentives most oil-consuming countries did not pass through fully the decline in world oil prices to consumers. Therefore it can be expected that investments will continue to promote and to diffuse energy saving technologies which will reduce the growth in oil demand. It can be anticipated that additional incentives will be set for further fossil fuel substitution due to expected climatic changes. In this regard it has to be recognized that biomass for energy utilization might gain some importance. But more promising seems the continuing introduction of more energy efficient transport equipment and transport systems.

The economic competitiveness of agricultural biomass for fossil energy substitution depends mostly on liquid fuel prices. Therefore recent World Bank (1989, pp 74) projections on liquid fuel prices will be discussed. Only if substantial increases in fuel prices can be expected investments in agricultural biomass production systems for energy substitution can be justified.

The recent price movements for petroleum can be described as follows: "The recovery of prices to an average of \$ 17.20/bbl in 1987 following the mid-1986 plunge to below \$ 10/bbl (from \$ 27 bbl in 1985) was reversed in 1988 despite growth in demand." (World Bank, 1989, p 49). Consumption and importation in EC-countries is expected to grow from 1987 to the year 2000 with an annual increasing rate of 0.6 % (see table 3.7).

The World Bank price forecasts have been calculated by taking together oil demand projections and expected production of two groups: non OPEC and OPEC sources. Due to the uncertainty in supply behaviour of these two groups different scenarios about future price evolutions can be anticipated. The World Bank (1989, pp 75) price projections are based on three scenarios:

a) The first scenario envisages the further disintegration of the OPEC. This would lead to a price competition with declining prices due to the fact that mainly those production capacities are utilized with nominal production costs below $ 10/bbl for several years. The lower price level could stimulate demand and could reduce incentives for energy-saving technologies. Both together could bring a moderate oil price increase from $ 11 to $ 12/bbl (in terms of 1985 dollars) by 2000.
b) The second scenario foresees a weak but functioning OPEC. It presumes that OPEC could increase efforts to regain control of markets. The likely result could be unstable prices.
c) The third scenario presumes that internal OPEC member bargaining would allow production control and prices would develop in such a way that development of alternative energy projects is reduced.

The World Bank presumes that the second and third scenario are the most likely ones. The medium- and long-term price projections based on scenario b) are given in table 3.8 and figure 3.1. It is anticipated that during the period from 1990 to 1995 production of oil in industrial countries will decline. This should lead to an increase in oil prices in nominal and real terms. The World Bank forecast contains an increase from about $ 13.80/bbl in 1990 to $ 14.10/bbl in 1995 in 1985 constant dollars. Assuming further increased demand after 1995 and reduced production in non OPEC supply countries petroleum prices are projected to increase moderately to about $ 17.90/bbl in the year 2000 in 1985 constant dollars. Only if the OPEC gains more quickly control over the supply behaviour of individual members it can be expected that oil prices will increase more quickly and could reach a level of $ 20/bbl by the year 2000 in 1985 constant dollars. On the other hand if scenario one prevails prices would be generally low and could fluctuate at a level of only $ 10 to 12/bbl for several years.

The outcome of the evaluation of the World Bank Price Projection is a moderate price increase for oil. It cannot be anticipated that prices in real terms will recover the high price level of more than $ 30/bbl which existed in the period from 1980 to 1985. Strong price incentives to develop alternative fuel sources including biomass production for energy substitution will not occur with a high probability. Nevertheless it has to be emphasized that oil prices might continue to fluctuate strongly and policy makers in industrialized

TABLE 3.9 VALUE OF IMPORTS AND EXPORTS OF FOREST PRODUCTS IN THE EC AND THE EC MEMBER STATES FROM 1970 TO 1987 IN MIO.$

		BELGIUM -LUX	DENMARK	FRANCE	GERMANY FR	GREECE	IRELAND	ITALY	NETHER-LANDS	PORTU-GAL	SPAIN	UK	EC
Imports	1985	1219.7	347.6	2838.8	4897.8	285.0	269.6	2653.0	1872.3	165.7	711.6	5123.5	20884.6
	1986	1502.9	1136.9	3650.0	6413.5	379.0	268.0	3317.9	2711.4	195.8	934.3	5123.5	25683.2
	1987	2238.8	1366.8	4987.0	8102.1	462.2	268.0	4518.1	3320.6	223.3	990.9	6207.5	32685.4
Exports	1985	606.9	181.7	1577.9	2679.8	32.0	33.2	719.7	362.6	540.2	465.1	704.1	8403.4
	1986	825.7	229.4	1892.6	3587.1	31.4	29.6	918.0	1298.6	673.5	505.5	876.9	10868.4
	1987	1318.1	271.2	2762.0	4454.6	37.1	29.6	1097.6	1679.8	940.3	508.8	1233.3	14332.5
Annual incremental changes from the average of 1970/72 to the average of 1985/87 in percent 1)													
Imports		10.443	9.865	11.097	10.421	9.675	8.162	10.798	10.967	12.044	9.778	7.506	9.814
Exports		9.341	11.015	12.538	16.065	15.417	5.494	11.586	15.585	14.954	19.176	12.285	13.609

TABLE 3.10 ROUNDWOOD PRODUCTION, IMPORTS AND EXPORTS IN THE EC

		BELGIUM -LUX	DENMARK	FRANCE	GERMANY FR	GREECE	IRELAND	ITALY	NETHER-LANDS	PORTU-GAL	SPAIN	UK	EC
Production	1985	3.251	2.303	38.901	30.650	2.353	1.277	9.448	1.061	9.108	15.166	4.805	118.823
	1986	3.348	2.203	39.869	30.359	2.893	1.245	9.623	1.136	9.432	17.084	5.237	122.429
	1987	3.528	2.203	40.901	33.739	2.945	1.245	9.122	1.156	9.420	17.539	5.204	127.002
Imports	1985	3.888	0.317	1.958	3.481	0.165	0.010	5.496	0.954	0.385	1.374	0.410	18.438
	1986	3.783	0.405	1.816	3.182	0.300	0.010	5.147	0.941	0.440	1.277	0.316	17.617
	1987	4.004	0.284	1.773	3.250	0.245	0.010	5.223	1.026	0.424	1.236	0.396	17.871
Exports	1985	1.123	1.088	4.956	4.553	0.001	0.324	0.012	0.816	0.691	0.567	0.465	14.596
	1986	1.445	0.976	5.939	4.176	0.001	0.324	0.024	0.710	0.603	0.578	0.391	15.167
	1987	1.578	0.953	5.430	4.062	0.003	0.324	0.013	0.832	0.695	0.748	0.581	15.219
Annual incremental changes from the average of 1970/72 to the average of 1985/87 in percent 1)													
Production		0.853	0.178	1.869	1.036	-0.234	8.021	-0.549	0.004	2.320	1.478	2.670	1.343
Imports		3.215	4.999	-2.817	-1.859	0.200	-6.091	0.510	0.314	4.365	1.632	-5.351	0.001
Exports		5.744	5.212	4.524	10.301		34.039	0.138	4.653	10.237	7.783	22.924	6.727

1) calculated using : $x_n = x_0 q^t$ and $q = 1 + p/100$

Source: FAO, Yearbook of Forest Products 1987, 1976, 1972

Figure 3.3 presents monthly prices for woodpulp and paper. Comparing these prices with world market prices for farm products, price fluctuations of the former are less pronounced. This is as well true for the different wood prices presented in figure 3.4. The range of pulpwood prices in Austria amounted between $ 30 and $ 50/cum and in Sweden between $ 20 and about $ 35/cum. Roundwood prices are about 200 % higher. Quick growing short rotation forest products have a low market value. For the economic assessment it is presumed that the average market price for these products will fluctuate in the range from $ 25 to $ 50/cum during the period of investigation - either 15 or 30 production years. It is further assumed that one cum of wood equals 600 kg of odt[1] and that the value for one odt fluctuates between $ 40 and $ 80.

