

Final Report

For DARCOF II research projects financed by grants from
The Directorate for Food, Fisheries and Agro Business
under the Danish Ministry of Food, Agriculture and Fisheries

1. Research program

Research in organic farming 2000-2005 (DARCOF II)

2. Project title and number

III.2 Economic analyses of the future development of organic farming
Effects at the field, farm, sector and macroeconomic levels

3. Head of project

Research Director Søren Elkjær Frandsen,
Danish Research Institute of Food Economics (FOI)

4. Participating institutes

Danish Research Institute of Food Economics (FOI)
Danish Institute of Agricultural Science, Department of Agricultural Engineering
(DIAS-DAE)

5. Other project staff

Lill Andersen, Researcher, FOI-Policy
Martin Andersen, Research Assistance, FOI-Policy
Brian Jacobsen, Senior Researcher, FOI-Farm
Lars-Bo Jacobsen, Researcher, FOI-Policy
Jørgen D. Jensen, Senior Researcher, FOI-Policy
Paul Kledal, Research Assistant, FOI-Farm
Niels Madsen, Student, FOI-Farm
Villy Nielsen, Senior Researcher, DIAS-DAE
Claus G. Sørensen, Senior Researcher, DIAS-DAE
Niels Tvedegaard, Research Assistant, FOI-Farm
Jens Erik Ørum, Researcher, FOI-Farm

6. Project period (month, year)

Start of project: 1. October 2000
End of project: 1. January 2004

7. Final report

A. Project summary

Table A.1: Work package list (from application)

No.	Work package title	Responsible Participants*	Budget (1.000 DKK)	Start	End	Deliverable no(s):
1	Labour and machinery systems in organic farming	DIAS-DAE	1,400	1.10.00	1.10.03	1,2,3
2	Organic farming at the farm level. A study of the conversion process.	FOI-Farm	1,860	1.01.01	1.10.03	4,5,7,8
3	Economic Analysis of organic farming at the regional level	FOI-Policy	0,500	1.11.01	1.07.03	9,10
4	Development of a dynamic general equilibrium model with organic farming	FOI-Policy	0,935	1.01.01	1.06.02	11,12
5	Economic analysis of organic farming at the sector and macroeconomic level	FOI-Policy	0,935	1.06.02	1.01.04	13,15

B. Objectives and expected achievements

B.1. Objectives

The objective of this research project is to analyse the future development of organic farming in Denmark from the field, farm, sector and macroeconomic perspectives. Emphasis will be placed on the economic impacts of a continued expansion of organic farming in Denmark taking into account the adjustment problems of converting conventional farming into organic farming. Part of the research will also be devoted to analysing the regional effects, the impact on various environmental indicators of organic farming as well as the economic effects of policy initiatives in general (i.e. changes in agricultural and environmental policies).

The research project is characterised by co-ordinated efforts from the field level to the farm, sector and macroeconomic levels. At the field and farm levels the project will focus on the specification of labour and machinery systems in organic farming. Furthermore, the implications for total production costs and cost structures for different farm types will be determined. Given these and existing data for cost structures in conventional and organic farming, existing farm, sector and macroeconomic models will be adjusted and extended to incorporate the information obtained through this research project. Key words for the research efforts are the analyses of barriers to entry, the effects of uncertainty with respect to future markets and prices for organic products, impacts of different policy initiatives as well as the dynamic processes of converting Danish conventional farming into organic farming.

A core activity of the project will be to undertake a number of illustrative scenarios describing the economic effects at the farm, sector and macroeconomic levels. The scenarios will be co-ordinated across all work packages. The scenarios will include both the construction of a baseline scenario describing possible perspectives for the

future expansion of organic farming in Denmark as well as a number of policy, regulatory and technology scenarios.

The results of the research project will illustrate the impacts of different designs of agricultural and environmental policies on the agricultural sector in general and on organic farming in particular. Furthermore, the results from the field and farm level analyses can be used to support farmers in converting to organic farming and to develop organic production systems.

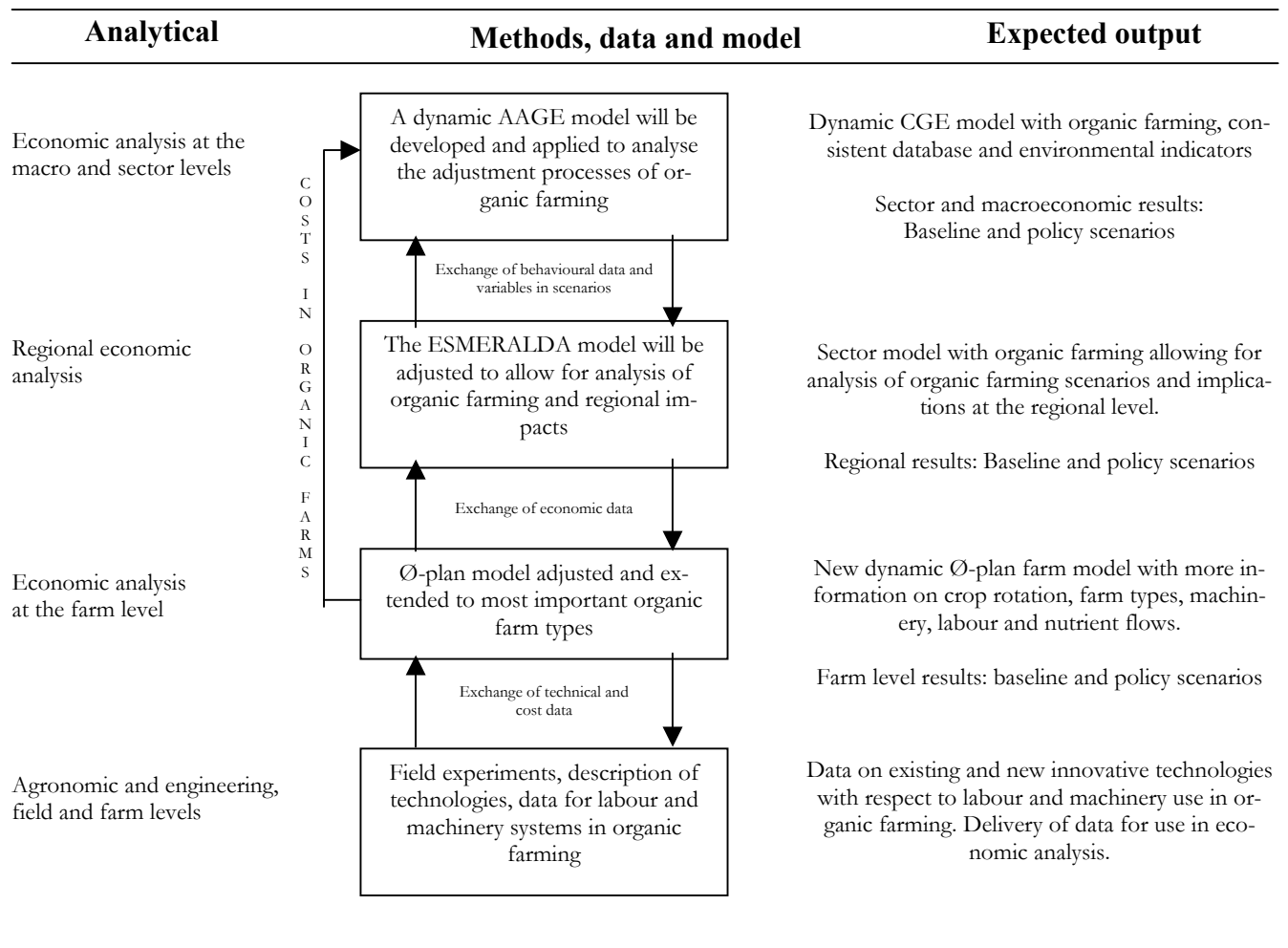
Finally, the results from the research project will be made available to the public through the FOI web site as well as through the publication of working papers, articles and research reports. Moreover, the research group is planning to arrange a final policy workshop with the objective of discussing methodology, data and policy implications.

Figure 1 illustrates the overall structure of the research project. The research project is divided into four analytical levels, ranging from research at the field level through the farm, regional and sector and macroeconomic levels. The project represents a unique integrated approach in the sense that the efforts are closely co-ordinated across the four analytical levels while at the same time the applied analytical methods differ reflecting their appropriateness for analysing the particular questions at hand at the different levels.

B.2. Expected results

The major planned achievements was:

- **Field and farm levels:** A description of the labour and machinery demand and costs involved in different organic lines of production dependent on different technological assumptions (existing and new innovative technologies).
- **Field and farm levels:** An analysis of the cost, direct energy use and impacts on environmental indicators of different organic production systems (existing and new innovative technologies).
- **Farm level:** Development of a farm model (Ø-plan) covering the most important organic farm types.
- **Sector and regional levels:** Adjustment of a sector econometric model ESMERALDA to describe and analyse organic farming at the regional level.
- **Sector and macroeconomic levels:** Development of a dynamic general equilibrium model for the Danish economy with organic farming included.
- **All levels:** Establishment of an overall consistent model structure – where consistency is established from the field to the farm, sector and macroeconomic level. Given the model structure the research team will be able - with relative short notice – to analyse the economic effects and impacts on environmental indicators of new policy initiatives.
- **All levels:** Construction of a consistent baseline scenario illustrating future developments of organic farming in Denmark dependent upon a number of different supply, demand and policy assumptions.
- **All levels:** Economic analyses of a large range of different agricultural, environmental, regulatory, and technology scenarios of which a number of scenarios will be co-ordinated across all 5 work packages.

Figure 1. Overview of the research project

C. Progress and results

C.1 Description (summary) of main results and conclusions

WP1. Labor and machinery systems

At the agronomic, engineering and field level the main results include extending and improving the data on labour and machinery demand for individual operations as well as for whole farm systems in organic farming. The methodology has included on-farm analyses, operations analyses for specific farm scenarios, and impact analysis of selected technology adoptions.

On-farm analyses

Existing labour and machinery data has been reviewed and missing data and knowledge have been identified (Sørensen & Nielsen, 2002). Ways of acquiring missing information and data have been evaluated. The use of traditional labour studies have been discarded in favour of both close-ended and open-ended questionnaire designed specifically for data acquisition on management tasks in 18 selected production systems, evenly divided between plant, cattle, and pig production systems. The design of the questionnaires included a carefully developed data collection protocol

to avoid bias in the process of data acquisition. In the same way, the survey on supplemental labour data for out-doors pig production included self-administered questionnaires containing close-ended questions on the daily and periodic labour requirement pertaining to the tending of pigs in out-door confinements. Six organic pig farmers were selected for this survey. The sampling method in both surveys was a combination of judgment sampling based on the assessments from agricultural advisers and a snowball sampling taking advantage of the respondents' ability to identify the population under study

The results of the empirical studies on the managerial efficiency for different organic production types indicated that the average management efforts ranged from 13.7 to 19.0% of the total labour input with a gross average of 15.8%. Statistical testing of the three means shows that a hypothesis of the means being equal can not be rejected ($p > 0.05$). Also, the labour and technical investigation into the organic pig production has revealed that the work operations are implemented in a rational way (Nielsen *et al.*, 2003). The layout seems to concentrate on having sows and piglets in out-door pens, while fattening pig are stalled in-house with access to out-door areas.

Farm scenarios

Scenario planning has been used as the method of combining factual data and expert evidence to create imaginable and credible scenarios envisioning possible futures. Through this interactive process a technical and biological description of a number of model farms representing different organic production systems (plant, cattle, pigs, mixed, vegetable, *etc.*) have been envisioned (Nielsen *et al.*, 2003). The description involves organic farm types, which are plausible and internal consistent in terms of logically following what is currently known and expected in the near future (Table 1)

Based on the information in Table 1 the model "Ø-plan" was used to quantify a number of prerequisites constituting the basis for the subsequent operational analyses. By using selected parts of the model a number of prerequisites including crop plans, fertiliser plans for animal manure, crop yields, feed production and feed plans, individual crop treatments, and execution time for treatments were derived. Additionally, the machinery complement was selected and dimensioned based on a requirement assessment fulfilling average timeliness thresholds. Upon quantification of all prerequisites, an operations analysis was carried out based on a generalised operations model (Nielsen *et al.*, 2003).

Specifically, the labour requirement on out-door pig production was based on norm data derived from the previously mentioned study of six pilot farms. The model was able to estimate the detailed labour and machinery demands and evaluate the scheduling of the operations to be performed. The labour requirement was estimated for an operation, a specific production, or the whole farm given technical-biological prerequisites like machinery system, machinery size, field size, crop yield, and with the intention of only identifying system related differences. The management tasks were estimated according to the results from on-farm analyses.

Table 1
Farm scenario description (adapted from Nielsen *et al.*, 2003)

	<i>Farm scenario Id</i>							
	<i>P0</i>	<i>P1*</i>	<i>P2</i>	<i>P3</i>	<i>M1</i>	<i>M2</i>	<i>M3</i>	<i>SI</i>
<i>Crops, ha:</i>								
Barley/underseed	10	10						10
Spring barley					20	25		10
Rye grass	05	05						
Grass clover	05	05			60	75	60	
Fallow grass clover								10
Oat/underseed	10	10		05				10
Sugar beets		04						
Carrots		01						
Peas	10	10		05				
Triticale/catch crop	10	10						
Potatoes	10	05		10				
Alfalfa			26					
Fallow grass			04					
Winter wheat			15					
Spring wheat						25		
Maize for silo				10	20			10
Barley/peas/whole crop			15	10	20	25	30	
Lupine				10				10
<i>Animals, number:</i>								
Cows					75	110	93	
Sows								70

* An alternative crop plan to P0 including carrots and beets. P1-BS and P1-RW have the same alternative crop plan but new technologies, band-steaming (BS) and robotic weeding (RW) respectively, are introduced. The farms labelled "P" in table 1 are solely plant production systems with the exception of P3 which have some feeding stocks. The "M" labelled farms are milk production systems and the farm labelled "S" is pig production systems with outdoor sows and piglets.

Cases of technology adoption

The continued development of organic farming requires that innovative technologies is introduced to fulfil the increasing professionalism, specialization and consideration for rational production. Two cases of technology adoption were envisioned focusing on labour intensive areas of organic production, like the substitution of manual weeding with mechanical weeding (Sørensen, 2001; Sørensen et al. 2004). Technologies that might be implemented in the next 5 years have been selected for further elaboration within the scope of case farms. As examples, the new technologies chosen consist of weeding robot and band-steam weeding aimed at reducing labour requirement. The technologies chosen will increase the capital invested, as it is assumed that a change towards more labour intensive farming is not likely. The selected technologies are either available or have been tested as a pilot technology, why they are probably available within the next 5-10 years.

The two technologies comprise a developed new prototype of an integrated machinery system for weeding involving band-steaming for intra-row weed control and a prototype technology based on a small autonomous vehicle, equipped with RTK-GPS for precision guidance, computer vision for plant recognition and active tools for weed removal. The band-steaming system can have a capacity range of 0.2 – 0.4 ha h⁻¹, while capacity of the robotic weeder may vary from 0.18 to 0.54 ha h⁻¹.

Operations analysis

The operational technical evaluation of the model farms has included both traditional working methods and innovative technology adoption scenarios (Table 2). The labour input, performance data and relevant economic parameters for these technologies were based on preliminary test data and deliberated assessments.

Table 2

Farm size, number of animal units (LU), labour demand and annual work input (Nielsen *et al.*, 2003)

Model farm	Area	Number	Labour demand		Number
	ha	LU*	h ha ⁻¹	h LU ⁻¹	Annual work input**
P0	60		16,6		0,6
P1	60		25,3		0,9
P1-RW	60		15,1		0,5
P1-BS	60		15,2		0,5
P2	60		6,5		0,2
P3	50	15	10,9	37,1	0,7
M1	120	112	6,4	23,9	2,1
M2	150	168	6,7	19,4	2,6
M3	90	139	6,1	21,2	2,1
S1	60	73	7,9	39,6	2,0

* LU = livestock unit

** The annual work input contains of 1665 hours of work a year.

The labour demand has been estimated for each of the model farms in Table 2. The labour requirement is relatively high for the model farm P0. The considerable input of labour is caused by the growing of potatoes on 17 % of the total adjoining area. In the case of P1, potatoes, sugar beets and carrots are grown on 8.3 %, 6.7 % and 1.7 % of the area, respectively. The introduction of a new crop plan in P1 involving sugar beets and carrots increase the labour demand by 53% compared to P0 due to the manual weeding and the cleaning and sorting of the carrots. Maintaining the altered crop plan and introducing robotic weeding and band-steaming for weed management in sugar beets reduces the labour demand by 85 % and 83 %, respectively. The reduction in labour demand for the carrots equals 60 % for both technologies, because still much manual labour must be devoted to the cleaning and sorting of the carrots.

The amount of labour input differs considerably between the different production configurations within the plant production system but also the allocation of the labour input during the year is affected. Model P1 demonstrates a high labour demand for manual weeding operations in sugar beets and carrots and it is concentrated in the summer period, where the other scenarios are low on labour demand in this period. In general, the model farms P0, P1-RW, and P1-BS reflect the seasonal pattern of work throughout spring and autumn (Nielsen *et al.*, 2003).

The yearly labour input for the arable farms range between 0.2 and 0.9 of the annual man work of 1665 hours in the organic plant production systems. The operations performed by a contractor in the various scenarios range from 7 % to 65 % of the overall field work. The use of contractor is more widely adapted by the dairy farms, where specialised machinery are needed in the case of manure handling, silage making, combine harvesting, *etc.* The contractor estimations are based on an assessment on whether the use of contractors offers an advantage to the farmer in terms of work

scheduling.

In summary, results show that the labour demand range from 6.1 to 16.6 h ha⁻¹ for fieldwork and from 16.5 to 39.6 h LU⁻¹ for work in the animal houses. The introduction of sugar beets and carrots into a specific crop plan increases the labour demand by 53% caused by the manual weeding and the cleaning and sorting of the carrots. By maintaining the altered crop plan and introducing the new technologies like robotic weeding and band-steaming for weed management in the production of sugar beets the labour demand is reduced by 85% and 83%, respectively.

WP2. Organic farming at the farm level

The analyses at the farm level have involved the extension of Ø-plan with a dairy module. Then the economic result for the case farms described in WP1 was calculated and the impact of new technology and legislation was analysed. Last part of the work constituted the data transfer to WP 3 and 4.