4. Economic aspects of afforestation on agricultural land with fast growing tree species in short rotations in the Federal Republic of Germany

In the agricultural policy discussion about alternative uses of factors presently engaged in farm production the cultivation of fast growing tree species in short rotations on former agricultural land receives increasing interest due to aspects like the security of domestic raw material supply and labour supply in rural areas. Some advantages of intensive practices of short rotation trees on former agricultural land are described by Makeschin, Rehfuess, Rüsch and Schörry (1989) and Steinbeck (1989):

1. Short rotation forestry offers relatively short-term returns on investments.
2. High yielding tree species are suitable for short rotation forestry under climatic conditions of Central Europe.
3. Industrial utilization of short rotation wood is supposed to enter the market for forest products.
4. From the ecological point of view afforestation is less intensive than traditional crop production.

The following investigation is based on a systematic analysis of German publications on the economic feasibility of production and utilization of biomass from short rotation forestry. On the basis of this investigation we define short rotation production activities. A multiperiod microeconomic

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1 odt: oven dry tons corresponding to absolute dry matter.

planning model is used for the evaluation of afforestation activities on former agricultural land. The results will be used for the sectoral analysis in chapter 5. For the microeconomic assessment of short rotation forestry the following definitions are used: Fast growing tree species used in forestry production are those which achieve on productive land an average annual total yield increase of 10 to 20 odt p.a.. Steinbeck (1981) defines: "Short rotation forests are plantations of closely spaced, broadleaved trees which are harvested repeatedly on cycles of less than 10 years. The key to high growth rates lies in the rootstocks. Once planted and established, they remain in the ground after each harvest of the above-ground portions and then resprout."

4.1. Economics of short rotation forestry activities

4.1.1 Production costs

Plants particularly suitable for short-rotation cultivation under climatic conditions of Central Europe are poplar and willow species. According to Dimitri (1986) a fundamental condition for choosing a suitable location is: "The better the location according to its water, air and nutrient supply, the wider is the cultivation suitability and the higher are yields and resistance to biotic and abiotic risks." Site preparation comparable to agricultural production is necessary for successful short-rotation establishment. The planned utilization determines the number of plants per hectare as well as protection, maintenance, and harvesting activities.

Table 4.1 summarize assumptions of various authors about management and total costs of establishment of short-rotation plantations. Further costs appear after the second vegetation period, for fencing and maintenance of the intensive short rotation forests. These are costs for chemical or mechanical weed control and additional fertilizer supply after each harvest.

A major cost item are the costs for harvesting (see table 4.2). In view of a range from ECU 10 odt to ECU 100 odt there seems to be still great uncertainty about efficient harvesting systems. More balanced are statements about the average annual output of the short rotation plantation. They range from about 10 to 15 odt per hectare and year on medium or good agricultural land.

Table 4.2 presents the main production costs categories. On the average of all statements about 60 % of total costs are harvesting costs, about 30 % plantation establishment and only about 10 % are required for fencing and maintenance respectively.

Although all authors used similiar assumptions about site, tree species and output the resulting costs for oven dry tons vary from ECU 70 odt to ECU 110 odt.

4.1.2 Utilization of woody biomass

Concerning the utilization of short rotation wood, most experiences are available for intensively produced poplar wood. Therefore the following analysis will concentrate on the utilization of fast grown poplar wood. Biomass from intensive cultured poplar plantations with an average production cycle of 5 - 10 years is generally suited for energy and industrial uses. The energy value of short-rotation poplar wood is in principle comparable to the value of conventional produced broadleaved wood.

Due to the technical problem of the high moisture content a substantial market for short rotation fuelwood does not exist. Therefore the establishment of short rotation forestry strongly depends on developments of competitive markets for short rotation products, competing with industrial restwood.[2]

As to industrial restwood for energy purposes Frühwald (1987) predicts an increasing competition with the use of wood in chemistry industry and from particle-board manufactures. The demand for industrial restwood for energy uses will further increase if prices for fossil fuels will rise and today's fuelwood will enter into particle-board manufacture and wood chemistry industry. An increased utilization of short rotation wood for energy uses may occur if developments on national and international markets admit the establishment of a market for short rotation fuelwood in common with feasible combustion or corburetion systems. Nevertheless it is presumed that short rotation forest products might enter the markets for fuel wood and restwood and might contribute to board and pulp production, where substantial markets for raw material supply exist in competitive markets.

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2 In the FRG about 5-10 million tons industrial residues were used in 1987.

other field crops

- Major pasture/fodder production activities are:
  dairy production, and
  beef production either on grass- or crop land
- Short rotation forestry is introduced up to a certain percentage on crop land and/or on pastures.

b) Calculation of gross margins for the mentioned farm activities; variable input requirements for the major activities have to be defined depending on farm size and yield levels; gross margins are determined both for EC-domestic prices and for anticipated world market prices.

c) Determination of price support for major activities.

d) Determination and comparison of farm income for different production and price scenarios; farm income is defined as total farm gross margin (this is identical to producer surplus: income of quasi-fixed factors of production)[3]; total farm gross margins are calculated multiplying gross margins of the different major production activities with their respective number of units.

The following scenarios with respect to income flows and net present values are compared over the time horizon for different farm sizes and farming systems (crop and fodder farms; see table 4.3):

I Reference situation I: The actual crop rotation is kept constant.

II Reference situation II: The actual crop rotation is changed over five production periods, substituting the activities with gross margins below the average with the three activities with highest gross margins (these are normally winter wheat, rapeseed and sugar beets and potatoes). These three activities gain after five periods one third of the crop land each. Since for sugar beets the EC-quota system exists, the sugar beet acreage has to be kept constant, and instead the potato acreage increases.

III Short rotation forestry is introduced on a scale of 25 % on crop land on a proportionate scale for all actual crop land activities over five years.

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3 In this stage of model design fixed capital reallocation has been neglected due to uncertainties in knowledge of afforestation activities on agricultural land.

4) situation 1) plus award for set-aside,

5) situation 2) plus award for set-aside,

6) award for set-aside.

In addition the model allows an economic assessment of changed labour requirements to indicate what impact short rotation forestry might have on the farm labour balance.

4.2.2 Assumptions on factor endowments of farms, yields and prices

Farms considered are average crop and dairy farms in Lower Saxony in the Kammerbezirk of Hannover. The crop ratio and the ratio of crop land and pasture are given in table 4.3 for average farms of different farm size groups. Due to yield increasing technological change it is presumed that output per ha will increase as presumed in table 4.4 with an incremental rate of either 1 or 2 % p.a..

TABLE 4.4 YIELD ASSUMPTIONS FOR FARM LEVEL EVALUATION OF SHORT ROTATION FORESTRY

A Crop Farms

		incremental annual change of yields	farm size from to in hectares			
			20-30	30-50	50-100	>100
cereals	100 kg/hectare	0.02	59.9	61.6	63.5	65.2
wheat	100 kg/hectare	0.02	70.4	71.7	74.0	73.0
rye	100 kg/hectare	0.01	43.7	46.9	47.3	48.1
barley	100 kg/hectare	0.02	56.5	55.9	56.1	58.6
oilseeds	100 kg/hectare	0.02	28.3	29.4	29.2	27.9
potatoes	100 kg/hectare	0.01	362.8	335.6	352.6	360.2
sugar beets	100 kg/hectare	0.02	469.7	460.8	478.5	462.7

B Cattle Farms

		incremental annual change of yields	farm size from to in hectares			
			20-30	30-50	50-100	>100
cereals	100 kg/hectare	0.02	50.2	45.7	45.4	54.4
wheat	100 kg/hectare	0.02	62.7	57.1	59.3	65.1
rye	100 kg/hectare	0.01	41.7	38.5	41.4	42.5
barley	100 kg/hectare	0.02	47.6	45.4	44.5	52.0
oilseeds	100 kg/hectare	0.02	31.9	28.4	28.6	30.0
potatoes	100 kg/hectare	0.01	321.9	328.1	343.5	269.8
sugar beets	100 kg/hectare	0.02	439.7	440.1	429.5	430.6
milk	kg/head	0.01	5289	5420	5592	5533
field forage	KStU/hectare	0.01	5900 1)	5900	5900	5900
			(5000) 2)	(5000)	(5000)	(5000)
pasture	KStU/hectare	0.01	3600 1)	3600	3600	3600
			(3000) 2)	(3000)	(3000)	(3000)

1) high yield level
2) low yield level
Source: Kammerstatistik Hannover 1987/88

Domestic prices and world market prices needed for the calculation of price support are taken from chapter 3. They are summarized in table 4.5. The time horizon considered is two production cycles with 15 production years each.