Extension of Ø-plan

At the beginning of the project the extension of the Ø-plan model with more enterprises and more crops was accomplished. With the addition of the dairy production module to the existing toolbox consisting of organic pig, arable and poultry farms all the major production enterprises are now covered. The model is a spreadsheet model, which carries out economic calculations over a six-year conversion period. The concept and some results are presented in Tvedegaard, 2002.

The calculations are based on the recent changes within the sector including a) the milk price premium has been reduced to 15%, b) the 100% organic feed requirement have increased the feeding costs. The conclusion from the simulations is that the economic results on organic dairy farms with a livestock density under 1,25 LU (Livestock unit) per hectare are better than conventional farming, whereas the opposite is the case for farms with more than 1,25 LU per hectare. It is therefore not profitable for intensive dairy farms to convert to organic farming. Furthermore, the analysis shows that the drop in organic grain prices in 2002 by 20% would increase the profit on intensive dairy farms, which buy feedstuff and reduce the income on extensive dairy farms, which sell cash crops. The calculations from the model have been used to assist the government in the considerations regarding a change in the structure of subsidies for organic agriculture in Denmark (Tvedgaard, 2002a-d).

Case farm analysis

It was decided to base the technical and farm level analysis on a case study approach where the case farms should constitute the organic farms of the future. The analysis of the present trends have shown that:

- a) Some organic dairy farmers with low productivity will leave farming as their income is declining;
- b) The number of conventional dairy farms converting to organic farming will be reduced to almost zero due to the high supply of milk compared to the demand;
- c) Farmers converting to organic farming will mainly consist of part time arable farmers and some pig farmers.
- d) The arable farms converting will become bigger. The farms converting or-

ganic production used to be hobby farms of 5-10 ha, but they are now part time farms of 20-50 hectares (Kledal, 2001c).

The actual development from year 2000 to 2003 has generally followed these predictions. Not included is that some part time arable farms have been converting back to conventional production probably because the requirements related to organic production does not always fit in with having a full time job outside the farm.

The case farms are constructed with these trends in mind and include the regional perspective on the conversion rate in order to support the analysis carried out in WP3. Scenario planning is used as the method of combining factual data and expert evidence to create imaginable and credible scenarios envisioning possible futures. Through an interactive process between research experts and agricultural advisors is a technical and biological description of 8 organic case-farms encountering 4 arable, 3 dairy and a single pig farm are envisioned (Nielsen *et al.*, 2003). The farming systems are based on very detailed descriptions of the current technology, crop rotation etc., which has been established in close cooperation with WP1 and through talks with e.g. local advisors in organic farming. The case farms are based on actual farms, and some of the owners of these farms have been interviewed in the beginning of the project.

To be able to build on the detail specifications regarding labour and machinery use, it was decided to build a FØJO-II model, instead of including this in the Ø-plan model. The FØJO-model is then used to calculate labour and machinery costs for the baseline and the scenarios. Results regarding machinery use, machinery costs and labour use are calculated at the crop, crop rotation and farm level. The model is as oppose to Ø-plan not dynamic in nature.

A comparison between machinery costs on organic farms and conventional farms based on study farms (dairy) does not seem to show significant differences. The conclusion is furthermore that the machinery costs on the case farms are a little lower than similar organic farms, which is probably due to the optimised machinery, which is used resulting in lower machinery capital per hectare.

The FØJO model includes a calculation of N- and P-surplus at the field level. The analyses show that the organic farms have a relative low N-surplus per hectare compared to conventional farms with the same stocking density. The N-surplus is highest on the dairy farms and lowest on crop farms. The P-surplus is below 10 kg P pr. hectare except for the pig farm.

In the baseline scenario the profit on the arable farms is negative, whereas it is positive on the pig farm (+200.000 DKK) and quite high on the dairy farms (+400-450.000 DKK). In general the income on the case farms are better than expected based on the results from all organic farms for the year 2000. The main explanations are higher yields and lower machinery costs.

Scenarios

The aim of the scenarios is to analyse the potentials and consequences of legislative changes and new technologies in organic farming. For the case farms the consequences on labour input, machinery input and operational cost are calculated.

The legislative changes have their focal point in the organic philosophy and could overall be described as a step towards a 100 percent organic production. The changes constitute 100 percent organic feed and straw as well as 100 pct. organic manure. The effects of such innovative and legislative changes have been evaluated with respect to input, operational costs and benefits.

The most relevant innovative technologies in an organic setting have been selected. The technologies include automatic milking, GPS controlled allocation of manure, band-steaming and robotic weeding for intra-row weed control. The first two technologies have the potential to be adopted by both conventional and organic farms, whereas organic farms mainly will adopt the weeding technologies.

Change in legislation

Based on national balance between supply and demand of organic nitrogen it is calculated that the price of N will almost double to 10 DKK pr. kg N. The analysis show that dairy farms will profit as they sell manure to crop farmers. A ban on conventional manure has a significant negative effect on the profitability of the crop producers. These farms will loose approximately 70.000 to 100.000 DKK while the dairy farms increase their profit by about 100.000 to 200.000 DKK. The geographical location constitutes a problem, as the dairy farms are mainly situated in the southern part of Jutland.

The restriction on the use of straw would increase the profitability of the crop producing case farms by 0 to 15.000 DKK while lowering the economic outcome by up to 2.700 DKK at case farms with animals.

Finally, the import of conventional feed is worth approximately 98.000 DKK at the case farm raising pigs, why a ban on conventional food would reduce the income of pig farms significantly.

In general the more restrictive legislation reduces the income on the type of organic farms, which already have low profit levels (arable and pigs), whereas it increases the profits on dairy farms, which have the highest profit levels in the organic sector. The more restrictive legislation will therefore not encourage more farmers to convert to organic farming unless either the prices or the subsidy levels are increased.

New technologies

The analysis indicates that some innovative technologies do increase the profit at some of the case farms, but also that the technologies do not influence the income on all farms. The economic benefits of automatic milking are limited, but probably positive if the utilisation of the robot is high. The potential of GPS controlled allocation of manure is most likely limited because of the highly uncertain effect on the crop yield.

On the other hand robotic weeding and especially band-steaming is expected to have great perspectives with respect to production of organic vegetables. Band-steaming and robotic weeding does decrease the operational costs while producing carrot and sugar beet by approximate 8 – 9,000 DKK per hectare. Such a reduction in operational cost is expected to have the potential to increase the production, as it will lower consumer prices of labour intensive organic vegetables.

However, the effect on the total operational cost in the organic arable farming is limited as the effects are mainly on crops like carrots and sugar beet, which constitute a small part of the total organic area.

WP3. Organic farming at the regional level

The research undertaken in WP 3 has yielded results in terms of new insights in the regional impacts of organic agriculture, but the research has also led to methodological advances. Results are summarised under two headings in the following.

Regional insights in organic agriculture

Where should organic food production be located? Four different concerns play a role in this respect, namely i) economic efficiency in production, ii) environmental concerns, iii) employment and rural development concerns and iv) distance to consumers.

In the Danish case, these concerns however contradict each other to some extent. Concerns for economic efficiency, environment and employment/rural development suggest localisation of organic production in the most animal-dense and rural regions in Jutland. On the other hand, concern for distance to consumers (and impacts on transport activity and associated externalities) would suggest locating the organic production in the eastern part of Denmark – close to Copenhagen.

During the last decade, production activities in the organic farming sector have become increasingly concentrated in the western parts of the country. For example, Jutland's share of the area cultivated according to organic principles has increased from 62 per cent in 1990 to 85 per cent in 2001, and around 90 per cent of milk is produced in Jutland, which is also the result of an increasing trend.

A projection of the future regional development in organic farming has been undertaken in coordination with the analyses in WP 5, implying an overall decrease in cattle and crop production and an increase in pig production in the years to come. The overall degree of regional concentration is projected to be more or less unchanged. On the one hand, a decrease in organic cattle production (which has a relatively high concentration in Jutland) will tend to reduce the degree of regional concentration. On the other hand, a moderate increase in organic pig production and a decrease in organic crop production point in the opposite direction.

The regional impacts of technological advances relevant to organic farming have been investigated. Specifically, introducing automatic milking and band-steaming have been addressed. Introduction of automatic milking in organic dairy farming may stimulate organic milk production – at the highest rate on the islands, but the largest absolute extent in Jutland. As the cost saving due to automatic milking is low, this impact is however considered to be relatively small.

Regional consequences of increasing the requirements to organic farming have been analysed. The assumed extra requirements imply that applied feeds and animal manure should be 100 % organic (as opposed to currently 75 %). These requirements impose an increase in the unit value of organic feeds (to the benefit of crop production and cost of livestock production) and of organic manure (to the benefit of livestock production and costs of crop production). Increased organic feed prices tend to

improve the balance between the organic livestock and crop production, which may attract the livestock production to the islands or alternatively the crop production to Jutland.

Methodological advances and insights

The amount of data available for regional analysis of organic farming has been limited. Hence, a major methodological contribution from the research in this project has been to develop approaches to analyse the regional development of organic farming with limited data availability.

A database for organic farms has been established. The database includes information about land use, livestock holds, labour, capital, production, revenues, costs and agricultural income for approximately 300 organic farms at the farm level, based on agricultural accounts data.

Behavioural parameters for organic farms have been estimated. Due to relatively limited data material, it has not been possible to estimate such behavioural parameters for organic farms using standard econometric techniques. Instead, a methodology for estimating/calibrating behavioural parameters for organic farms has been developed. The procedure takes into account information from corresponding econometrically estimated parameters for conventional farms, as well as the specificities of organic farming (different input structure, crop composition etc.). Four sets of behavioural parameters for organic farms have been estimated: crop farms, cattle farms, pig farms and part-time farms. Combined with the established database, the parameters enable simulations of the adjustments to e.g. price changes at the farm level.

A methodology for representing organic farming at the national and regional level using the farm accounts database, has been developed. The approach aggregates farm-level data to the national and regional level in a way that ensures maximum consistency with official numbers concerning e.g. number of farms, land use etc. in specific regions.

Data, behavioural parameters and aggregation procedure for organic farms have been combined with corresponding data and parameters for conventional farms in an integrated agricultural sector model – ESMERALDA. The integrated model enables simulation of adjustments to changed economic conditions for approximately 300 different organic farms and 1500 conventional farms, and the consequences of these adjustments at the national and regional level. The developed model has been applied for the above-mentioned analyses, and will also be useful for future analyses related to organic farming at the regional level.

A stationary Markov chain model describing the organic farm structure development has been developed and estimated using a Maximum Entropy approach, based on farm structure data from Statistics Denmark. The model describes the development for four farm types (crop farms, cattle farms, pig farms and part-time farms), each type divided in seven size categories. This structure enables the modelling of trends in the distribution of farms between lines of production as well as trends toward concentration of organic farms in two size groups: small part-time holdings and large professional farms.

A methodology for incorporating the effects of new technology in organic farming into the database and sector model has been developed. Analyses in WP2 have led to

results concerning changes in cost structures on organic farms due to the introduction of these new technologies (e.g. decrease in labour unit cost and increase in capital unit costs, etc.). Such changes have been used for modifying the cost data for the farms in ESMERALDA, thus enabling analysis of these new technologies in this model framework.

WP4. Development of a dynamic model with organic farming

The organic dynamic version of the AAGE model is now developed and fully operational. Data from work package 2 and 3 has been included successfully in the model and the linkages to the other research packages have therefore been guaranteed. The model is now capable of simulation the development of organic farming from the short run to the medium and long run taking into account parts of the dynamic adjustments processes necessary to convert conventional farming into organic farming. Most of the challenges, which has prolonged the development of the model significantly, has been the implementation of the theoretical microeconomic foundation allowing for in particular the short run dynamic behaviour in organic farming. The development of the model has been the interchange between model implementation and an intensive testing and evaluation of the simulated results.

The developed theoretical specification of the model describes the short and long run behavior in the agricultural sector with specific features regarding:

- The allocation of land between agricultural sectors (organic and conventional) is determined in the short run by sector specific rate of return to land and by a parameter representing the land allocation elasticity, which indicates the speed of conversion. In the long run rate of return to land is equalized across all the land using sectors.
- The model covers land under conversion to organic production on a net-basis. I.e. only if the total organic land increases conventional land will be allocated to organic production; and only if total organic land decreases organic land will be allocated to conventional purposes.
- Organic land using sectors produces two commodities, an organic and a conventional product. The mix is determined by the fraction of land being fully organic in the specific sector.
- Further, an environmental sub module has been developed linking the emission of 8 emission types contributed by the use of 40 energy commodities to the core model. Furthermore agricultural specific nutritional balances for nitrogen and phosphorus have also been developed.

These new theoretical and quantitative features represent important new contributions within the areas of applied general equilibrium models. Further, the developed model is clearly the first of its kind not alone in Denmark but also internationally. In particular, developing dynamic economic models simulating short and medium term forecasts is clearly among the most challenging task for model builders as the model and data requirements are very high.

In the projects second year ambitions were expanded and several months of research was devoted to the construction of a credible historical simulation for the period 1995 to 2002 in which the model tracks the historical development of e.g. organic farming and explains the contributing forces behind the build up of excess or-

ganic production. This task was somewhat more demanding than expected and the research has clearly identified new areas of research and tasks to be performed in the future to further develop the applied general equilibrium economic models to better track the development of given production sectors in a macroeconomic and theoretically consistent set-up. These aspects also relates to the possibility within the framework of the economic model to analyze and explain the contributing factors (e.g. conversion period, organic subsidies and behavior in the processing industries) behind the excess production in the organic sectors in the short run. Although the research did not result in a fully acceptable version of the model to explain the historical developments, several technical insights and new modules have been identified and developed to be further exploited in future research.

The developed model, being general in as so far as it covers not alone organic farming but also the other primary agricultural sectors, the processing industries as well as the rest of the Danish Economy (i.e. the whole food chain is represented) will definitely be of use for applied research as well as studies undertaken for the Danish Government in the future. In particular in those cases where the analysis is of general nature the studies will automatically include the consequences for the production and consumption of organic products, i.e. future changes in the Common Agricultural Policy and the environmental, structural and macroeconomic policies. In that respect the developed tools will be of use in future economic studies and possible new research projects with an economy-wide perspective.

WP5. Organic farming at the sector and macroeconomic level

The identification of the important principles for constructing a baseline using the dynamic AAGE model has been completed and a credible baseline for the fully developed model, including the 10 primary and 9 processing organic sectors have been constructed for the period 2003 to 2020.

The baseline includes result for the Danish economy for each year in the period 2003 to 2020. The macro economic development is determined by a likely growth path, given by exogenous assumption for aggregate public and private consumption, investment, net export, employment etc. In the first years these exogenous assumption are based on forecast from the Danish Economic Council, while the reminder of the period is based on an average of the first part of the period.

Furthermore, all ongoing policy developments and known shocks to the economy are included in the baseline to ensure that the subsequent policy scenarios are undertaken in an economy where all known developments and shocks are accounted for. These considerations apply especially to changes in the common agricultural policy. One other important assumption applied is that the market for organic milk will be in balance within the first 10 years of the projection period.

Given these assumptions the model then endogenously determines the future development in each of the included sectors. That is the model will typically determine changes in the sectoral production and input demand for labour, capital, land as well as for intermediates taking into account changes in relative prices.

Due to the 2003-reform of the CAP (The Midterm Review) it was decided to expand

the baseline analysis into two parts. First, a baseline excluding the decided reform and second a baseline in which the reform package is included. Thereby the study allows a description of impacts of the 2003 CAP reform. The combined scenario (the baseline inclusive the reform) constitutes the starting point for the subsequent policy scenarios.

The most important insights from the baseline can be summarised as follows:

- A modest increase in the production of all organic products except for milk and roughage;
- An increased consumption of organic products throughout the period;
- A moderate increase in exports;
- Despite the positive developments for production, consumption and exports, a significant fall in the organic agricultural land is predicted. This is explained by the assumed balance in the market for organic milk as the production adjusts to demand;
- The implementation of the 2003 CAP reform has a positive impact on organic agricultural land but less so on organic production. That is, the reform implies an extensification of the organic production.

The full description of the results is published in the final version of a FOI report as well as in one of the planned Policy Briefs from the research project.

In addition to the constructed baselines, a number of policy scenarios have been analysed, namely:

Scenario 1: A legislative scenario (100 percent organic farming)

Scenario 2: A technological scenario (increased productivity in organic farming)

Scenario 3: An increased domestic and foreign demand for organic products

Scenario 4: An increase in the subsidies to organic land

Scenario 5: An increased taxation of environmental harmful inputs

Scenario 1 and 2 are project wide scenarios and results are comparable with scenarios in the other work packages. Included in scenario 2 are results for changes in inputs from Work Packages 2. Scenario 3-5 all aims at positive effects for the organic sector using different methods. Scenario 3 assumes changed preferences towards organic products in Denmark and increased export opportunities on foreign markets. In scenario 4 we assume that policy makers increases the level of organic subsidy, while in scenario 5 policymakers issues new taxes on environmental harmful inputs used in conventional agriculture. These scenarios allows us to evaluate the effects of the different instruments on various targets such as welfare, organic sector size, environmental indicators etc. in a dynamic framework that is both in the short and long run.

Important results and policy insights from these studies include:

- A legislation demanding use of 100 percent organic fodder and a ban on conventional manure use only have moderate effect on the animal production caused by a significant increase in organic manure prices. The cereal sector loses on export markets but gains some on the domestic market through in-

- creased cereals demand for fodder purposes.
- A unilateral organic technological progress does not result in significant increases in production of organic milk due to the existence of the milk quota. Instead the benefits from technological progress are split into three parts: Increased milk quota rent to *both* the organic and conventional producers and partly to consumers of milk. On the other hand production not linked to the dairy sector does experience relative larger increases in production due to technological progress.
 - A shift in both the domestic and foreign demand in favour of organic products has potentially large positive effects on land allocated to organic purposes as well as the organic production. For the milk production however the increased demand results in relative smaller increase in production because a part of the increased willingness to pay is capitalised in the milk quota for both organic and conventional producers.
 - Subsidising organic land does favour the allocation of land for this purposes but the production of organic produce are affected relative little, that is subsidy leads to a extensification of organic production. Also subsidies are capitalized in land rental in organic *and* conventional sectors.
 - Taxing environmental harmful inputs used in conventional agriculture lowers the return to land in conventional agriculture and thus benefits the relative competitiveness in organic agriculture resulting in increased allocation of land for organic purposes.

In all policy scenarios the overall macro economy (and economic welfare) are only influenced marginally.