TABLE 4.6 AGGREGATED VARIABLE INPUT COSTS IN ECU/HECTARE IN THE FIRST PRODUCTION PERIOD

	costs per ha in ECU
wheat	500
winter barley	410
spring barley	310
rye	350
oats	260
rape	440
sugar beets	700
potatoes	800
pasture	200
forage crops	400

For the comparison variable input prices are kept constant, with the exception of seed prices which depend on the evolution of EC-domestic prices. The initial variable input costs for the major activities are presented in table 4.6. It is presumed that the fertilizer applications depend on yield levels, while other inputs are kept in constant quantities. Output prices for short rotation forestry products are taken from the results drawn in chapter 3. Prices are modified to show the impact of higher price levels on the competitiveness of the short rotation forestry activities. Wood prices are ECU 50, 75, 100 and 150 odt. Presuming that short rotation forestry products could be used for feedstuff of the pulpwood production, most likely wood prices would be in the range between $ 30 and $ 40 per cum. Assuming that one cum has a weight of about 600 kg odt, the most probable prices per odt are from ECU 45 to ECU 75.

4.2.3 <u>Impact of the introduction of short rotation forestry in crop farms</u>

Four different crop farm groups are considered for the on farm level assessment of the introduction of short rotation forestry. The evaluation is based on farm records for the production year 1987/88 of average crop farms in the Kammerbezirk Hannover in Lower Saxony. The farm size classes are from 20 to 30 hectares, 30 to 50 hectares, 50 to 100 hectares and 100 hectares and

TABLE 4.7 NET PRESENT VALUES OF GROSS MARGINS OF MAJOR CROPS PER HECTARE IN CROP FARMS FOR THIRTY PRODUCTION PERIODS IN ECU

A Net Present Values in Domestic EC-Prices

	farm size from to in hectares			
	20-30	30-50	50-100	>100
wheat	18041	18574	22477	21297
winter barley	14807	13013	16427	14222
spring barley	10379	9211	11529	12413
rye	7444	8548	10359	11828
oats	10948	10948	11373	12930
rapeseed	14656	16880	16121	15912
sugar beets	36561	36103	37371	35098
potatoes	26449	21500	25280	28629
wood 1)	1098	1098	1098	1098
wood 2)	8442	8442	8442	8442

B Net Present Values in World Market Prices

	farm size from to in hectares			
	20-30	30-50	50-100	>100
wheat	8708	9069	9707	9429
winter barley	3202	2291	3401	2905
spring barley	1663	1095	2007	2007
rye	1851	2545	2632	4302
oats	1811	1811	1811	2106
rapeseed	730	1130	1057	584
sugar beets	2169	1832	2535	1912
potatoes	26449	21500	25280	28629
wood 1)	1098	1098	1098	1098
wood 2)	8442	8442	8442	8442

C Net Present Values of Calculated Price Support

	farm size from to in hectares			
	20-30	30-50	50-100	>100
wheat	9333	9505	12770	11867
winter barley	11605	10722	13026	11317
spring barley	8716	8117	9521	10406
rye	5593	6003	7727	7526
oats	9137	9137	9562	10824
rapeseed	13926	15749	15064	15328
sugar beets	34392	34272	34836	33185
potatoes	0	0	0	0
wood 1) 2)	0	0	0	0

1) wood price 75 ECU/odt
hired labour for harvest activities of short rotation forestry (40 ECU/odt)
2) wood price 75 ECU/odt
own labour for harvest activities of short rotation forestry (15 ECU/odt)

forestry net present values of average gross margins reduce by about 10 % (comparison of row I with row IV in part B, table 4.8). In part C the net present values for short rotation forestry are shown. The net present values for afforestation amount from only 4.9 % to 5.7 % of the value achieved with the actual cropping pattern. Income from afforestation is about ten times smaller than the present average set-aside reward. In situation where afforestation would receive equal price support as crop production net present values of gross margins from afforestation would remain about 30 % below average gross margins without afforestation (see part C in table 4.8). In part D of table 4.8 net present values of required subsidies are presented to gain equal gross margins if certain afforestation strategies are implemented. They are highest if farmers try to optimize crop ratio and implement short rotation forestry on 25 % of the arable crop land, and they are lowest if the least competitive crops are displaced. In part E the calculated net present values for the respective average price support are given. These values are highest if the least competitive crop are substituted by afforestation activities, and they are smallest if afforestation is undertaken, without changing the actual crop ratio.

Summarizing, it has to be stressed that with wood prices of ECU 75 odt short rotation forestry would reduce anticipated farm gross margins. If no subsidies are payed income reduction is about 20 % if the actual cropping pattern is kept. If the least competitive crops are substituted income reduction amounts to about 10 %. To have an unchanged income flow after afforestation, short rotation forestry must be supported in the range of actual price support for average field crops. This would be the price support calculated for cereals in table 4.7, under the assumption that the least competitive food crops are replaced by afforestation activities. Taking into account that considerable uncertainty about expected prices and expected yields exists, but yield and price expectations for food crops are better known by farmers, farmers would switch from field crops to afforestation only if they could anticipate considerable higher gross margins from afforestation than from field crops. Paying the present reward for set-aside as a subsidy for short rotation forestry would not be a sufficient incentive to implement afforestation. Afforestation would win in the case of faster declining domestic food prices and increased world market prices for wood products. Nevertheless it must be kept in mind that net present values of gross margins for field crops at world market prices (part B in table 4.7) are twice as high as the respective values for short rotation forestry. With regard to the gross margin for wheat at

In figure 4.1 and 4.2 the development of average farm gross margins for the farm size group 50 to 100 hectares during the 30 years period is shown for alternative wood prices ranging from ECU 50 odt to ECU 150 odt for two afforestation strategies. In figure 4.1 the gross margins are shown for the situation that 25 % of the crop land is converted to short rotation forestry activities, while the previous crop ratio remains. In figure 4.2 gross margins are presented for the case that afforestation on 25 % of the land with the least competitive food crops is undertaken. In such a situation gross margins are higher. Due to the price and yield assumptions, competitiveness of afforestation increases with time.

Figures 4.3 and 4.4 present the respective subsidies per hectare required for unchanged gross margins. In the case where afforestation is carried out leaving the actual cropping pattern unchanged, competitiveness is only achieved if wood prices increase to values above ECU 150 odt after 9 to 10 production periods. If afforestation takes place on the land used for the least competitive crops competitiveness without acreage subsidies is already achieved if wood prices would be higher than ECU 100 odt. If the more optimistic assumptions about the yield level of 60, 75 and 90 odt will not be achieved and yields would remain 25 % below the optimistic values, wood prices would have to increase by at least 20 % additionally.
Declining domestic food prices and increased wood prices are a precondition for achieving competitiveness of short rotation forestry on arable crop land under prevailing production conditions. Competitiveness of afforestation will increase if own labour can be used for harvesting (results are given in table 4.9).