In all cases the results from the studies include impacts on the production and consumption of organic and conventional agricultural products, farm income, land prices and reallocation of land between the organic and conventional land using sectors as well as a number of macroeconomic variables such as gross national production, private consumption, as well as the contributions by organic farming to obtaining environmental goals.

Among the interesting insights is also that a growing organic production reflecting increased demand and prices for organic products (a market based growth) will lead to a growth in the size of the sector as measured by both the volume of production as well as the size of the agricultural organic area. On the other hand, a growth being driven by increased subsidies to organic land will lead to an extensification of the organic production as the size of organic land will increase somewhat while the total production and sales of organic production will only increase marginally compared to a market based growth.

It is obvious from the studies and the results obtained that although a number of the results are conclusive – it is also obvious that the analyses also posses a large number of issues which can be analysed by applying the developed models and databases in future research projects or specific reports for the government. Among such possible initiatives is the impacts of different policy initiatives in the area of further changes in the Common Agricultural Policy, new environmental initiatives as well as the impacts of particular export / import oriented initiatives.

C.2 Fulfilment of deliverables and milestones

WP1: Labour and machinery systems in organic farming	Time schedule, according to application	Deviations, if any	Full filled
Deliverables			
D1: Paper on existing labour and machinery data on organic farming tasks	1.12.2001		Accomplished
D2: Paper on innovative technologies and work methods	1.06.2002		Accomplished
D3: Whole-farm analysis of labour and machinery demand, labour budgets and labour profiles for selected farm types with a specified collection of work operations (DIAS report)	1.06.2003		Accomplished
Organic Farming Scenarios: Operations analysis and costs of implementing innovative technologies (Int. article)	Not in application		Submitted
Milestones			
1: Existing labour and machinery data related to organic production practices identified			Accomplished
2: Completion of plan for data acquisition on labour demand and machinery capacities			Accomplished
3: Selected technologies and work methods			Accomplished
4: Preliminary completion of collection of data on labour demand and machinery capacities for selected technologies and work methods			Accomplished
5: Selection, design and analysis of model farms with adapted technologies			Accomplished
6: Selection and design of model farms with adapted technologies			Accomplished
7: Completion of analysis and modelling of labour and machinery demand, labour budgets and labour profiles for selected farm types			Accomplished
8: Labour and machinery data and models delivered for economic scenario analysis			Accomplished
9: Publication on integrated labour and machinery data and models			Accomplished

WP2: Organic farming at the farm level – A study of the conversion process	Time schedule according to application	Deviations, if any	Full filled
---	--	--------------------	-------------

Deliverables			
* An SJFI report on Ø-plan Dairy	Not in application		Accomplished
** A paper on describing the scenarios	Not in application		Accomplished
D4: An FOI paper on the machinery and labour costs	1.09.2002	1.05.2004	Partially Accomplished
D5: An FOI paper as documentation for the new Ø-plan model	1.10.2002		Not accomplished Replaced by **
D6: Mid term Workshop – presentation and discussion of preliminary results	1.06.2002		Not Accomplished
D7: An FOI paper on the data to be used in the sector analysis	1.02.2003	1.05.2004	Partially Accomplished
D8: An FOI report on the results from the different farms	1.10.2003	1.06.2004	Partially Accomplished
Milestones			
1: Labour and machinery data from WP1			Accomplished
2: New crop rotations and farm types are included in Ø-plan			Accomplished
3: Nutrient surplus are included in Ø-plan			Partly accomplished See ***
4: Machinery and labour for new technologies are included in Ø-plan			Partly accomplished See ***
*** New FØJO model is created	Not in application		Accomplished
5: Verification of the whole farm results in relation to study farms			Accomplished
6: Analyse the impact of changes in regulation etc.			Accomplished
7: Data for sector analysis are prepared			Accomplished
8: Report on the effect of different scenarios on model farms		1.06.2004	Partially Accomplished

WP3: Economic Analysis of organic farming at the regional level	Time schedule according to application	Deviations, if any	Full filled
Deliverables			
D9: FØI-working paper on the development of ESMEALDA	1.2.2003	Merged with D10	
D10: An SJFI-report on baseline results and a selected number of policy scenarios	1.10.2003	1.06.2004	Partially Accomplished
Milestones			
1. Study of the representation of organic farms in the ESMEALDA database			Accomplished
2. Determination of behavioural parameters for organic farms			Accomplished
3. Representation of organic farms on a regional basis (aggregation)			Accomplished
4. Linking of environmental indicators to organic farms			Accomplished
5. Economic potentials for organic farming in different regions of Denmark			Accomplished
6. Undertaken policy scenarios.			Accomplished
7. Report on results found.		1.06.2004	Partially Accomplished

Note: D9. During the work, it emerged that the model development was tightly integrated with the scenario analyses in D10, and it was decided to merge the two deliverables into one, devoting a chapter of the report in D10 to the developments of the economic model.

WP 4: Development of a dynamic general equilibrium model with organic farming	Time schedule according to application	Deviations, if any*	Full filled
Deliverables			
FOI-report on the standard dynamic AAGE model	Not in application	1.01.2002	
D11: An FOI-working paper documenting the theoretical structure chosen and the applied economic data and environmental indicators. The working paper will also discuss similarities and differences across organic sectors and across conventional and organic farming sectors.	1.11.2001	1.06. 2004	Partially Accomplished
D12: An FOI-report describing the dynamic version of the AAGE model and a few illustrative scenarios focusing specifically upon the new features relative to the static version of the model.	1.06.2002	Substituted by report above. Rest is in D11 and D13	Partially Accomplished
Milestones			
1. Identification of the theoretical microeconomic model structure and associated data.			Accomplished
2. Data collecting of macroeconomic data such as capital stocks, investments and rates of return			Accomplished
3. Data collecting of environmental indicators and adjusting them to the database and model.			Accomplished
4. Adjustments of farm level data for organic farm types delivered from work package 2.			Accomplished
5. Adjustments of behavioural parameters in CGE model according to results found in WP 2 and 3.			Accomplished
6. Programming the dynamic version of the CGE model and 'fitting data to that structure'.			Accomplished
7. Testing the implemented dynamic model.			Accomplished
8. A fully operational dynamic version of AAGE general equilibrium model documented.			Partially Accomplished

WP 5: Economic analysis of organic farming at the sector and macroeconomic level	Time schedule according to application	Deviations, if any*	Full filled
Deliverables			
D13: An FOI report analysing a number of different scenarios, including a baseline scenario describing possible future developments of organic farming in Denmark.	1.10.2003	1.06.2004	Partially Accomplished
D14: Final Policy Workshop – presentation and discussion of results and policy implications	1.01.2004	Autumn 2004	In preparation
D15: A FOI report concluding the overall project with its main focus on the overall results found in the research project – from field level to farm, regional and sector and macroeconomic level.	1.01.2004	1.06.2004	Substituted by 4-5 Policy Briefs
Milestones			
1: Identification of principles for constructing a baseline using the dynamic AAGE model			Accomplished
2: Identification of major determinants behind the development of organic farming			Accomplished
3: Identification and design of baseline scenario and policy scenarios.			Accomplished
4: Undertaking simulations and undertaken sensitivity analysis.			Accomplished
5: Documenting the work and the results found in research report and popular and scientific articles		1.06.2004	Partially Accomplished

D. Description of deviations and subsequent adjustments of plans

The project period has been extended by half a year due to more extensive work for the government in preparation of the Danish Aquatic Programme III. This has mainly prolonged the final reports and policy briefs from WP2 to WP5 until May-June 2004. It is the intension to host a concluding workshop when all the publications have been finalised.

WP1

Whole-farm analysis of labour and machinery demand, labour budgets and labour profiles for selected farm types with a specified collection of work operations has been reported in a DIAS report. Supplemental to that report, an international article with review procedure has been written summarising on the operations analysis for the designed farm scenarios including the two cases of technology adoption and the results from the study on management tasks in organic farming systems. Also, the operations analysis is supplemented with an economic feasibility study of introducing new technologies into the organic farming system (in cooperation with WP2) .

WP2

The work has generally progressed according to plan, although the work on Ø-plan has focused somewhat more on the development of Ø-plan for dairy than originally anticipated. It was found necessary and useful to calculate and publish the effects of new prices and 100% organic feed requirement thereby contributing to the debate and concerns on the present challenges meet by organic farming. (Tvedegaard, 2002.) This FOI report was not originally scheduled as part of the overall research

package.

It was decided to create a FØJO II model instead of extending the Ø-plan model. The reason for this was to use the detailed data for each farm operation from WP1 and to avoid overloading the Ø-plan. This advantage was the ability to calculate the cost structure down to the field level. However the conclusion is that results at the field level do not always give the right profit levels as there are considerable effects between crops. Results at the farm level give a true picture of the costs as the crop rotation is seen as a whole. The nutrient surplus can be calculated from the FØJO-model and will be included in the final FØI-report.

The FØJO model has also made it possible to deliver cost structures e.g. measured per kg of milk. The "translation" of farm level results to sector level input has been carried out according to procedures previously used in the Bichel-committee, but the task was not completed until medio 2003.

A working paper on the adjustments in Ø-plan was subsequently replaced by two working papers on the FØJO-II model. The last working paper includes not only the data transfer to the sector model, but also other parts of the model calculations. Instead of the mid term workshop, which was indented at the outset, close contacts to local organic advisors were initiated instead. Furthermore, the expert knowledge needed regarding new technologies was collected from other research groups (etc. at Flakkebjerg and Bygholm). The project and the possible scenarios were also presented and discussed at the mid term seminar for the entire FØJO II program, why the benefits from a further workshop probably would have been limited. In hindsight, the scenarios chosen still seem relevant to the actual development since then. The inclusion of vegetables as suggested by the FØJO secretariat at the mid term review has also been beneficial to the project.

WP3

The objective of WP 3 has been to adjust the sector econometric model ESMERALDA to describe and analyse organic farming at the regional level. Early in the project phase, it was decided to concentrate the main part of this work package's efforts to a shorter time period than originally planned. This is in part motivated by the regard to overall co-ordination of staff use within FOI, and in part by the dependency on data from other work packages.

The research activities in WP3 have been closely connected with ongoing research activities at FØI related to quantitative policy analysis concerning nutrients and pesticides, and thus has drawn on much the same resources and analytical expertise. This connection has had important implications for the final timing of activities in WP3, because the preparations of an Aquatic Environmental Action Plan III (VMP3) in 2003 have led to unexpectedly high demand for this analytical expertise. Due to these tasks, the finalisation of WP3 has been delayed by 6 months. However, research in WP3 has also benefited from the activities in VMP3, in terms of model simulation experience, provision of environmental indicators, etc., thus improving the efficiency of the work undertaken in WP3.

WP4

Deliverable 11 was intended to document and discuss the results from the theoretical

structure chosen as well as to present and discuss the applied economic data and environmental indicators included in the economic model and database. Given the very different content of these two aspects of the development of the economic model and the related data, it has been decided to document each of them in two separate working papers, namely

D11A: A FOI working paper entitled: Development of a Dynamic General Equilibrium Model for Denmark and D11B: A FOI working paper entitled: Extending the Dynamic AAGE-model with Environmental Indicators.

Both working papers exists in first drafts and they will be finalised in May 2004. The delay of these documents was a deliberate decision to allow more time to undertake the testing of the developed model as well as allowing the initiation of the construction of the baseline and the policy scenarios, cf. WP5.

Deliverable 12 was intended to describe the fully developed applied dynamic general equilibrium model. A large part of the work with developing the dynamic model was initiated much earlier than expected due to the visit of Philip Adams from Monash University, Australia (as documented and described in earlier status reports from the project) – and therefore a major part of D12 has already been documented in the FOI report published early 2002. The remaining part of the model development and therefore a part of deliverable 12 has been undertaken since then with particular focus on modelling the adjustment path of the Danish organic sectors.

Having concluded the research with respect to developing both an entirely new theoretical structure suitable for describing the adjustment path of the Danish organic farming sectors and fitting the data to this structure has been a very demand and challenging task. In particular developing the theoretical structure for describing the dynamic adjustment path of converting agricultural land into organic land turned out to be somewhat more challenging than expected given the overall model structure and the macroeconomic and sectoral constraints. Further, the sensitivity of the fluctuations within the dynamic model to particular combinations of important parameter settings has also posed serious modelling challenges. This is, nevertheless, a well-know phenomena within the dynamic macro-economic models and the need for modelling of a rather minor sector such as the organic farming has increased the problems of numerical instability – a very challenging task to get around in a consistent and robust way.

In the projects second year the ambitions for the developed model was greatly expanded. It was decided to try to let the developed theory be able to explain the historical development of organic farming so as to have the model explain the forces behind the evolvement of excess production in particular in the dairy sector. Being very ambitious and novel within the area of CGE modelling it has not been possible to conclude the development of a stable theory that fully can tackle this issue satisfactory within the projects time frame. It turned out that the model was highly sensitive to parameter changes and could easily run into numerical instability with certain parameter settings. Presently it is therefore not possible to draw general policy conclusions in this particular area. However, the process has lead to some scientific insights for future development and ideas for tackling this issue in other ways in the future.

WP 5

Due to delays in WP4 deliverable 13 has also been delayed but a preliminary draft exists and the final report will be finalised in May 2004. Due to the decision to reform the CAP in 2003 it was decided to expand the baseline analysis to include an evaluation of the implication of the reform for organic production. This means that the baseline analysis consist of a pre reform baseline and a reform policy scenario and subsequent a baseline including the 2003-reform. The post reform baseline forms the likely development subsequent policy scenarios are measured against.

The intention of deliverable 15 was to conclude the overall projects combining results from all work packages in one report. During the project FOI has started to publicise Policy briefs as a new mean to reach a wider audience. It has been decided to substitute deliverable 15 by 4-5 Policy Briefs to be published in May-June 2004. This decision reflects a wish to make the results of the research more accessible for policy makers and a wider public audience.

E. Project publications and other products**1. Articles in international, scientific journals with review procedures**

Sørensen, C.G.; Madsen, N.A.; Jacobsen, B.H. (2004). Organic Farming Scenarios – Operations Analysis and Costs of Implementing New Technologies. *Biosystems Engineering* (submitted).

2. Papers presented at congresses, symposiums, etc.

Jacobsen, Lars-Bo (2002), Do support payments for organic farming achieve environmental goals efficiently? Paper presented at The OECD Workshop on Organic Agriculture 23-26 September 2002, Washington D.C., United States

Jacobsen, Lars-Bo (2002), Is the promotion of organic farming the most cost efficient way of achieving environmental goals? - A Danish Case story. Paper presented at the 14th International Input-Output Techniques Conference 10-15 October 2002, Montreal, Canada.

Kledahl, Poul (2002). Who are the potential organic farmers? Limits to growth in organic farming in Denmark. Paper presented at the 13th International Farm Management Congress, Arnhem, The Netherlands.

Sørensen, C.G.; Nielsen, V. (2003). Labour and machinery systems in organic farming. Management and Technology Applications to Empower Agriculture and Agro-food Systems. Proc. XXX Ciosta-CIGR V Congress, Turin, Italy. ISBN 88-888 54-09-6(2), 525-533.

3. Reports, articles in agricultural journals, etc.

Jacobsen, Lars-Bo, Paul Rye Kledal og Niels Tvedegaard (2001): Produktion og afsætning af økologisk mælk 1995 – 2006. Notat udarbejdet til Direktoratet for Fødevarerhverv.

Jacobsen, Lars-Bo (2001): Perspektiver for økologisk jordbrug. Tidsskrift for Landøkonomi 4/1001 P256, december 2001

Kledal, P. (2002). Økologi, marked og magt. [Organic production, market and power] Forskningsnytt nr. 3, juli 2002. Sveriges Landbrugsuniversitet.

Kledal, P. (2002). Tilgangen af økologer går i stå [The conversion has stopped]. Økologisk Jordbrug nr. 270 af 23 august 2002. Interview til artikel.

Kledal, Paul Rye (2001), Økologi for fremtiden, Jord og Viden nr. 2001. 11.

Kledal, Paul Rye (2001a), Melklister, billefangere og økologisk raps, Jord og Viden nr. 2001. 15.

Madsen, N. A. (2003). En driftsøkonomisk analyse af Økologisk Jordbrug – med fokus på ny teknologi og regelændringer. Speciale fra Den Kgl. Veterinær og Landbohøjskole, Institut for Økonomi, Skov og Landskab.

Nielsen, V.; Sørensen, C.G.; Mortensen, H.S. (2003). Scenarieanalyser vedr. driftsteknisk indsats i økologisk jordbrug. Danmarks JordbrugsForskning, Rapport nr. 188, 2003, 189 sider

Sørensen, C.G. (2001). Økologisk teknologi: indikationer vedr. eksisterende/innovative teknologi samt valg af teknologi til scenarier, Working paper, DIAS-DAE. Website: <http://www.agrsci.dk/jbt/cgs/>

Sørensen, C.G.; Nielsen, V.N. (2002). Labour and machinery analysis in organic farming. Current status on available data and models, DIAS-DAE. Website: <http://www.agrsci.dk/jbt/cgs/>

Tvedegaard, Niels (2002). Økologisk mælkeproduktion – økonomiske analyser. [Organic milk production – An economic analysis]. FOI report no. 137. Danish Institute of Food Economics.

Tvedegaard, N. (2002a) Notat om økonomien i konventionel og økologisk jordbrug af 21.2. Til Miljø- og økologikontoret under Direktoratet for Fødevarerhverv.

Tvedegaard, N. (2002b). Notat vedrørende økologitilskud af 5.3.2002. Til Fødevarerministeriets Departement.

Tvedegaard, N. (2002c). Notat om økonomien ved økologisk mælkeproduktion af 7.3.2002. Til Fødevarerministeriets Departement.

Tvedegaard, N. (2002d). Notat om kvælstoftildeling i økologisk samt pesticidfrit jordbrug af 5.6.2002. Til Fødevareministeriets Departement.

4. Oral presentations, public meetings, field days, etc.

Jacobsen, B.H.; Kledahl, P. and Jacobsen, Lars-Bo (2002). Why is organic farming in Denmark successful? Presentation for researchers from LEI, The Netherlands.

Jacobsen, Lars-Bo (2002), Does organic farming achieve environmental goals? Scenario analysis using a CGE approach, Presentation at the Fifth Annual conference on Global Economic Analysis, Taipei, Taiwan, June, 2002.