Under realistic price assumption for domestic food products and wood from short rotation forestry, short rotation forestry will be implemented on crop farms only if acreage subsidies are provided which are at least equivalent to the price support granted to food crops through CAP-market regulations. Price support has been defined as the difference of gross margins calculated with anticipated domestic and world market prices. Subsidies in the range of actual set-aside awards would not be sufficient to motivate farmers to implement short rotation forestry on crop land.

Figure 4.3 Income transfer requirements for unchanged gross margins after proportionate afforestation of 25 % of cropland unchanged cop ratio for field crops

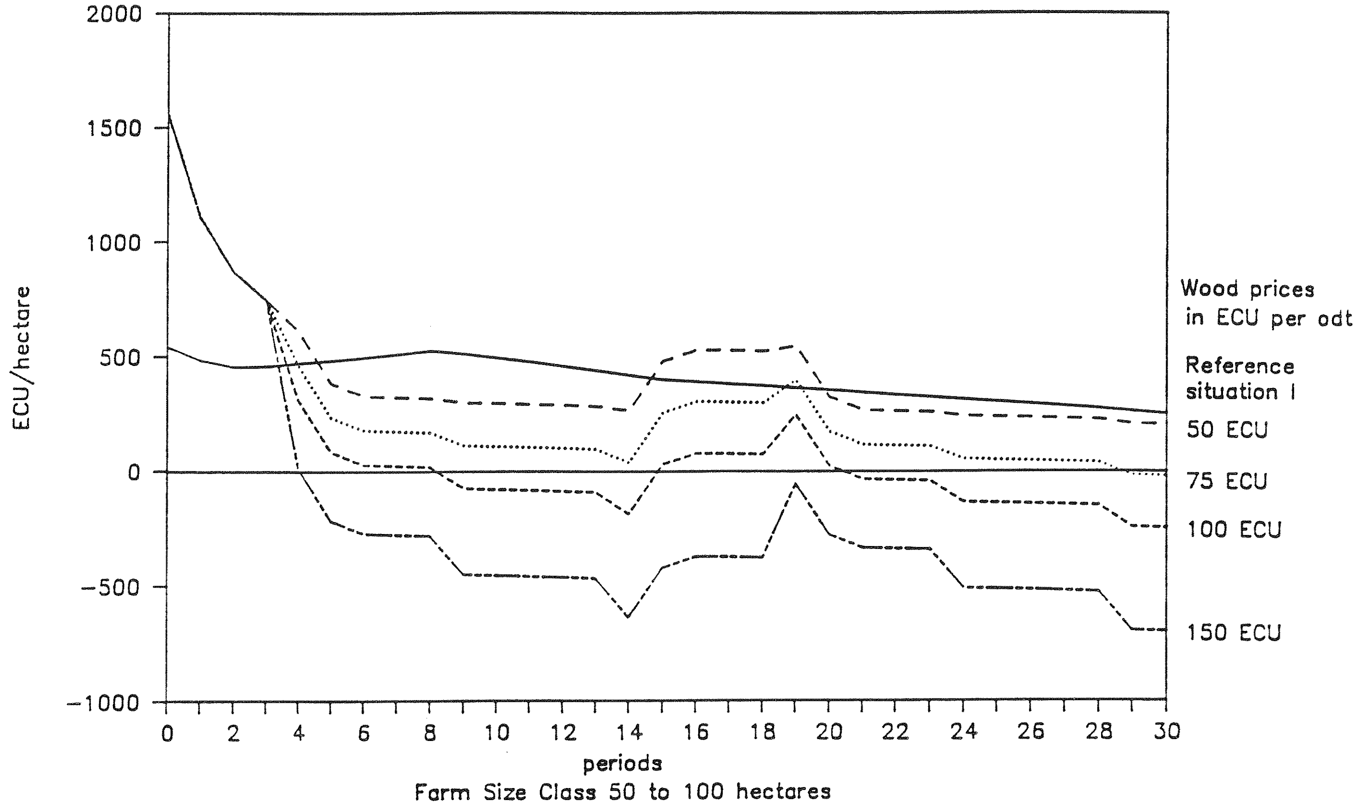
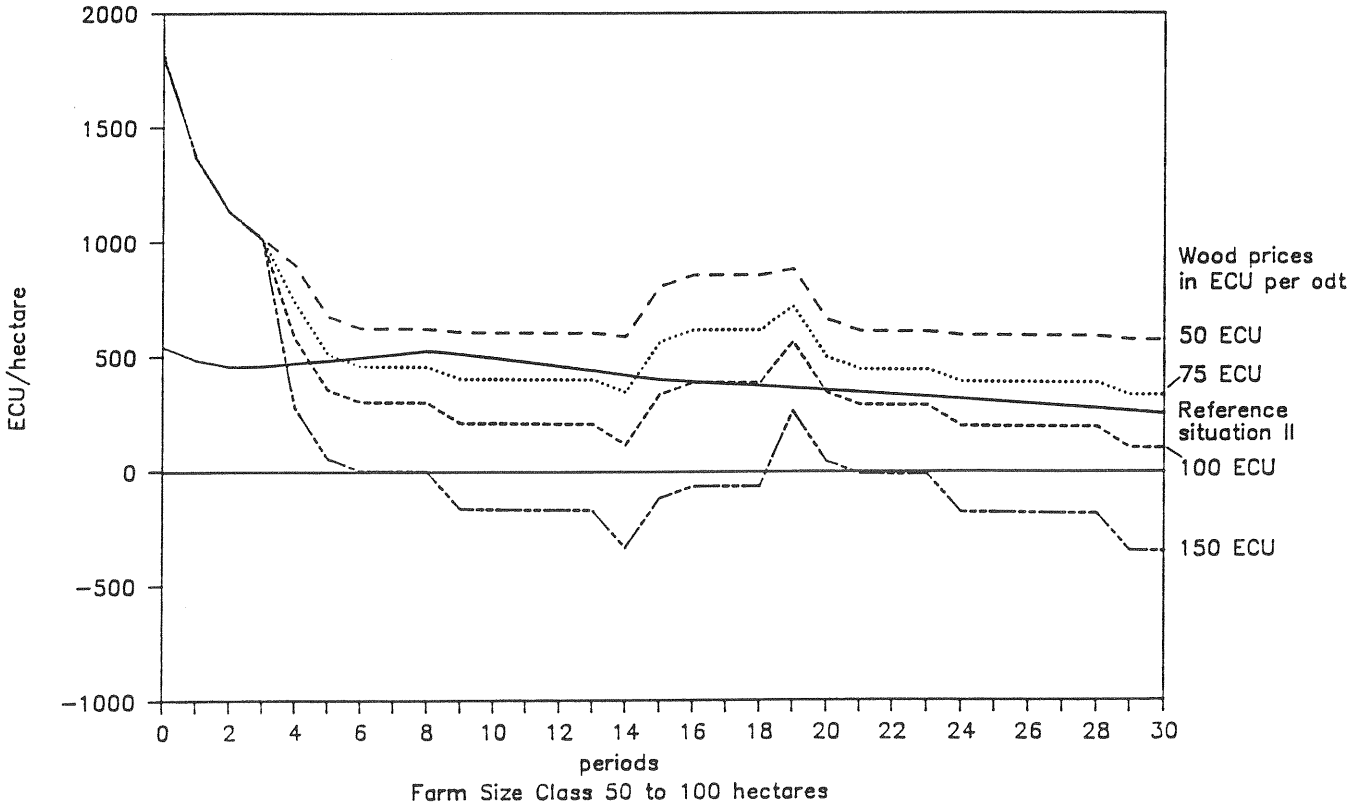


Figure 4.4 Income transfer requirements for unchanged gross margins in crop farms proportionate afforestation after optimizing cropping pattern



4.2.4 Impact of the introduction of short rotation forestry on cattle farms

Dairy farms considered for the analysis of competitiveness of short rotation forestry are also located in the Kammerbezirk Hannover of Lower Saxony. They belong to four farm size classes: with 20 to 30 ha, 30 to 50 ha, 50 to 100 ha and more than 100 ha. Production figures are taken from average farm records for the four size classes considered for the production year 1987/88. As shown in table 4.3 to 4.6 cattle farms have both crop land and pastures. Their cropping pattern and yield levels are different from those of the crop farms. In principle afforestation is possible either on crop land or on pastures.

The economic assessment of afforestation on crop land is similar to the evaluation carried out for crop farms. Only more emphasis must be drawn on the determination of gross margins for forage crops and pastures. The gross margins can be determined only if the forage utilization is known. Therefore two livestock activities are specified: dairy production and beef production. It is presumed that the gross margins for forage crops and for pasture are determined in accordance with the productive value of starch units in the two livestock activities. Due to the fact that dairy production is highly protected by CAP-price support and quota systems it is presumed that short rotation forestry might be an alternative for pasture/crop land utilization only for the area used for beef production. For this exercise again the price support is determined using the differences of gross margin for beef production between domestic and world market prices. Due to the lower yields of field crops, input requirements are supposed to be 10 % lower than on crop farms.

Table 4.10 presents net present values of gross margins of major activities on pasture and on crop land under domestic and under world market prices and of calculated price support. The time horizon considered is again thirty production periods. Gross margins for pasture and crop land used are given for two production opportunities: dairy and beef. With regard to harvesting activities of short rotation forestry it is presumed that on farm labour is used and variable harvesting expenditures of ECU 15 odt are presumed.

Due to the present milk market policy gross margin for pasture and forage crops are highest if these acreages are used for dairy production. This holds also if the evaluation is carried out with world market milk prices. Therefore it follows that land used for dairy production will not be planted with short rotation forestry. Crop land excluding the acreage used for forage production will be planted with short rotation coppice up to 25 % of the respective total acreage according to afforestation strategies I to V explained in chapter 4.2.1. In general gross margins for forage production for beef are smaller than gross margins for field crops (table 4.10). After this the impact of declining beef production is shown if land formerly used for forage production will be used for cash crops. Finally number of starch units produced from pasture required for dairy production are being calculated. The surplus acreage used for beef production is than taken for short rotation forestry, substituting beef production.

The impact of afforestation on crop land excluding forage land is documented in table 4.11. In part A net present values of total farm gross margins are given. In the first reference situation the actual cropping pattern remains unchanged. In the second reference situation the cropping pattern is changed towards crops with higher gross margins within five periods. The row called proportionate afforestation indicates the gross margin decline, if short rotation forestry is implemented within five years on 25 % of the crop land. Compared with reference situation I gross margin reduction amounts to about 15 %. In the next row the net present values for gross margins are given in the case that 25 % of the crop land is used for short rotation forestry when the least competitive cash crops are replaced by short rotation forestry within five years. Income reduction is only about 5 % on crop land compared with reference situation I. In the fifth row the net present values are presented for the case that afforestation is implemented within a more optimal production situation. Compared with reference situation II, gross margins decline by about 20 %.

Part B of table 4.11 presents figures of net present values of gross margins on a per hectare basis. In general it has to be emphasized that like crop farms gross margins from crop land in cattle farms would decline in a range between 5 to 20 % if short rotation forestry would be implemented on 25 % of crop land if moderate wood yields could be expected and own labour would be used for establishment and harvesting.

The respective net present values of gross margins for short rotation forestry activities are documented in part C of table 4.11. Expected gross margins from afforestation are about 30 to 40 % of expected gross margins from average crop production depending on farm size classes. If forest products would receive the same market support as agricultural products, gross margins of short rotation forestry would be about 60 % of those of crops. If forest products would be subsidized per hectare with the present average amount of the set-aside reward, afforestation would attain gross margins equal to crop production. The net present values of subsidies required to achieve equal gross margins between with and without afforestation are given in part D of table 4.11. These values would be smallest if the least competitive crops are replaced by afforestation. In this case they would be smaller than the average price support presented in part E of table 4.11. Without subsidies in the range of actual price support for cash crops, short rotation forestry would not be competitive. Due to the uncertainties with regard to yields and prices it will hardly be considered by farmers as a substitute for crop on production cattle farms.

Table 4.12 presents the results for afforestation of pasture land not required for dairy production. First it indicates that income on cattle farms could be increased if beef production will decline based on forage produced on crop land (part A). Therefore this land will not be considered for afforestation but for increased cash crop production. In part B of table 4.12 results for short rotation forestry on pastures are presented for pastures not needed for dairy production but for beef production. First the net present value of gross margins from afforestation are shown, second and third the respective values for the gross margins of beef production with world market and with EC-prices. If beef production on pasture is evaluated at world market prices beef production would be less competitive than afforestation. Under presumed EC-price conditions afforestation could become competitive with beef production if wood prices would slightly increase from about ECU 75 odt to ECU 85 odt depending on the prices and effectiveness of beef production in the respective farm size groups. Afforestation of pastures used for beef production would become highly competitive if this activity would receive support equivalent either to present average set-aside rewards or to present price support of beef production. To illustrate the results of the multiperiod farm simulation model figure 4.5 presents development of some gross margins for cattle farms of the size group from 50 to 100 hectares. The figure shows the high competitiveness of dairy production, the average gross margin for cash crops, for forest products with wood prices of ECU 75 odt and the low competition of beef production on pasture not required for dairy production.

5. Multiperiod analysis of technical and institutional change in the domain of renewable resources and food products

5.1 Ex ante evaluation of technical progress and institutional change

Ex post investigations of the social benefits and costs of institutional change and technical progress are based on the concept of economic rents (Just, Hueth and Schmitz, 1982, pp 33). The main problem is to determine the shift of respective supply functions and to calculate incremental changes in consumer and producer rents (Hertford and Schmitz, 1977, pp 148). With regard to markets where price stabilization programmes exist incremental changes in market intervention expenditure must be added.
Ex ante studies of the impact of technical progress and institutional change can be classified into four groups (Norton and Davis, 1981, pp 692): "a) those using scoring models, b) those employing benefit-cost analysis, c) those using simulation models and d) those using mathematical programming".

For our purpose, to evaluate anticipated technical progress and institutional change in the domain of traditional food production and renewable resources to be used as fossil fuel substitutes, a sectoral multiperiod simulation model was designed which allows for a multiperiod cost-benefit-considerations. The multiperiod simulation model results in projections for the supply and demand of the traditional food product and the amount of feedstock available for the production of fossil fuel or wood substitutes. Therefore, it is presumed that from a predetermined surface of land 1) wheat will be produced for internal demand, 2) wheat will be exported up to a certain quantity at existing world market prices, and 3) the remaining land can be used for feedstock production. Three feedstocks - wheat, sugar-beets and potatoes - will be utilized to produce ethanol. The fourth, rapeseed, will be converted into rapeseed oil and the fifth, short rotation forestry, supplies wood under world market conditions. Ethanol and rapeseed oil will substitute fossil fuel imports (petrol or diesel) also at world market conditions. Within the interdependent part of the model prices for wheat and for the renewable resources, and the distribution of a predetermined budget for market intervention between export subsidies for wheat and price supports for renewable resources will be determined.

Ethanol is a distinct commodity but the present large-scale ethanol industry dates only to 1980. The opportunity for improvements in costs and efficiency of conversion processes exist. In the near term, changes in technology will focus on fermentation, distillation, and energy utilization and in capital saving design of conversion plants. There are three new technologies in grain-based production which might be implemented in a large scale in the near future: " 1) the replacement of yeast with the Zymomonus mobilis bacteria, 2) membrane separation of solubles to reduce the energy required ... in the waste-water treatment phase, and 3) the immobilization of enzymes and yeasts..." (USDA, 1988, p 11). Beyond these specific improvements reduced operating costs will occur through inventions in process control and waste heat utilization. USDA concludes that in a period of 5 years additional operating cost savings of ECU 0.0125 per l ethanol are possible over the cost minimizing state-of-the-art technology.

Technologies that may prove to be beneficial in the longer run include alternative feedstocks. It is expected that plant breeding efforts will lead towards increased yields and augmented starch and sugar contents. This will reduce feedstock costs. USDA states further that mainly research in cellulose conversion and processing of renewable resources into energy substitutes (like ethanol) and better prices for chemicals might be a major development in agriculture. The key innovations are expected in the following fields (USDA, 1988, p 12): 1) micro organisms which efficiently ferment a broad range of sugars in addition to glucose, 2) processes which convert biomass materials into processed cellulose, lignin and hemi cellulose, 3) chemical modifications of cellulosic materials to products which substitute products derived from petrol sources, and 4) the implementation of an industrial infrastructure based on the utilization of renewable resources. To accelerate inventions in the above mentioned domain it might be important to switch research and development activities to favour the concept of agro-chemical-refineries.

Nevertheless, the precise outcome of these efforts on capital, operating costs and on supply prices of one final product - fuels from renewable resources - is uncertain but the efforts will reduce production costs because a higher ratio of agricultural biomass will be converted into fuels and/or chemicals.

b) Rapeseed oil

The processing costs to gain rapeseed oil from rapeseed are well known. Technologies are mature technical progress reducing processing costs to use first for meeting the internal wheat demand and second for export requirements. After these requirements have been met the remaining surface will be planted with crops to supply feedstocks for renewable resources.

Within the endogeneous part of the model five equations for each line of feedstock production determine the level of export subsidies, the level of price support for ethanol, rapeseed oil or forest products, the supply price of the renewable resources (wheat, ethanol, rapeseed oil or forest products) and the wheat price within the EC. In total, there exist five times five independent equations. For total export subsidies (E) the following equation is presumed[4]:

$$(5.1)\quad E_r = a_e\, Q_e \cdot (P_{i,r} - P_w)$$

where Q_e is the volume exported, $P_{i,r}$ means internal and P_w world wheat market prices and a_e stands for "income efficiency" of the export subsidy.[5]

Price support for renewable resources S_r is the difference between the supply price of the renewable resource (ethanol or rapeseed oil) $P_{s,r}$ and the import price for energy P_e weighted by the volume of the renewable resource which can be drawn from the feedstock volume Q_r and the conversion coefficient b_r:

$$(5.2)\quad S_r = b_r\, Q_r\, (P_{s,r} - P_e)$$

The supply price for the renewable resource from the respective feedstocks is calculated using the respective conversion costs C_r, the value of by-products $P_{b,r}$ and the feedstock price $P_{f,r}$:

$$(5.3)\quad P_{s,r} = C_r - P_{b,r} + (1/b_r) \cdot P_{f,r}$$

Further it is assumed that the total of export subsidies (1) and price supports (2) are equal to the total support budget M:

$$(5.4)\quad M = E_r + S_r$$

4 for presentation the time index t has been neglected, r stands for the respective biomass

5 for quantitative assessment (a_e) is assumed to equal 2.5. The internal wheat price depends on the raw material for renewable resources (r) (wheat, sugar beets, potatoes, rapeseed or forest products)

5.4 Assessment of welfare effects

As shown in chapter 2 agricultural policy changes have an impact on consumer and producer rents and they might change support budget expenditures. Rents and support budget expenditures might change as well due to technical progress. Therefore the following multiperiod cost-benefit-calculations are undertaken to calculate the incremental welfare effects:

Producer rent changes (= changes in total gross margins):

(5.9) $RP_r = \Sigma\ (1/1+i)^t\ [L_{r(t)} \cdot G_{r(t)} - L_{r(*)} \cdot G_{r(*)}]$

- * for reference situation
- r product lines
- i discount rate
- L land allocation
- G gross margin

Consumer rent changes:

(5.10) $RC = \Sigma\ (1/1+i)^t\ [P_{I(*)} - P_{I(t)}]\ Q_I\ [1 + z \cdot n_I]$

with $z = [P_{I(t)} - P_{I(*t)}] / 2 \cdot P_{I(*t)}$

- Q_I volume of internal demand
- $P_{I(*t)}$ reference price for food without technical progress and institutional change
- P_I prices due to policy change and technical progress
- n_I price elasticity

Support budget expenditures:

(5.11) $MR = \Sigma\ 1/(1+i)^t\ [M_{(r,t)} - M^*_{(r,t)}]$

- MR budget allocation
- M support budget without changes
- M* support budget after introduction of policy and technical changes

TABLE 5.2 YIELD AND COST STRUCTURE FOR DIFFERENT PRODUCTION OPTIONS OF RENEWABLE RESOURCES IN THE FIRST PRODUCTION PERIOD

basic food product feedstocks	yield 100 kg/ha	variable costs in ECU/ha 1)	conversion operating and capital costs per 1000 l renewable resource 2) in ECU	yield of energy substitute per kg feedstock
wheat	477	500	200	0.350
sugar beets	600	1350	200	0.097
potatoes	400	1350	200	0.108
rape-seed	25	500	100	0.380

1) including incremental labour opportunity costs for sugar beets and potatoes, therefore higher variable costs than within microeconomic evolution
2) see USDA and Barthel et al.

TABLE 5.3 YIELD AND COST STRUCTURE FOR SHORT ROTATION FORESTRY ON CROPLAND PER YEAR AND HECTARE

production period	yields bdt	variable costs in ECU		gross margins in ECU	
		own labour for harvesting 1)	hired labour for harvesting 1)	own labour for harvesting 1)	hired labour for harvesting 1)
1	0	2138	2138	-2138	-2138
2	0	707	707	- 707	- 707
3	0	185	185	- 185	- 185
4	0	185	185	- 185	- 185
5	60	1085	4685	3415	- 185
6	0	261	261	- 261	- 261
7	0	185	185	- 185	- 185
8	0	185	185	- 185	- 185
9	0	185	185	- 185	- 185
10	75	1310	5810	4315	- 185
11	0	261	261	- 261	- 261
12	0	185	185	- 185	- 185
13	0	185	185	- 185	- 185
14	0	185	185	- 185	- 185
15	90	1535	6935	5215	- 185
average	15	480 2)	750 2)	350 2)	70 2)

1) Harvesting costs: own labour 15 ECU/odt
hired labour 40 ECU/odt
2) Average after calculation of net present values, discout rate 3 %

III In addition to I and II technical progress reduces fixed conversion costs with a rate of 2 % p.a. and increases the yield of final products (ethanol and rapeseed) within the conversion process by 2 % p.a. as well.

IV In addition to III it is supposed that tax exceptions in an amount of ECU 300 per 1000 l ethanol or rapeseed oil respectively are granted due to environmental reasons.

With regard to commodity supply the different assumptions about yield increase result in the acreage allocation and ethanol, rapeseed oil and forest product supply as indicated in table 5.5. The costs and benefits for the different techno-institutional scenarios and the two different world market conditions are given in table 5.6. Net present values for costs and benefits for the reference situation and the four different scenarios are provided. The time horizon considered is 15 periods, and the social discount rate is 5 % p.a.

The reference situation results in a positive net present value of producer rent. In this situation biomass production does not take place. All wheat surplus is exported with export restitutions being 250 % of the price difference between domestic and world market prices. If ethanol production could be implemented with a deficiency payment system producer rent would decline. Producers' burden would be highest if access wheat land would be used for ethanol production with sugar beets and potatoes. Producers' disadvantage can be reduced by yield increasing and cost saving technologies (scenario II and III). Rapeseed production as a feedstock for fossil fuel substitution will reduce producer rent more moderately than wheat production for ethanol. Short rotation forestry is more favourable than ethanol from wheat and rapeseed oil production. Producer rent decline is stopped if short rotation forestry is implemented and if wood prices would increase to a level of ECU 100 odt. Producer surplus declines because prices for wheat decline due to the fact that the support budget is entirely used for the deficiency payments allocated towards ethanol or rapeseed oil price support respectively. As shown in figure 5.3 and table 5.8 EC-domestic wheat prices will fall under the level of presumed world market prices if biomass production is considered. The development of respective gross margins is given in table 5.7 and figure 5.2. The time when this happens depends on the feedstock used and the scenario considered. The higher the price difference between world fuel prices and domestic fuel substitute supply prices the more accentuated the prices for wheat will decline within the EC. Therefore under anticipated world market

TABLE 5.8 EVOLUTION OF DOMESTIC EC-WHEAT SUPPLY PRICES IN ECU PER TON FOR DIFFERENT TECHNICAL AND ISTITUTIONAL OPTIONS OF BIOMASS PRODUCTION

Period Year	1 85/86	3 87/88	5 89/90	7 91/92	9 93/94	11 95/96	13 97/98	15 99/00
Scenario/Production option								
World market wheat price	165	157	137	134	131	132	136	137
Reference situation	194	187	180	174	169	163	158	154
Ethanol from wheat I	194	179	165	152	140	129	118	108
Ethanol from wheat II	194	183	172	162	153	143	135	127
Ethanol from wheat III	194	183	173	164	155	147	139	132
Ethanol from wheat IV	194	189	183	178	174	169	165	161
Ethanol from sugar beets I	194	169	146	125	107	91	76	63
Ethanol from sugar beets II	194	172	152	134	118	103	90	78
Ethanol from sugar beets III	194	173	154	138	123	111	100	90
Ethanol from sugar beets IV	194	185	177	171	166	161	157	153
Ethanol from potatoes I	194	169	146	126	108	91	77	64
Ethanol from potatoes II	194	173	153	135	119	104	91	79
Ethanol from potatoes III	194	173	155	139	125	112	102	92
Ethanol from potatoes IV	194	187	181	176	172	168	165	163
Rape seed I	194	181	168	156	145	135	125	117
Rape seed II	194	184	175	166	157	149	141	134
Rape seed III	194	184	175	166	158	149	142	134
Rape seed IV	194	187	181	174	168	162	156	150
Short rotation forestry								
Forest products I	194	182	170	159	148	138	129	120
Forest products II-IV	194	185	177	168	161	153	146	139

TABLE 5.9 EVOLUTION OF BIOMASS SUPPLY PRICES IN ECU FOR DIFFERENT TECHNICAL AND INSTITUTIONAL OPTIONS OF BIOMASS PRODUCTION

Period Year	1 85/86	3 87/88	5 89/90	7 91/92	9 93/94	11 95/96	13 97/98	15 99/00
Scenario/Production option			in ECU/1000 l					
World market price for petrol	120	107	97	102	102	103	117	131
Ethanol from wheat I	734	694	657	622	590	559	531	505
Ethanol from wheat II	734	702	672	643	615	589	565	542
Ethanol from wheat III	734	716	699	684	669	655	642	630
Ethanol from wheat IV	734	732	731	731	732	734	736	740
Ethanol from sugar beets I	648	628	610	591	574	557	541	526
Ethanol from sugar beets II	648	614	583	554	527	502	479	458
Ethanol from sugar beets III	648	624	603	583	564	547	531	517
Ethanol from sugar beets IV	648	640	634	630	627	626	625	626
Ethanol from potatoes I	589	572	556	540	525	510	496	483
Ethanol from potatoes II	589	560	533	507	484	462	441	423
Ethanol from potatoes III	589	568	548	530	513	497	483	470
Ethanol from potatoes IV	589	584	580	577	576	576	578	580
World market price for natural oils								
Palm oil price	342	394	418	392	396	399	380	361
Rape seed I	1074	1052	1031	1010	988	968	947	927
Rape seed II	1074	1033	993	955	918	883	849	817
Rape seed III	1074	1067	1061	1054	1048	1041	1035	1029
Rape seed IV	1074	1083	1093	1102	1111	1120	1129	1138
World market price				in ECU/odt				
for forest products	75	75	75	75	75	75	75	75
Short rotation forestry								
Forest products I	62	61	60	59	57	56	55	54
Forest products II-IV	62	60	57	55	53	51	49	47

Description of scenarios and production options see text.

Figure 5.3 Evolution of gross margins on cropland for different biomass production lines

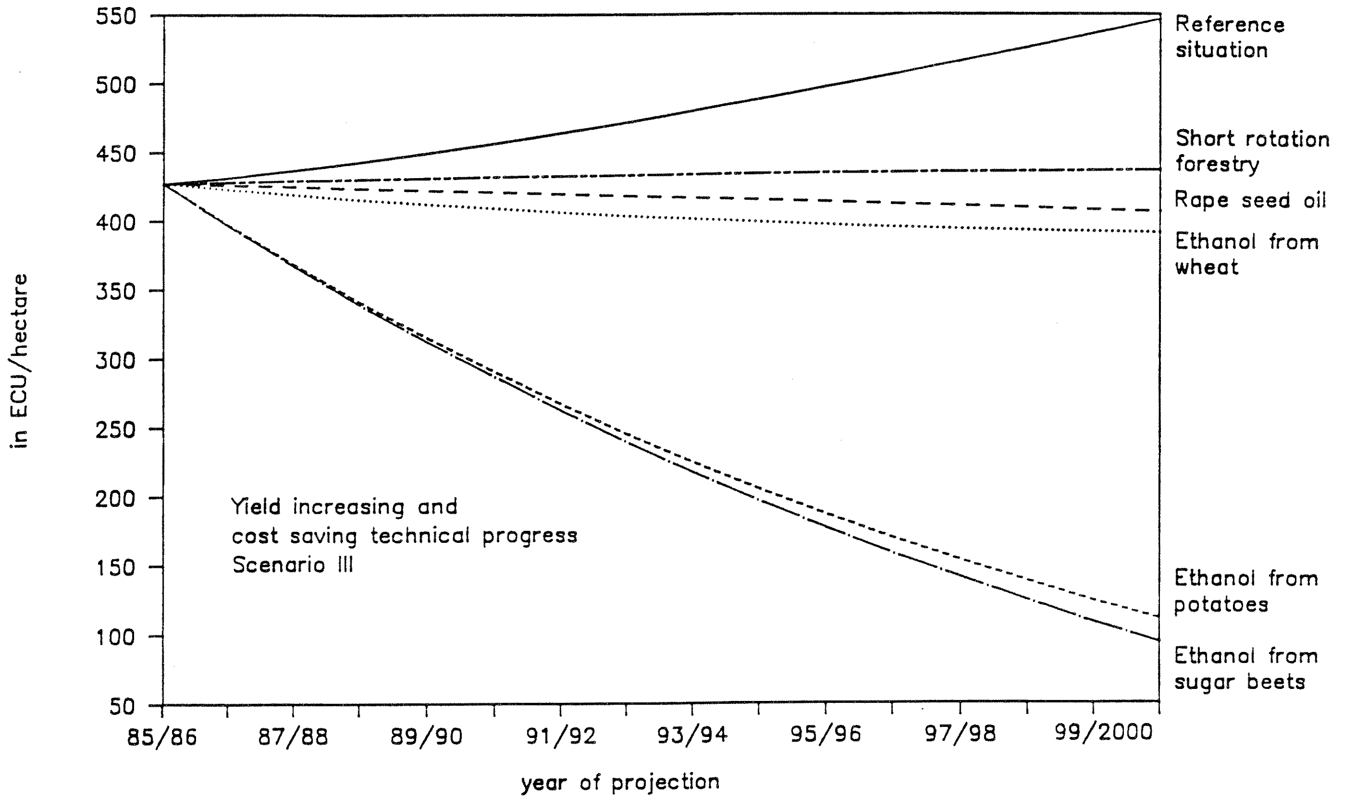
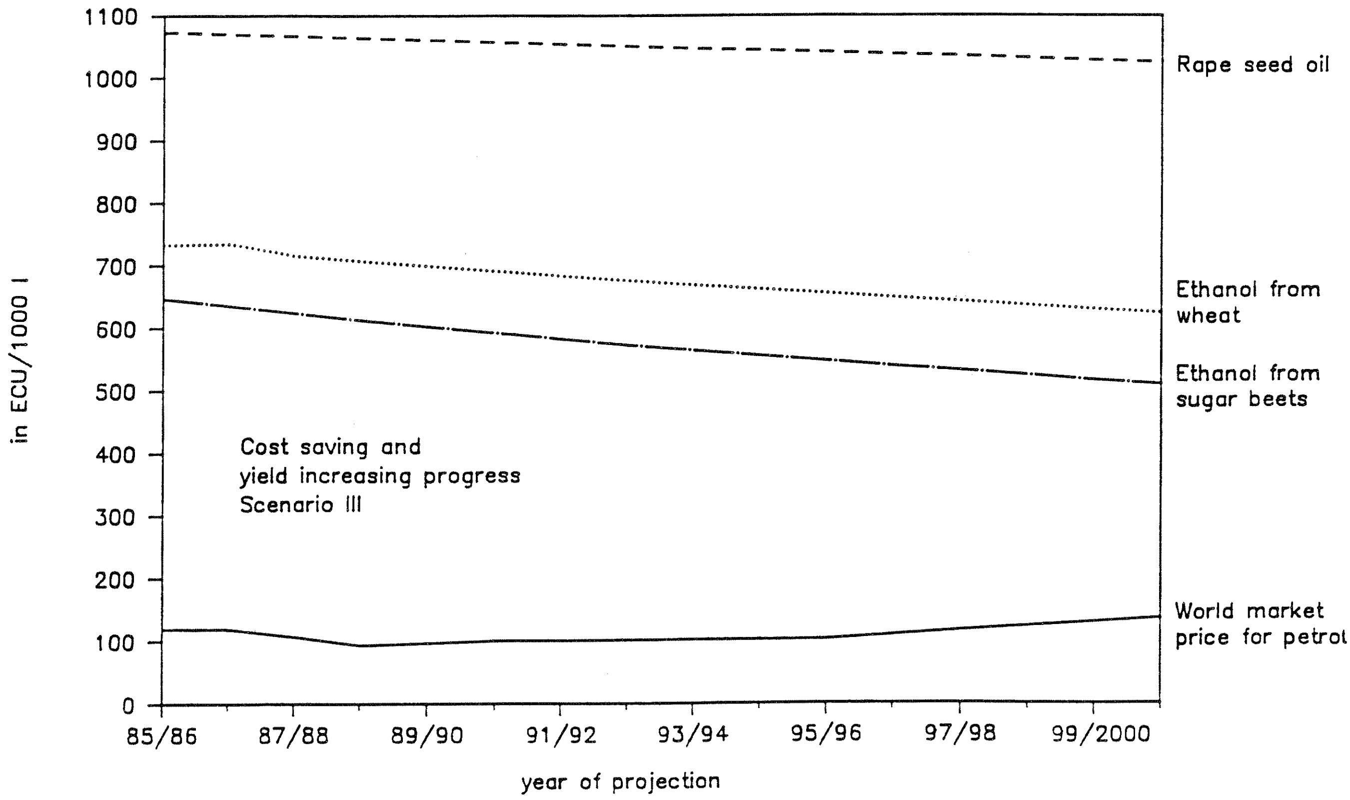


Figure 5.4 Evolution of supply prices for renewable resources



financial burden of the CAP. For the economic evaluation two types of multiperiod models have been designed: the first for on farm assessment and the second for sectoral analysis.

Public decisions within the EC about agricultural policy instruments strongly influence the distribution of welfare among three groups of economic agents: producers, consumers, and tax payers. Defining the public as consumers and taxpayers, public welfare is measured by public surplus being consumer surplus less budget expenditures for commodity programmes. Producer welfare is measured by producer surplus.

The concern of agricultural policy in renewable resources is mainly caused by the increasing surplus in traditional food production and the willingness to reduce energy imports. Interest groups asking for institutional and technical change in the domain of renewable resources are mainly farmers, suppliers of conversion plants, potential utilizers, tax payers and policy makers.

Opportunity costs for agricultural biomass for energy substitution for the evaluation of biomass policies and projects have to be world market prices. For the activity to evaluate biomass projects, land opportunity costs and feed stock opportunity costs have to be assessed. Biomass lines considered are ethanol, rapeseed oil and forest products. The following prices have to be considered: wheat, maize, soya for the assessment of feedstock and land opportunity costs; different world markets for natural oils which compete with the EC-internal rapeseed (and sunflower) production, forest products to evaluate the impact of afforestation and petrol prices to get the opportunity costs for the energy substitutes. The outcome of the market price evaluation are more or less constant agricultural prices and moderate increasing fossil fuel world market prices. Anticipated price evolutions do therefore not favour biomass production until the year 2000.

The <u>multiperiod on farm level model</u> concentrates on an assessment of short rotation forestry activities within the set up of crop and cattle farms.

The results on short rotation forestry on crop and cattle farms can be summarized as follows:
Due to the fact that agricultural production is highly protected within the EC, short rotation forestry is not a competitive cash crop on crop land. Only

IV in addition to scenario III

tax excemption for biomass products substituting fossil fuel imports.

The introduction of biomass production under anticipated world market and technical changes, presuming a constant CAP-support budget leads towards more declining producers' gross margins than in a situation where biomass is not produced but all surplus products are being exported.

The on farm and sector models can always be applied to show the welfare implications of a changing environment in a multiperiod framework.

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Supply of renewable resources

(A9) $Q_{r(t)} = Y_{r(t)} \cdot L_{r(t)}$ supply of feedstock, with r = 1, ..., 5

(A10) $Q_{S(t)} = b_{R(0)} \cdot e^{R(t)} \cdot Q_{(r,t)}$ supply of fossil fuel substitutes drawn from r = 1, ..., 5; b revers to the supply of fossil fuel to be drawn from one unit feedstock

(A11) $C_{(r,t)} = C_{(r,0)} \cdot e^{C(r)t}$ development of operating and capital cost of fossil fuel production

For the calculation of the values in the endogeneous part of the multiperiod simulation model assumptions have to be made about world market prices for wheat, by-products and fossil fuel (energy):

(A12) $P_{W(t)} = P_{W(0)} \cdot e^{W(t)}$ world wheat market prices

(A13) $P_{s(t)} = P_{S(0)} \cdot e^{S(t)}$ world soya market prices to assess by-product credits

(A14) $P_{E(t)} = P_{E(0)} \cdot e^{I(t)}$ world energy market price changes

The income per land unit for all production alternatives is given by the respective gross margins.

(A15) $G_{I(t)} = P_{I(t)} \cdot Y_{I(t)} - VC_{I(0)} \cdot e^{V(I)t}$
gross margin for wheat produced for internal demand

(A16) $G_{E(t)} = P_{E(t)} \cdot Y_{E(t)} - VC_{E(0)} \cdot e^{V(E)t}$
gross margin for wheat produced for exports

(A17) $G_{r(t)} = P_{r(t)} \cdot Y_{r(t)} - VC_{r(0)} \cdot e^{V(r)t}$
gross margin for respective renewable resource