Jacobsen, Lars-Bo (2001), Perspektiver for økologisk landbrug. Foredrag på årsmødet for økologisk rådgivning på Sjællands. Lyngby Landbrugsskole . d. 1 december 2001.

Jacobsen, Lars-Bo (March 2001): Organic farming. Lecture at the course "Introduction to Organic Farming". Royal Veterinary and Agricultural University

Jacobsen, Lars-Bo (March 2001): Potential for organic farming – Sector- and Economy-wide implication. Presentation for the Minister of Food, Agricultural and Fisheries at her SJFI visit.

Jacobsen, Lars-Bo (June, 2001): Potential for organic farming – Sector- and Economy-wide implication. Presentation, June 12, 2001, Meeting of the Organic Food Council

Jacobsen, Lars-Bo (August, 2001): Potential for organic farming – Sector- and Economy-wide implication. Lecture at the workshop on the SJFI organic projects.

Jacobsen, Lars-Bo (August, 2001): Perspectives on Organic agriculture. Lecture at the course: Agriculture and the Danish Economy.

Jacobsen, Lars-Bo (September 2001): Perspectives on Organic agriculture. Presentation for a group of organic farmers, Borup Denmark

Kledal, P. (2002), Mad, marked og magt. [Organic production, market and power] Økologi-kongres 2002: Mellem værdier og vækst. Foredrag i plenum 21 november 2002

Kledal, Paul Rye (March 2001), Økologisk Jordbrug for fremtiden. Økologisk Forum.

Kledal, Paul Rye (March 2001), Potentialet for økologisk produktion frem til år 2010". Præsentation for Fødevareministeren ved hendes besøg på SJFI

Kledal, Paul Rye (June 2001), Økologisk Jordbrug for fremtiden. Præsentation for det økologiske fødevareråd.

Kledal, Paul Rye (August 2001), Økologisk Jordbrug for fremtiden". SJFI workshop

Kledal, Paul Rye (September 2001), Økologisk jordbrug, Wilhjelmudvalget og diskurser i natursyn. Foredrag ved VUC-Nordfyn, temaugle om natur og miljø

Sørensen, C.G. (2001). Labour and machinery input in organic farming. Wageningen Agricultural University, June 15, 2001

Sørensen, C.G., (2002). Challenges for the future research and development. Meeting with AGCO, Bygholm, 22.1.02

Sørensen, C.G., (2002). Mekaniserings- og driftsplanlægning. Kursus vedr. landbrugsmaskiner, Den Kgl. Veterinær- og Landbohøjskole, 15.5.02.

Sørensen, C.G. (2002). Operational research in agriculture. Site-Specific Management Center, Purdue University, USA, 18.7.02

Tvedegaard, N. (2002). Potentialet i økologisk planteavl. [The potential in organic crop production]. Efterårskonferencen på Nyborg Strand arrangeret af Landskontoret for Planteavl og Danmarks JordbrugsForskning.

Tvedegaard, Niels (February, 2001), Accounts and the economic perspectives in organic agriculture (crops, pork and poultry) including a demonstration of Ø-plan, guest lectures at KVL

Tvedegaard, Niels (March 2001), Demonstration of Ø-plan, Annual Meeting at Økologisk Landscenter

Tvedegaard, Niels (March 2001), Demonstration of Ø-plan, The Organic Agricultural School.

Tvedegaard, Niels (August 2001), The economic situation during and after converting to organic farming. Lecture at the workshop on the SJFI organic projects.

F. Scientific education

A Master student has been working on the project and has finished his M. Sc. thesis in the project period.

Dr. Philip Adams from CoPS and the IMPACT project at the University of Melbourne, Australia has during 2000 and 2001 visited FOI for a long period. He has in cooperation with the FOI-Policy team contributed to the development of the Dynamic AAGE model with a particular focus on the dynamic specification, structural forecasting and features related to the technical specification of organic farming and its adjustments processes. The co-operation with Philip Adams and several other researchers at the University of Melbourne, Australia, has continued since his return to Australia.

G. National and international cooperation

WP1

WP1 has been associated with a number of ongoing research projects within The Danish Institute of Agricultural Sciences (DIAS), covering topics like the fertility of the soil in relation to organic cropping praxis and soil treatment, weed control, row cropping systems, and robotic systems (e.g. *Band heating for intro-row weed control* (BANHEAT), *Autonomous Platform and Information system for registration of crops and weeds* (API))

WP1 has been using information and experiences obtained from international contacts and co-operation (e.g. CIGR-Working Group 17: “*Models, Methods and Database for Labour and Machinery in Agriculture*” with participants from Germany, The Netherlands, Finland and Denmark).

WP2

A close contact to local organic advisors mainly in the Southern part of Jutland and at the Danish Agricultural Advisory Centre in Århus is undertaken as an integrated part of the research. There is close contact with the FØJOII project on new production systems in organic pig production (e.g. questionnaire on workload (WP1) and assumptions for the Ø-plan calculations). As a contractor in the EU-project “Further development of Organic Farming in Europe, with Particular Emphasis on EU Enlargement” (EU-CEEOPF), the members of this WP follow the current developments in Organic farming in Europe and in Denmark. It also shows that the situation in Denmark is different as the organic area is decreasing, whereas it is increasing in most other European countries. There has also been close contact with LEI in the Netherlands in order to pass on experience on the development of Organic agriculture in Denmark.

WP 3:

The activities in WP3 have benefited from FOI’s participation in national and international research projects and networks, and the insights obtained in WP3 have contributed to analyses in other projects. The analyses undertaken as part of the preparations of an Aquatic Environmental Action Plan III (VMP3) in 2003, is an example of such interactions, where analyses from ESMERALDA have been linked to environmental models in order to determine the effects on a number of environmental impacts, e.g. nitrate leaching and climate change (see Jacobsen et al., 2004).

WP 4 and 5:

The project is co-ordinated with other economic research projects at the FOI, including the SSF financed research project entitled: “A dynamic General Equilibrium Model of the Danish Economy”, which has made the visit of Dr. Philip Adams possible. In addition synergy is obtained by linking the present research project a larger research project focusing on the perspectives of the Danish pig production and its economy wide impacts financed by Norma and Frode Jacobsens Fond as well a large research project focusing on the food quality and safety issues financed under the so-called “Innovation Law”. The significant costs associated with developing the dynamic model is thereby split between several distinct research projects.

The project is also co-ordinated with the DARCOF II research project headed by AKF (project III.1). The project focuses in particular on the consumption of and willingness to pay for organic products. Results from that research project will be used in the construction of the demand system in the organic version of the dynamic general equilibrium

model of the Danish Economy.

H. Critical reflection on the project

The key focus of the present research project was economic modelling of organic farming at the field, farm, sector and macroeconomic level. The objective was in particular to integrate the different approaches to addressing economic challenges facing the organic farming sector in Denmark keeping in mind the overall objectives of DARCOF II. As mentioned above particular efforts was also devoted to co-ordinate this project with project III.1 focusing in particular on the demand for organic products.

The contribution to the overall objectives of the DARCOF II was therefore to add an economic perspective to the overall research package hoping thereby to contribute to the discussion of the future development of the organic farming sector in Denmark. The recent development of demand and supply of organic products in Denmark and in particular the excess supply of organic production, falling prices and the discussion of the future of the Common Agricultural Policy also stresses the importance of developing a “economic tool-box” enabling analysing these challenges and possible changes in the economic and policy framework in which the organic sectors will be developing the coming years.

The objective of the research project and the methods applied are clearly unique by international standards. Several of the research activities and the developments of the economic models are new and challenging and in addition relative difficult problems to solve technically. Nevertheless, the issues addressed are highly relevant to the future development of organic farming. The technical challenges have in part lead to some delays while other tasks as been undertaken somewhat quicker than originally anticipated. The changes and challenges facing organic production during the last 12-15 months has also lead to some adjustments in the research efforts stressing even stronger the need for understanding the dynamic adjustment processes of converting conventional farming into organic practices, cf. the discussion below in each of the work packages.

WP 1.

The standard method used for data acquisition on labour and machinery data and knowledge is the work-study with its precise measurement of all relevant part operations contained within a work process. This method ensures that it is possible to create labour models predicting labour and machinery input under various circumstances. However, the method is resource demanding and this project has not allowed for a comprehensive use of the concept for acquiring data on new work methods and technologies used in organic farming. Instead, a compromise has been reached allowing for qualified adapting of existing data and the use of a carefully designed questionnaire as the way of collecting supplemental empirical data. A combination of judgment sampling and snowball sampling was used to ensure proper identification of the population under study. In general, special considerations have been given to the constraints on the use of such acquired data.

The use of older data for adaptation to new technologies also has required special

attention. To some extent it has been possible to extend and adapt the use of available data to new technologies by considering the special new features of the technology. If, however, such new features differ very significantly from the existing technology the invoking of a detailed study would be required. When this is not possible, the constraints on the analysis have to be taken into account. The assessed operational performance of the band-steamer has a high degree of accuracy, as a detailed study on its performance has been carried out as part of the project "*Band heating for intro-row weed control*". As regards the robotic weeder the operational performance is more uncertain and may only be denoted as a capacity range based on various references. Also, an important uncertain parameter is the weeding efficiency expressing the completeness of the weeding process. New research seems to indicate that a weeding efficiency above 75% in sugar beets may be difficult to obtain unless the technology is significantly improved.

Detailed labour and technical analysis of horticultural production methods is not carried out due to lack of comprehensive empirical data on this production type. Only newly generated aggregated data based on expert assessments are available (Ørum & Christensen, 2001) and has not been sufficient for the analysis at hand. As this project has not given any opportunity for collecting new detailed and comprehensive empirical data such analyses have been discarded. However, in connection with the analysis of the selected case farms the possibility and perspectives of including horticulture production as a supplement or a substitution for parts of traditional plant production has been discussed.

Even as organic pig production only comprises a small segment of the organic sector this production has been included in the case farm analysis. Labour and machinery data and analysis are in demand because there is a need to identify the most feasible production systems in terms of labour and technology input. A number of specific research activities within organic pig production (e.g. the FØJO project: *Resource use, environmental impact and economy in organic pig production systems (PIGSYS)*) are requiring the availability of data on labour and machinery input for evaluating the production economy.

Ørum, J.E.; Christensen, J. (2001). *Produktionstekniske analyser af mulighederne for en reduceret pesticidanvendelse I dansk gartneri. Rapport nr. 128, Statens Jordbrugs- og Fiskeriøkonomiske Institut, 2001*

WP2:

The perspectives for organic crop production have changed dramatically since the start of the project. In year 2000 it was anticipated that the 100% organic feed requirement on dairy farms would increase the demand for organic feed well beyond the supply. But since then the 100% feed requirement has been quickly adopted and the area with organic feed increased mainly on the dairy farms. As the supply of feed more than equalled the demand, there has been a large decrease in organic grain prices. This illustrates the volatility of a small market where exports are limited. This also shows the need for sensitivity analysis on prices in relation to the conversion, and underlines the risk involved.

The use of the case farm approach limits the possibilities of a cost analysis on a wide range of farm types. It does on the other hand make a detailed analysis of the cost

and labour use based on the detailed data received from WP1. The case farms also include arable farms with organic vegetables to show the impact on technological change in this type of farm. The analysis as well as the data transfer to the sector model took longer to carry out than expected.

In the data transition process from farm to sector level some details regarding specific production systems at the farm level has to be translated to the sector level being represented as one representative organic farm. This transformation is both difficult and unique, and one important parameter is the change in capital requirement for farms converting from conventional to organic. It was the intension that the project could be extended to allow sector results to be related back to the farm level in order to give the farm level interpretations and implications. This reflection will be of more qualitative nature.

WP3:

Data coverage has been less than ideal for the analyses of regional aspects related to organic farming, as was also noted in the application. This shortage of data has had implications for the provision of behavioural parameters in organic agriculture on the one hand, and the description of the geographical distribution of organic agriculture on the other hand. Concerning behavioural parameters, this implies that it has been necessary to base parts of the analyses on assumptions or calibrations instead of empirical data, which again implies some degree of uncertainty in the results. For example, the amount of data available has not been sufficient to estimate behavioural parameters for input substitution, land allocation etc. at the farm level using econometric methods. Nor has the amount of data been sufficient for obtaining econometrically estimated parameters for developments in the farm structure, including the conversion between organic and conventional farming. Despite these data problems, the applied parameters are considered to provide a reasonable impression of the economic behaviour in the organic agricultural sector.

Lack of data concerning the geographical localisation of organic production activities implies that the level of precision in the regional dimension is lower than originally desired. Data of reasonable quality are available for three aggregate regions (Sealand, Funen and Jutland), but the availability of high-quality data for individual counties has been more limited, and the use of less representative data and supplementary assumptions have been necessary in order to obtain results at the county level. Results at the county level are relatively sensitive to the assumptions made, whereas results for the above-mentioned aggregate regions are more robust.

At the outset, it was expected to use an organics-expanded version of the ESMERALDA model as a post-model to the Dynamic-AAGE model developed in WP4, and furthermore to “bridge the gap” between the farm-level analysis in WP2 and the sector-/macroeconomic analysis in WP5. However, this model linkage has proven to be more a complex task than originally expected. As a consequence, the planned link between the models has not been established to the full extent. Despite this problem, correspondence between scenario definitions and model results has been ensured to a large extent and the insights gained from the results in WP3 are considered to be reliable and largely consistent with results from the other work packages.

As mentioned in section C.1, the analyses indicate that environmental concerns may

suggest locating organic farming in regions where aquatic environmental problems are relatively prominent. With regard to this suggestion, the above-mentioned low precision concerning regional distribution should however be underlined. Furthermore, it should be mentioned that this is a relatively partial perspective, in that only the localisation of organic farming has been considered – not the complete range of policy instruments addressing aquatic environment quality.

WP 4 and WP 5.

Generally the outcome of WP4 is closely in line with the original application (all milestones accomplished), however during the project new issues came up and some were implemented others failed.

In the project's second year the ambitions for the developed model were greatly expanded. It was decided to try to let the developed theory be able to explain the historical development of organic farming so as to have the model explain the forces behind the evolution of excess production in particular in the dairy sector. Being very ambitious and very novel within the area of CGE modelling it was not possible to develop fully a stable theory and model that can tackle this issue satisfactorily within the project's time frame. It turned out that the model was highly sensitive to parameter changes and could even run into numerical instability with certain parameter settings. Therefore, it is not possible to draw general policy conclusions in this area. However, the process has led to some scientific insights for future development and ideas for tackling this issue in other ways.

In general the development of new theory for organic farming to be implemented in the CGE model turned out to be more challenging and time consuming than originally planned because of the increased ambition mentioned above but also because of unforeseen general numerical problems with a model both comprising large sectors and small organic sectors in a dynamic framework, a few of these problems could probably have been foreseen.

The project also relied on the continued assistance of Dr. Philip Adams, Monash University after his visit to the Danish Institute of Food Economics. This was a great help considering overall objectives and for strategic issues. However, considering the day-to-day development cycle it was more difficult due to Dr. Adams' tight schedule and new and more time-consuming position at Monash University. It would probably have been better to include one or two visits to Monash University to take full advantage of the research capacity at the Centre of Policy Studies, Monash University.

In the original application one working paper was planned for the documentation of the theoretical structure chosen and the development of the model to describe environmental indicators. During the project it became apparent that this was somewhat arbitrary mix of issues. Instead it was decided to write two working papers one documenting the developed theory for organic farming and its implementation and another describing the implementation of environmental indicators. The latter thus have a broader economic perspective while the former are closely related to organic farming.

Also a report documenting the model with illustrative scenarios was planned. Due to delays the illustrative scenarios were considered obsolete; instead more emphasis was added to policy scenarios in WP 5 Especially the Mid term reform of the Common Agri-

cultural Policy seemed to be of particular relevance for the organic sector in Denmark.

8. Budget

A. Account for any change in budgets

Due to the delay of a few of the tasks it has been decided to postpone 300.000 Danish Kr. from year 2002 to 2003.

Due to technical problems the payment of 150.000 DKK was postponed to 2004.

B. Budget for the whole project (1.000 DKK)

Year:	Consumption before 2003	Consumption 2003	Original budget
Man-months			
Scientific personnel	62	29,5	91,5
Technical personnel	14	6,0	22,0

Year:	Consumption before 2003	Consumption 2003	Original budget
Salaries			
Scientific personnel	2008	1324	3335
Technical personnel	352	132	482
Other operational costs	621	255	875
Equipment	0	0	0
Others (please specify)	0	0	0
Direct costs	2981	1711	4692
Indirect costs (20% of direct costs)	596	342	938
Total	3577	2053	5630

Comments:

9. Signatures and stamps

Name	Institute	Date	Signature
Head of project			

 Appendix I. Detailed budget
A. Budget for each participating institute (1.000 DKr)Name of Institute: **Danish Research Institute of Food Economics**

Year:	Consumption before 2003	Consumption 2003	Original budget
Man-months			
Scientific personnel	50	25	75
Technical personnel	6	3	9

Year:	Consumption before 2003	Consumption 2003	Original budget
Salaries			
Scientific personnel	1570	1160	2730
Technical personnel	130	65	195
Other operational costs	400	200	600
Equipment	0	0	0
Others (please specify)	0	0	0
Direct costs	2100	1425	3525
Indirect costs (20% of direct costs)	420	285	705
Total	2520	1710	4230

Comments:

B. Budget for each participating department (1.000 DKK)

Name of Institute and department: **Danish Institute of Agricultural Sciences, Dept. of Agricultural Engineering**

Year:	Consumption before 2003	Consumption 2003	Original budget
Man-months			
Scientific personnel	12	4,5	16,5
Technical personnel	3,5	6,5	13

Year:	Consumption before 2003	Consumption 2003	Original budget
Salaries			
Scientific personnel	438	164	602
Technical personnel	222	67	289
Other operational costs	221	55	276
Equipment	0	0	0
Others (please specify)	0	0	0
Direct costs	881	286	1167
Indirect costs (20% of direct costs)	176	57	233
Total	1057	343	1400

Comments:

C. Budget for co-financing from each participating institute (1.000 DKK)

Name of Institute:

Year:	Consumption before 2003	Consumption 2003	Original budget
Man-months			
Scientific personnel			
Technical personnel			

Year:	Consumption before 2003	Consumption 2003	Original budget
Salaries			
Scientific personnel			
Technical personnel			
Other operational costs			
Equipment			
Others (please specify)			
Direct costs			
Indirect costs (20% of direct costs)			
Total			

Comments:
