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Does organic farming achieve environmental goals efficiently?

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Abstract

Concerns about the impact of modern agriculture on the environment have in the past few decades resulted in strict legislation concerning the leaching of nitrogen from Danish farms and their use of pesticides. An often-heard argument in recent years is that conversion to organic farming is a solution to many environmental problems. Hence, in the late 1990s several initiatives to support the development of organic farming have been taken among others permanent direct support for producing organically. This was made possible by the 1992 reform of the common European Agricultural Policy that allowed for specific subsidy for environmental friendly production.

This paper discusses the cost efficiency of two alternative policy measures for obtaining an overall reduction in the use of nitrogen and pesticides in Danish agriculture. The first policy measure is a subsidy for producers who produce organically and thus reduces the use of nitrogen and abandons the use of pesticides. The other policy measure is the use of taxes levied on fertilisers and pesticides.

Using an Applied General Equilibrium (AGE) model the two policies measures are compared. The paper concludes that an overall reduction in the use of pesticides and fertilisers is most efficiently obtained by taxing those agents using these inputs. The size of the organic sectors should be determined by consumers' willingness to pay for organic products.

1. Introduction

Concerns about the impact of modern agriculture on the environment have in the past few decades resulted in strict legislation concerning the leaching of nitrogen from Danish farms and their use of pesticides. An often-heard argument in recent years is that conversion to organic farming is a solution to many environmental problems. Hence, in the late 1990s several initiatives to support the development of organic farming have been taken.

Until the mid-1990s organic farmland in Denmark was held at a stable level of around 1 percent of the total cultivated area. Particularly around 1994/95 increased demand for organic products and favourable support for organic production led to a significant growth in organic farmland. Today organic farmland accounts for 5 percent of the total agricultural area, and 6.6 percent if land under conversion is included. Organic milk is the most important product accounting for around 80 percent of the total value of production. The rapid increase in organic production has, however, not been followed by a similar increase in demand. After a significant preference shift towards organic products in the mid-1990s consumer tastes have only changed slowly in the most recent years. This has resulted in a situation where approximately 60 percent of the current organic milk production is used for non-organic purposes.

Frandsen and Jacobsen (1999 a) show that the cost to society of a complete transformation of Danish agriculture into organic production would be around 2-3 percent of real GDP, whereas the cost of a complete or partial ban on pesticides would account to 0.82 and 0.35 percent of real GDP respectively (Frandsen and Jacobsen, 1999b)[1].

While the above-mentioned analyses focused on pesticides and organics separately, this paper addresses both issues simultaneously and also addresses the use of fertilizers in the agricultural sector. Moreover, the scenarios in this paper are less radical. Scenarios resulting in the same reduction in the use of pesticides and nitrogen are compared, by using two different policy instruments, namely subsidies to organic farmers in the first case, and taxes on fertilizer and pesticides in the other.

In all scenarios positive environmental effects from organic farming are measured by changes in the use of pesticides and nitrogen. An obvious critique is to argue that organic farming generates many other positive benefits to society, and that it would be wrong to merely choose between two alternative scenarios based on this measure of success alone. Yet it is important to keep in mind the overall goal of a policy. In the case of Denmark, for example, it would be fair to conclude that there is a general concern about the effects of the use of pesticides and the effects of nitrogen leaching. Observing the policy initiatives taken within the past two decades reveals these concerns[2]. Other concerns have also been voiced: animal welfare, biodiversity, healthy and safe food etc. Clearly, less or no use of pesticides is good for the environment to the extent the environment is being harmed by present practices, and since pesticides are not used in organic farming at all, it is clear that organic farmers do not harm the environment by this one indicator.

It is not entirely clear, however, that organic farmers do better on animal welfare (Kristensen and Thamsborg 2000). Nor has it been proved that organic food is healthier than conventional food (Jensen et.al. 2001). There also lacks a discussion on whether in fact there is a biodiversity problem in relation to organic and conventional farming and further more it is not clear cut that organic farmers do better on this front either. Comparing conventional and organic farming shows an increase in the number of earthworms and springtails but also a decrease in the number of skylarks (Langer et al. 2002

[1] A governmental committee commissioned to analyse pesticide use in Denmark used both reports. (The Bichel Committee 1999).

[2] The Danish Aquatic Programme 1 and 2 implemented in 1987 and 1998 (See Jacobsen 2002). Taxes on pesticides (13-27 percent) were introduced in 1996 and increased by approximately 100 percent in 1998.

It is clear that organic farming changes the biodiversity on the arable land, but it is not clear from practical policy work that this is necessarily a change for the better from the point of view of society at large, or that organic farming is the best way to achieve a certain amount of biodiversity. In fact the Wilhjelm Committee[3] (2001) concluded,

“Denmark is one of the European countries with the fewest natural areas in relation to total land area.”

And furthermore,

“The quality of Denmark’s nature and biodiversity has never been so poor. This is due to the fact that natural habitats are too constricted, contain too many nutrients and too little water, and that natural areas are fragmented and overgrown. Furthermore, the poor quality is also caused by the inability of nature and natural habitats to cope with both contemporary intensive farming, and the widespread decline of extensive farming.”

In this light the Wilhjelm Committee suggest enhancement of nature management, securing natural forest, nature should be considered in grant schemes, establishment of buffer zones around vulnerable nature, establishment of national natural areas, more nature around watercourses and nature monitoring and quality planning. That is the Wilhjelm Committee suggest that improved biodiversity is mostly achieved through increases in and protection of existing natural areas. In this light the relation between conventional and organic farming on arable land play a minor role although the Committee also notes that the committee supports the continuation of initiatives to promote organic farming within the market framework.

The scenario is calculated using Danish Research Institute of Food Economics Agricultural Applied General Equilibrium model (AAGE) of the Danish economy. The advantage of using the AGE approach is that this modelling framework covers the interdependencies between the individual industries, interaction between industries and consumers and between domestic and foreign agents. The model thus covers the whole Danish economy and is characterised by a requirement that there are equilibrium in all markets. The model therefore calculates long run results of a given policy scenario.

This paper is organized in 6 sections. Section 2 describes the construction of the database that is used in the AGE-model (Applied General Equilibrium). The AGE-model is described in section 3. The scenarios are described in section 4 and the results are analysed in section 5. Section 6 concludes.

2. Construction of the input-output data

Analysing organic farming in a AGE modelling framework requires a database that explicitly describes the production structures of each organic sector as well as the distribution of organic products for intermediate and final use.

The Danish Research Institute of Food Economics has produced agricultural specific input-output tables for the Danish economy for many years. In order to analyse the development of organic farming extensions of this work have been undertaken, resulting in a detailed description of organic farming as well as the processing of the primary products.

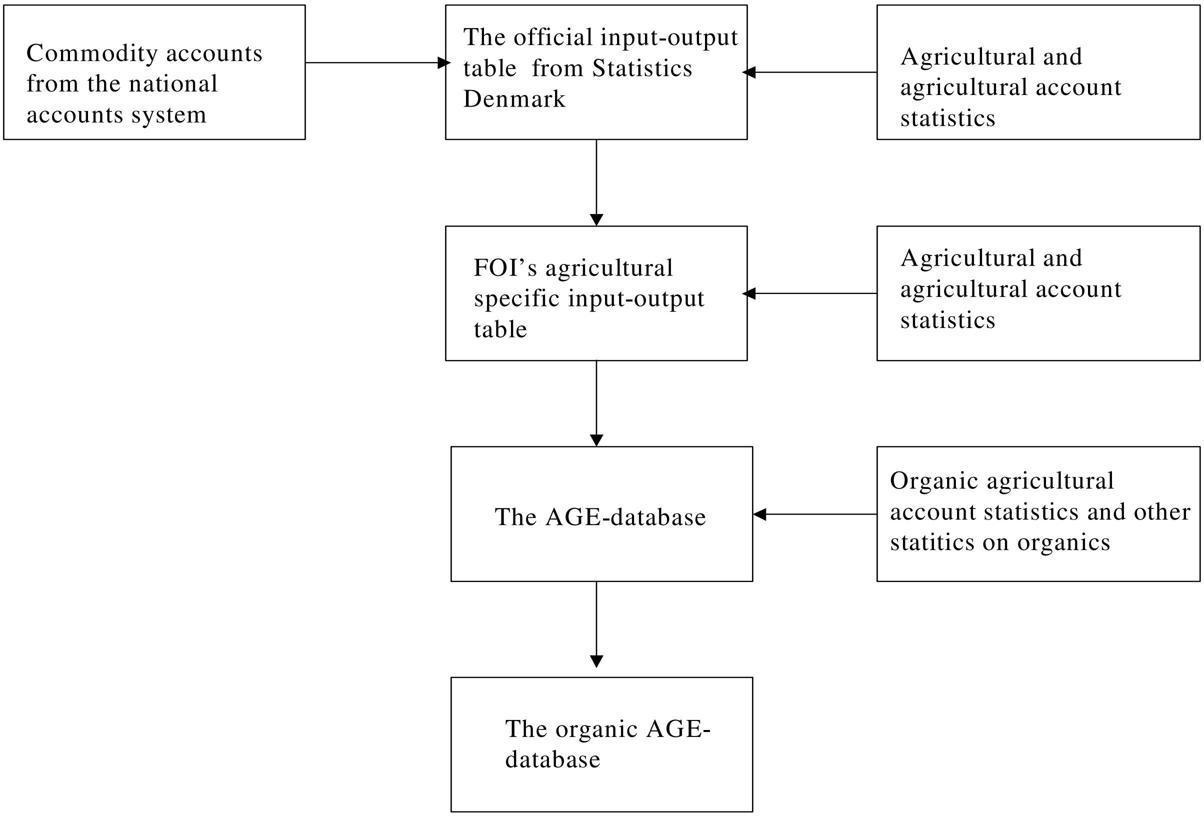
[3] The Danish government in March 2000 appointed the Wilhjelm Committee. The task of the Committee was to prepare a report as a basis for a government action plan on biodiversity and nature conservation.

The process of expanding the original database is illustrated in figure 2.1. Starting from the top, the first two levels illustrate the construction of the standard AGE-database without the specific description of organic production.

Initially the agricultural specific input-output table of the Danish economy is constructed. Disaggregating those commodity accounts that are used by Statistics Denmark for constructing the agricultural sector in their official input-output table basically does this. This disaggregation is done by extensive use of various agricultural statistics and sector specific farm accounts.

The second level illustrates how the agricultural specific input-output table together with agricultural and sector specific farm accounts comprises the basis for construction of the AGE-database. This work involves the disaggregation of farm income into components related to the rental of capital, the return to land and the farmer's own labour input. Moreover, some additional adjustments and aggregations to the sector specification of the AGE model are performed.

Fig 2.1 Constructing the organic AGE-database



The third level in fig 2.1 shows that the organic AGE-database is constructed from the existing database. A main part of this work is the calculation of organic mark-ups that represent as percentage changes the change in input use of producing one unit of organic production compared to one unit of conventional production. The continued expansion of the organic production and improvement in the collection of primary statistics to cover organic production (the commodity accounts) will determine whether these calculations will move up to the top level of this data construction process.

The general AGE-database describes the Danish economy using an industry and commodity aggregation with 50 industries and 56 commodities of which 10 industries and 12 commodities related to the primary agriculture. In the organic version the database is expanded with similar organic sectors and commodities (excluding fur farming) thus leading to 19 primary industries and 23 commodities. Moreover, a number of processing industries are also disaggregated into organic and conventional sectors, resulting in a total of 18 organic industries and 20 organic commodities. The final database thus covers 68 industries and 76 commodities.

The organic mark-ups used in the third levels are for selected industries shown in table 2.1 In the vegetable sectors, for example, production takes place without the use of chemical, fertilizer or pesticides (-100%). Instead these sectors generally use more of other inputs compared to conventional production (positive percentage changes). For organic cereal production, for example, demanded inputs from contract operations are 2.5 times higher than for conventional production, potato production demands twice as much, while the production of roughage requires just 32 percent more contract operations compared to conventional production.

The table also reveals large variation in the demand for land. Organic cereal production needs 61 percent more land to produce one unit compared to conventional production while the production of organic roughage needs 25 percent more land than its conventional counterpart.

The last two columns in table 2.1 show the changes in demand for inputs in the organic cattle and pig sectors. Generally, the organic pig sector needs more inputs compared to conventional pig production though the input of electricity and other energy is 45 percent lower in organic production. Compared to organic pig production, the organic cattle producers generally show moderate percentage changes in their input demand per unit produced compared to conventional cattle production.

Table 2.1 Organic mark-ups for selected industries in percent.

	Cereal	Potatoes	Roughage	Cattle	Pigs
Seeds for sowing/Roughage	115.0	311.0	15.0	6.1	
Concentrates				-13.0	56.0
Manure	8.5	120.0	-16.4		
Chemistry and fertilizer	-100.0	-100.0	-100.0		
Pesticides	-100.0	-100.0	-100.0		
Intermediates	165.0	351.0	55.0	11.0	71.0
Contracts operations	242.0	215.0	32.0	-3.0	72.0
Fuel	57.0	145.0	-9.0	4.0	58.0
Electricity and other energy	120.0	153.0	41.0	14.0	-45.0
Equipment	84.0	126.0	18.0	19.0	62.0
Automobile cost	223.0	343.0	73.0	42.0	135.0
Construction	116.0	150.0	60.0	40.0	211.1
Service	108.5	261.1	37.5	9.6	66.7
Capital	78.7	165.2	24.5	9.2	10.2
Labour	84.0	152.0	-11.0	2.0	93.0
Land	60.5	81.8	25.4		
Unit cost	68.3	132.6	3.8	9.4	63.0

At the bottom of the table all the percentage changes are weighted together yielding the percentage change in unit cost. This reveals that the cost of producing one unit of organic cereal is 68 percent higher than cost of producing one unit of the conventional product. In potato production the unit cost is 133 percent higher, while the two tightly connected roughage and cattle sectors show moderate increases in unit costs compared to their conventional counterparts. In other words organic production is generally more resource demanding than conventional production, and thereby leading to relatively higher output prices.

3. The AAGE model

There are five types of agents in the AAGE (**A**gricultural **A**pplied **G**eneral **E**quilibrium) model: industries, capital creators, households, governments, and foreigners. The current database of the model identifies 68 industries producing 76 commodities (see appendix A). For each industry there is an associated capital creator. The capital creators each produce units of capital that are specific to the associated industry. There is a single representative household and a single government sector. Finally, there are foreigners, whose behaviour is summarised by export demand curves for Danish products, and by supply curves for imports.

The nature of markets and prices

AAGE determines supplies and demands of commodities through optimising behaviour of agents in competitive markets. Optimising behaviour also determines industry demands for labour and capital.

The assumption of competitive markets implies equality between the producer's price and the marginal cost in each industry. Demand is assumed to equal supply in all markets other than the labour market (where excess supply conditions can hold). The government intervenes in markets by imposing sales taxes on commodities. This places wedges between the prices paid by purchasers and prices received by the producers. The model recognises margin commodities (e.g. retail trade and freight) that are required for each market transaction (the movement of a commodity from the producer to the purchaser). The costs of the margins are included in purchasers' prices.

Demands for inputs to be used in the production of commodities

AAGE recognises two broad categories of inputs: intermediate inputs and primary factors. Firms in each industry are assumed to choose the mix of inputs, which minimises the costs of production for their level of output. They are constrained in their choice of inputs by nested production technologies (see appendix B). For the land-using industries (see appendix A), AAGE specifies nested substitutions between:

capital, labour, energy and herbicides (CLEH);

land, fertiliser and insecticides (LFI);

CLEH and LFI (CLEHLFI); and

CLEHLFI and an aggregate of remaining intermediate inputs

For non-land using industries substitution is allowed between capital, labour and energy (CLE) and between CLE and aggregate non-energy intermediate inputs.

Household demands

The representative household buys bundles of goods to maximise a utility function subject to a household expenditure constraint. The bundles are combinations of imported and domestic goods.

Demands for inputs to capital creation and the determination of investment

Capital creators for each industry combine inputs to form units of capital. In choosing these inputs, they cost minimise subject to technologies similar to that used for current production; the only difference being that they do not use primary factors. The use of primary factors in capital creation is recognised through inputs of the construction commodity.

Government's demands for commodities

The government demands commodities. In AAGE, there are several ways of handling these demands, including: (i) endogenously, by a rule such as moving government expenditures with household consumption expenditure or with domestic absorption; (ii) endogenously, as an instrument which varies to accommodate an exogenously determined target such as a required level of government deficit; and (iii) exogenously. In the computation in this paper government demand changes follow household consumption expenditures.

Foreign demand (international exports)

Two categories of exports are defined: traditional, which are the main exported commodities, and non-traditional. Traditional export commodities face individual downward-sloping foreign demand schedules. The commodity composition of aggregate non-traditional exports is treated as a Leontief aggregate. Total demand is related to the average price via a single downward-sloping foreign demand schedule. Contrary to many conventional agricultural products all organic products are assumed to be traditional export commodities.

Demand for foreign imports

For all industries, AAGE includes the standard Armington specification for imported and domestically produced inputs. This assumes that users of a given commodity regard the domestic and the imported varieties of this commodity as imperfect substitutes. The Armington assumption is also used in input demands for industry investment and in household demands for consumption.

Computing solutions for AAGE

AAGE is a system of non-linear equations. It is solved using GEMPACK, a suite of programs for implementing and solving economic models. A linear, differential version of the AAGE equation system is specified in syntax similar to ordinary algebra. GEMPACK then solves the system of non-linear equations as an Initial Value problem, using a standard method, such as Euler or midpoint. For details of the algorithms available in GEMPACK, see Harrison and Pearson (1996).

4. Scenarios

A baseline is constructed to introduce all ongoing policy developments and known shocks to the economy so as to ensure that the policy shocks are undertaken in an economy where all known developments and shocks are accounted for.

We introduce four alternative scenarios. First, the *preference* scenario is introduced, where domestic and foreign consumers of Danish products change their preferences in favour of organic products. The *preference* scenario is then compared with three policy scenarios in the absence of the assumed consumer preference change.

The first two policy experiments (*Sub-A* and *Sub-B*) use subsidies to agricultural land in the organic sectors to induce a movement of land into organic production to achieve a positive environmental effect. The first policy experiment (*Sub-A*) is designed so as to achieve the same share of organic land as obtained in the *preference* scenario. This does not automatically result in the same reduction in the use of harmful inputs. Therefore, the second policy experiment (*sub-B*) uses such subsidies to achieve the same effects on the environmental indicators as obtained in the *preference* scenario.

The third policy experiment (*Tax*) imposes environmental taxes on fertilizer and pesticide use to achieve the same effects on the environmental indicators as in the *preference* scenario and *Sub-B*. The idea is to compare two different policy instruments, namely subsidies to land and input taxes that achieve the same effect on the use of environmentally harmful inputs (fertilizers and pesticides).

The policy implication would be to choose the policy that achieves the same goal at the lowest cost to society.

Expected results from the analysis

The introduced subsidies lower the cost of using land in the organic sectors (the purchasers' price of land is reduced), thereby yielding pure profit in the organic sector and hence stimulating entry to organic production. This leads to an increase in the demand for land, with an upward pressure on the basic price of land as a result. The subsidy also changes the relative price of land thus leading to a substitution effect resulting in an extensification of organic production. In other words, more land and less capital and labour is used per produced unit.

Subsidies are thus expected to increase the production of organic products but are also expected to lead to an extensification of organic production. The exact extent of these two effects depends on how demand for organic products is affected.

The environmental taxes imposed on the use of fertilizers and pesticides increases the unit cost of production. Substituting taxed inputs with other inputs can moderate this increase in unit cost. The substitution elasticity controls the extent to which this can be done. A higher unit cost requires a higher product price if profits are to remain unchanged. Yet a higher product price tends to lower demand. A decline in production releases resources to be used in other sectors of the economy and tends to lower the prices and required rental of these resources because of the increase in supply. Since the taxes are levied on conventional land- using sectors and land is only used in the agricultural sectors (whereas labour, capital and other inputs are also used in the rest of the economy), land is expected to bear the greatest burden of the levied taxes in the form of lower returns to land. Relative lower returns to land will also results in a substitution effect where the land-using sectors will substitute other inputs, especially capital and labour, for land.

5. Results

This section presents selected results of the calculated scenarios, including the effects on production, exports, consumption, land and labour use and the environmental indicators. Section 5 concludes by presenting the macroeconomic impacts. The presentation focuses on the results for the primary agricultural and associated processing sectors. Since the main issue addressed is the comparison of the results from applying the two different policy instruments this will be the focus of the analysis[4].

Production and organic land

In the *baseline* aggregate organic production in the primary agricultural sector increases by an average of 5 pct. p.a. This results in 5 pct. of total land being used for organic production (Fig 5.1) and almost 6 pct. of the total production volume arising from organic production.

Fig 5.1 also shows that the assumed changes in *preference* scenario have significant effects on both the organic share of land (8.7 pct.) and it's share of the total agricultural production volume (10.7 pct). Aggregate organic production increases by 84.4 pct whereas conventional production falls by 4.7 pct. (see table C.1). The last three scenarios are to be compared with the *preference* scenario since scenario *Sub-A* results in the same share of land allocated to organic production whereas scenarios *Sub-B* and *Tax* result in the same reduction in the use of nitrogen and pesticides.

The land subsidies lower the purchaser's price of land, thereby lowering the unit price of organic products and stimulating demand. Lower land prices also stimulate a substitution of all other inputs in favour of land thus leading to an extensification of organic production. Comparing with the *preference* scenario it is clear that it is the land substitution effect that dominates in *Sub-A* and *Sub-B*. In scenario *Sub-A* and *Sub-B* the share of land are higher than or equal to the land shares in the *Preference* scenario, whereas the increase in production is much smaller (production increases by 17 pct. (*Sub-A*) and 18 pct. (*Sub-B*) compared to 84 in the *preference* scenario, see table C.2 in appendix C.

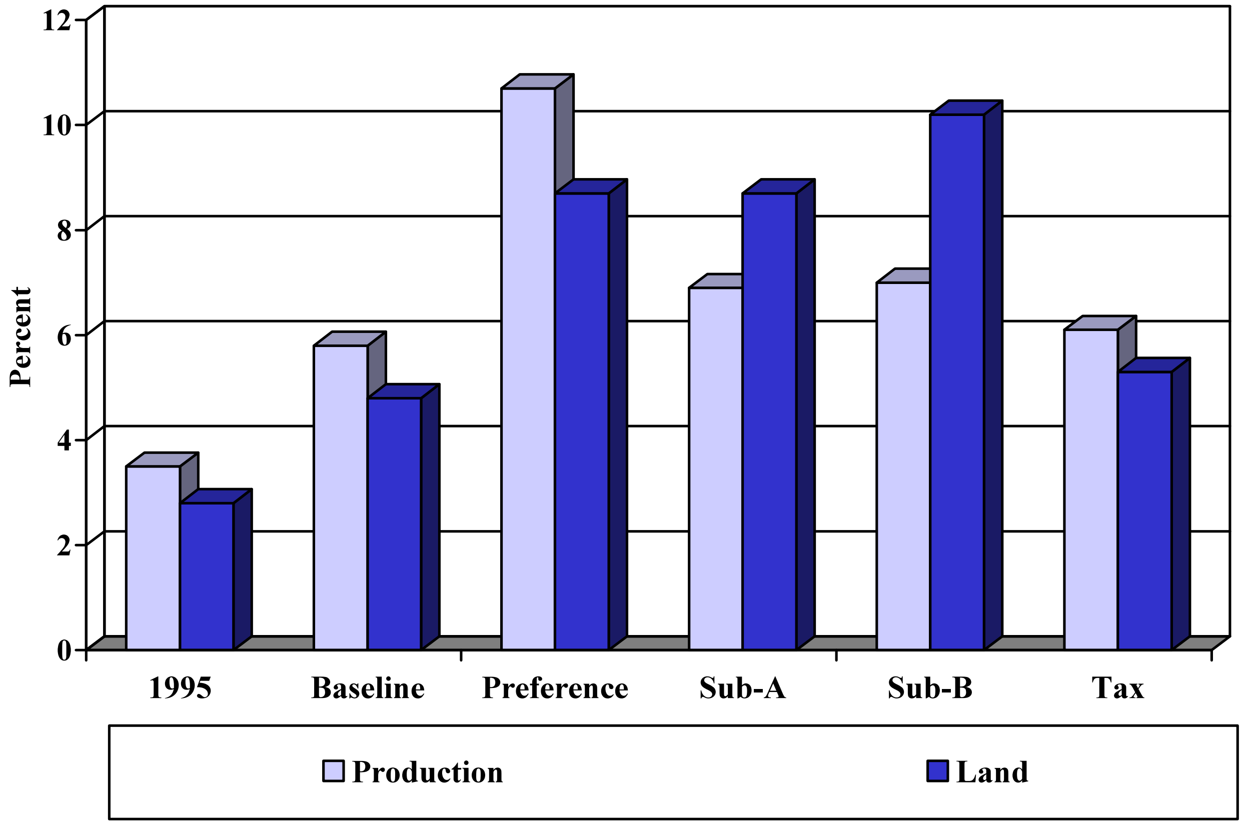
In the last scenario (*Tax*), environmental taxes are imposed on inputs used only in the conventional sector in a magnitude that insures the same aggregate effect on the input of nitrogen and pesticides as in the *preference* scenario and *Sub-B* (see fig 5.3 and 5.4 below).

In the *preference* scenario it is the movement of land into organic production that achieves the aggregate reduction in the use of nitrogen and pesticides. In fact, conventional farmers use these chemicals more intensively in this scenario due to a substitution effect generated by a slight increase in land prices.

From fig 5.1 it is clear that the taxes achieves the same effects on the environmental indicators without the same increase in organic sector's share of total land and production. The reason is straightforward: the environmental taxes generate a substitution effect in the conventional agricultural sector. Since conventional farming is still the largest sector only small changes in the behaviour of conventional farmers are required to achieve the same overall reduction in the environmental indicators that was the result of the *preference* scenario.

[4] A more thorough presentation of the *Baseline* and the *Preference* scenario can be found in Jacobsen (2001).

Fig 5.1 The organic sector's share of the total agricultural production volume and land usage



Note: Details can be found in appendix table C.1

Organic consumption and exports

The representative household determines its composition of total consumption to maximize a given utility function. In the top nest, the consumer system determines the composition of a number of aggregate goods by a Stone-Geary linear expenditure system. The expenditure system identifies four broad food commodities; Bread and flour, Meat, Dairy and Other[5]. Beneath this nest a CES function determines the composition of organic and conventional products using econometrically estimated elasticities[6]. At the bottom of the nesting structure, a CES function controls the domestic and foreign composition of all commodities. In the CES nest between conventional and organic products a "twist" variable is built in to allow for cost-neutral changes in the composition of organic and conventional consumption.

Consumption decisions are influenced by changes in income and relative prices, but in both the *baseline* and the *preference* scenario, the exogenous twist variable also plays an important role. It is this variable that is shocked and the results show that most of the changes in organic consumption directly reflect the shock to the twist variable.

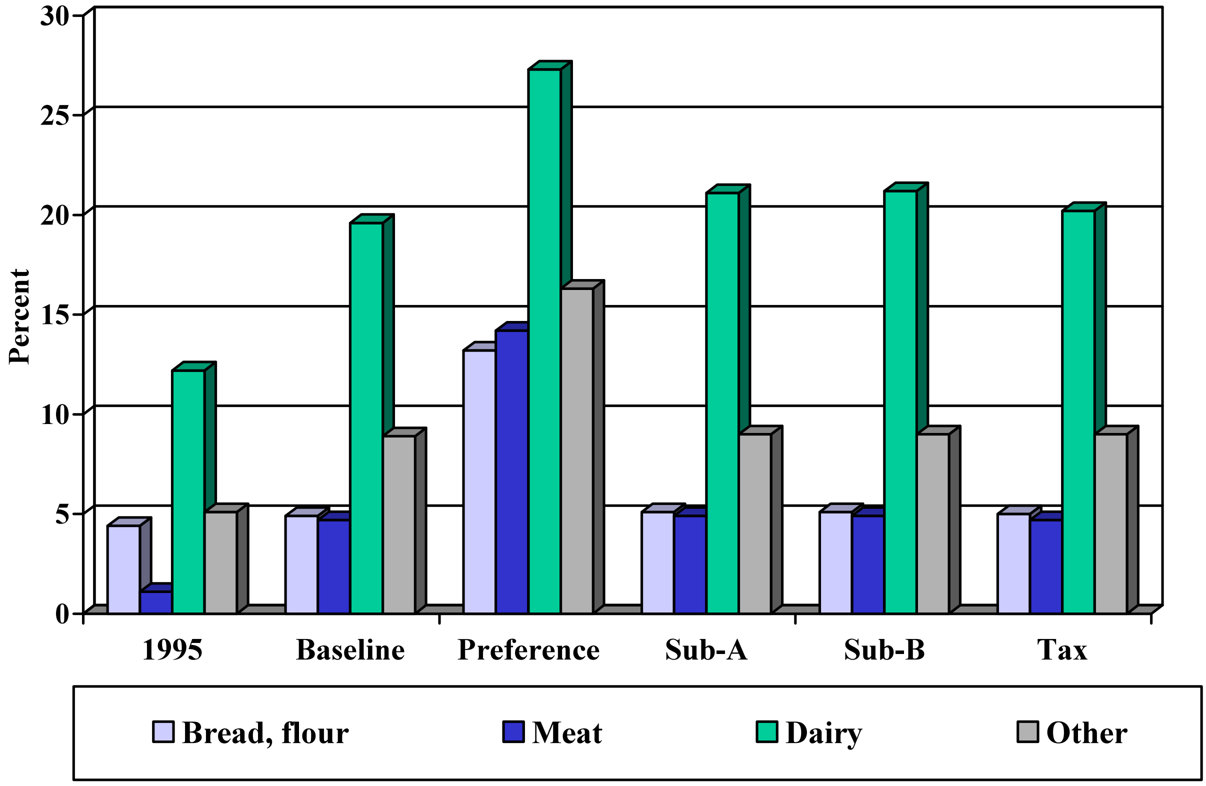
[5] Mostly vegetables.

[6] Wier and Smed (2000)

Changed relative prices also affect the consumption decision of the consumer, but the resulting consumption shares of organic products are in both the baseline and in the preference scenario mostly explained by the assumed changes in preferences, i.e. the exogenous shock to the twist variable explained above. In the preference scenario the consumption of organic dairy products amounts to 27 percent of total consumption in this category while for the other three categories, organic consumption amounts to around 15 percent. At the aggregate level, organic food consumption amounts to 17 percent of the total (table C.3 in appendix) in this *Preference* scenario.

When compared to the *baseline* results (fig 5.2), it is apparent that the consumption decisions are not markedly influenced by the introduction of the subsidies and taxes in the last three scenarios. As explained earlier, changes in consumption are explained primarily by income changes and consumers' responsiveness to changes in relative prices. In the last three scenarios only moderate effects are seen compared with the *baseline* results even though all three experiments change the price structure in favour of organic products and higher elasticities in the demand for organic products[7]. The reason is that the large price effect is seen most directly on the primary product. When the products have been processed, the price effect is smaller due to the fact that the primary product only accounts for a fraction of total costs in the processing industries.

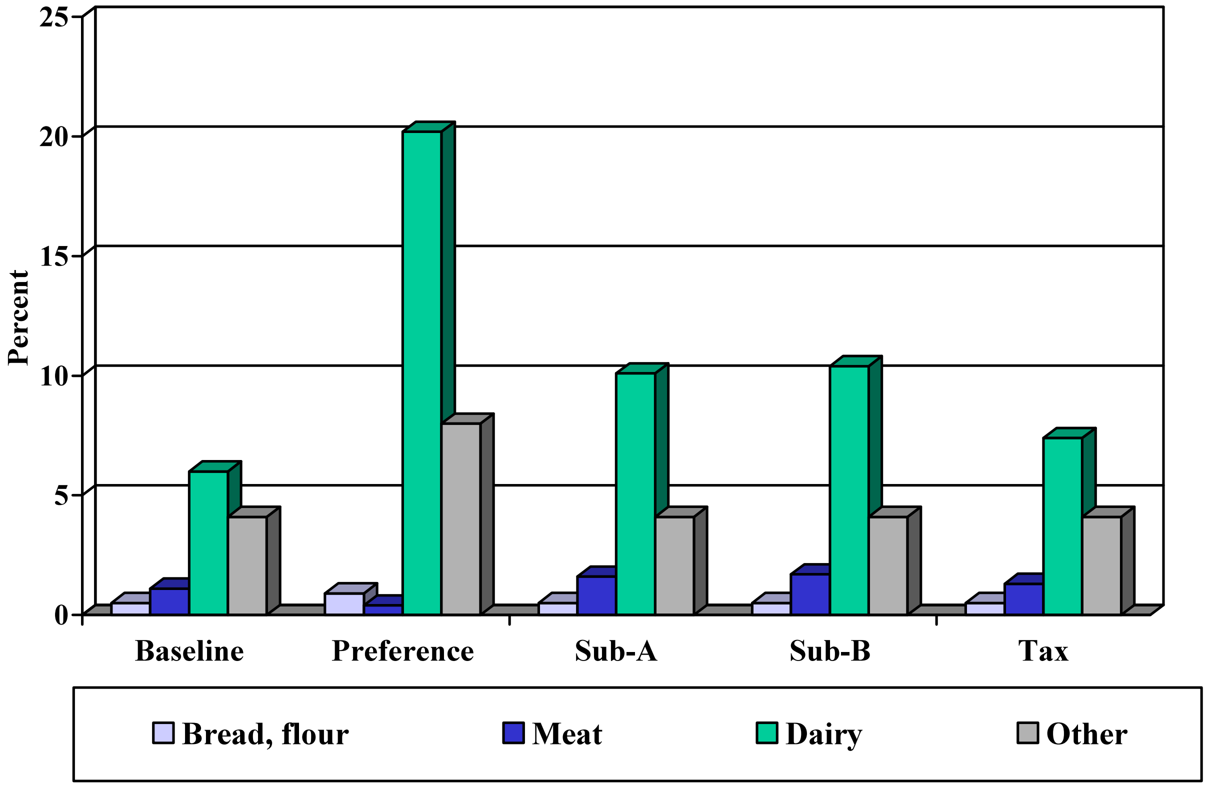
Fig 5.2 Organic consumption shares, volume index



[7] The cross-price elasticity's between conventional and organic products varies between 1.5 and 2.2 in the four consumption groups.

In the *Baseline* the share of organic exports is calculated to increase from practically zero in the initial situation to somewhere around one to six percent. In the *Preference* scenario there is an assumed change in foreigners' demand curves in favour of organic products at the given prices. Meat exports declines even though the demand curve is shifted. This is a result of the increased domestic demand pressuring prices upwards, thereby resulting in lower export demand. In other words, the price effect dominates the shift in the export demand schedule. As with the domestic consumption, only moderate effects are seen in the last three scenarios and for the same reasons. For dairy products stronger effects are seen due to an assumed higher elasticity in the export demand function.

Table 5.3 Organic export shares, volume index.



Bread, flour is an aggregate of 8 commodities meat and other is an aggregate of 6 and 3 commodities.

Results for both domestic consumption and exports show that both land subsidies and the environmental taxes affect demand. Yet keeping in mind that either land use or the effect on the environmental indicators is the same as in the *preference* scenario (depending on which scenario we are examining) it is evident that these policy instruments can affect land use and input choices, but they do relatively little to overall demand and production.

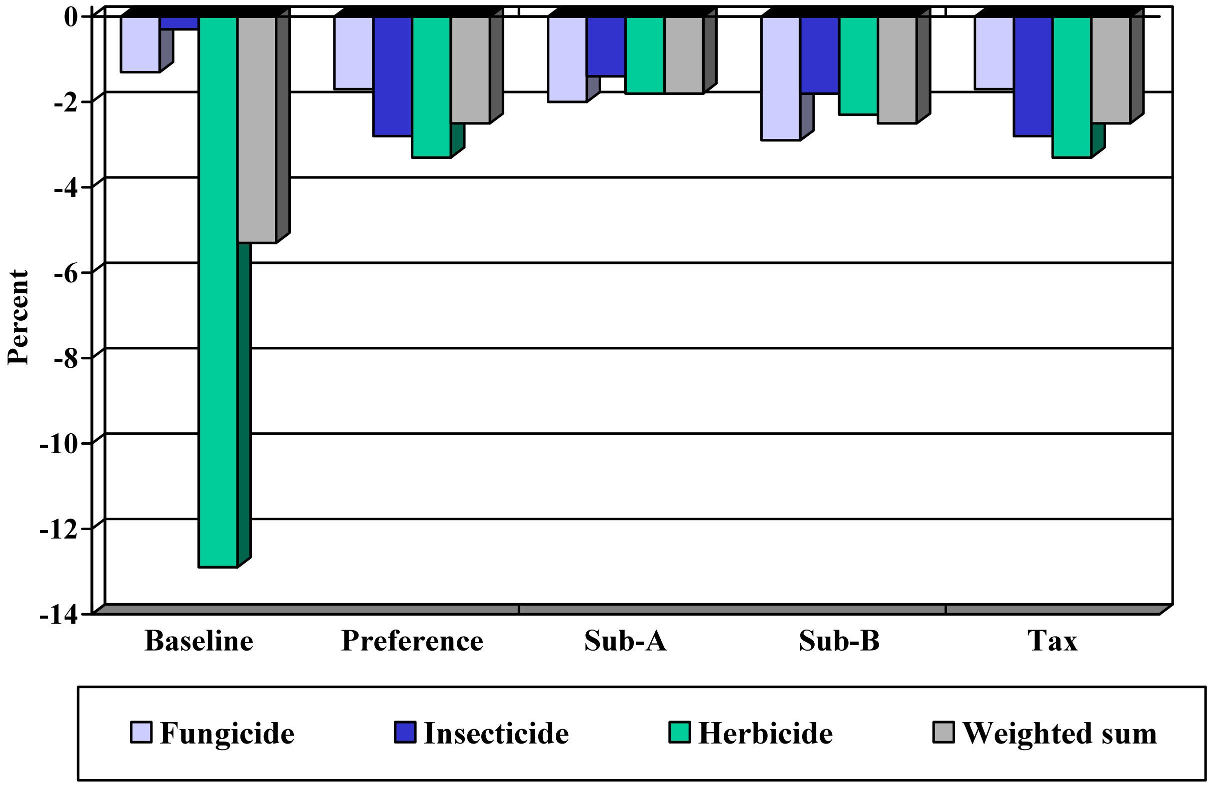
Environmental indicators

The baseline shows a decrease in the use of pesticides (fig 5.4) because of an increase in the taxes on pesticides during the base case period. The use of nitrogen, on the other hand, increases during the

Baseline(fig 5.5). This is mainly due to increased production of manure (pig production increases by more than 30 percent).

In the *Preference* scenario, the movement of land into organic production results in decreases in both the use of pesticides (fig 5.4) and nitrogen (fig 5.5).

Fig 5.4 Changes in the use of pesticides



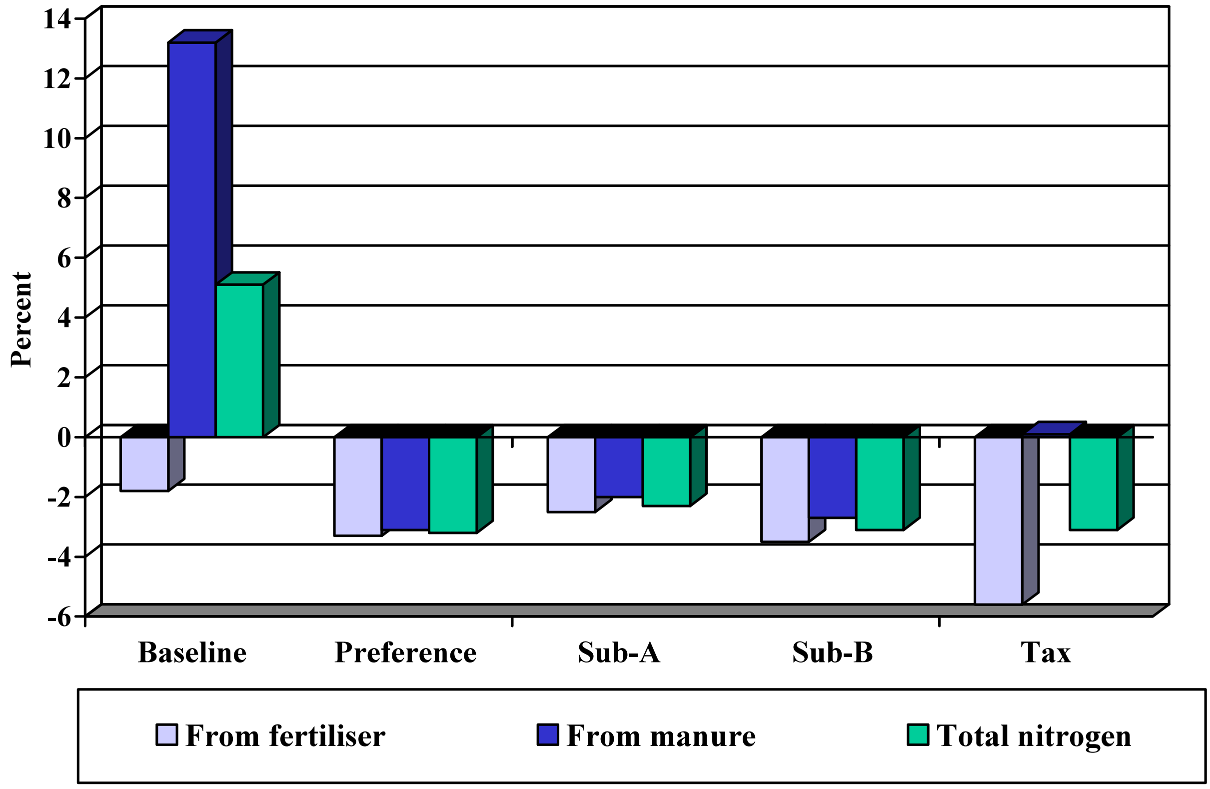
Introducing subsidies to organic land that insure the same organic area as in the *Preference* scenario is not enough to achieve the same reduction in the use of pesticides (*Sub-A*). As fig 5.4 shows the decrease is less than 2 percent measured by the weighted sum. The reason is that the use of land in conventional production changes to a more pesticide intensive allocation than was the case in the *preference* scenario. In scenario *Sub-B* these subsidies to organic land are increased to attract more land, thereby resulting in the same reduction in the weighted sum of pesticides as in the *preference* scenario[8]. In the *Tax* scenario taxes are introduced to exactly match the reduction in the *Preference* scenario. Total pesticide use falls by 2.5 percent in this scenario.

As with pesticides, introducing subsidies to organic land that insure the same organic area as in the *Preference* scenario, is not enough to achieve the same reduction in the use of nitrogen (*Sub-A*). The decrease is slightly more than 2 percent (fig 5.5). The reason is that the allocation of land in conventional production changes to a situation where more fertilizer is used than was the case in the *Preference* scenario. In scenario *Sub-B* these subsidies to organic land are increased to attract more land, thereby resulting in the same reduction in the use of nitrogen. In the *Tax* scenario environmental taxes are

[8] The weighted sum is used since there is only one policy variable to alter (the subsidy to land).

introduced that result in the same reduction in the total use of nitrogen whereas the composition is quite different. In the *Tax* scenario the total change is a result of a decrease in the use of fertilizers. In fact, there is a small increase in the use of manure due to a slight increase in the animal production[9].

Fig 5.5 Changes in the use of nitrogen



Employment

In the *Baseline* the total number of full time workers in primary agriculture falls by almost 13,000 persons (table 5.1). This is mainly due to structural development and increases in labour productivity. In the *Preference* scenario the demand shift from conventional to organic commodities is also reflected in the employment result. The total number of employed in the conventional sectors thus falls by 3,211 persons while employment in the organic sectors increases by 3,100 fulltime employees. Thus net-employment in the primary agricultural sectors falls by just 111 persons.

Both subsidy scenarios work in the same way, with the strongest effects being in *Sub-B*. Employment in the conventional sectors falls by almost 1,200 persons in this scenario while 600 more persons are employed in the primary organic sectors. In the *Tax* scenario the effects are more moderate, with 163 persons leaving the conventional sectors and 179 entering the primary organic sectors.

[9] The reason is that there is an increased demand from slaughterhouses (pigs) due to a fall in their unit cost. The scenario results in lower returns to capital and labour and this fall dominates the increase in pig price.

In the two subsidy scenarios it is mainly the movement of land that explains the results. Land moves out of conventional production resulting in less production and less use of labour. The released land moves into organic production, but since demand does not follow the inflow of land, this results in an extensification effect in organic production: all other inputs are to some extent substituted by land in the organic production.

In the *Tax* scenario, the taxes result in both lower conventional production and thereby also less demand for inputs of land, labour and capital, but also in a substitution effect where taxed inputs are substituted with other inputs (especially labour). The result is a more labour intensive conventional production. For the organic producers the *Tax* scenario first of all results in lower land prices, pressuring the unit prices to decline and thus stimulating demand and production. Yet the lower land prices also result in a minor substitution effect between land and other inputs. As can be seen from table 5.1 the *Tax* scenario results in a minor net increase in the use of labour in the primary agricultural sector.

Table 5.1 Employment, number of fulltime persons

			Deviation from Baseline			
	1995	Baseline	Preference	Sub-A	Sub-B	Tax
Primary, conventional	84978	71521	-3211	-961	-1198	-163
Primary, organic	2837	3608	3100	547	600	179
Total primary agriculture	*87815*	*75130*	*-111*	*-414*	*-599*	*16*
Processing, conventional	33197	25815	-1281	-640	-865	-12
Processing, organic	582	819	803	171	186	59
Total	121594	101764	-589	-883	-1278	63

Macroeconomic consequences

The macroeconomic consequences of all four preference and policy scenarios are small. The effect on real GDP varies between a fall of 0.01 percent and 0.08 percent, i.e. the consequences for the economy as a whole are small. But the magnitude of change in the different scenarios does reveal that there are differences in the relative cost to society.

In the preference scenario real GDP and consumption fall by 0.07 and 0.14 percent respectively, but these declines can't be interpreted as a situation in which society is worse off since they are a result of changed consumer preferences. If consumers change their preferences in favour of a product that is produced at a higher cost, (thus lowering the total real consumption potential) it must be because they are better off by this choice. In other words, the new consumption bundle yields a higher utility to the consumer.

At first sight it seems somewhat contradictory that the aggregate capital stock decreases (0.04) while aggregate investments increases (0.04). This is nevertheless an effect of assumed fixed investment/capital ratios in each industry and the fact that a decline capital stocks in industries with relatively low investment/capital rates weigh more in the total result than increasing capital stocks in industries with relatively large investment/capital ratios.

The three other scenarios, on the other hand, are a result of policy intervention, and the results must be interpreted as costs to society. If these scenarios result in the same effects on the policy objective, these figures may also guide us to the most cost-effective policy of those analysed. Finally, a policy instrument should only be used if the benefit to society is higher than the cost. In this context it should be noted that all potential benefits are not a part of this analysis.

Table 5.1 Macroeconomic consequences.

	1995-Level	Preference		Sub-A		Sub-B		Tax	
	Billion DKK	Million DKK	Percent	Million DKK	Percent	Million DKK	Percent	Million DKK	Procent
Real GDP	1037.7	-728	-0.07	-617	-0.06	-859	-0.08	-128	-0.01
Real private consumption	511.1	-740	-0.14	-392	-0.08	-557	-0.11	40	0.01
Real public consumption	260.3	-360	-0.14	-190	-0.08	-271	-0.11	19	0.01
Real investments	189.3	82	0.04	-190	-0.10	-272	-0.15	-17	-0.01
Real stocks	39.3	0	0.00	0	0.00	0	0.00	0	0.00
Real exports	296.0	320	0.11	171	0.06	194	0.06	-159	-0.05
Real imports	258.3	-22	-0.01	-7	0.00	-96	-0.04	45	0.02
Real capital stock			-0.04		-0.09		-0.13		-0.01
GDP deflator			-0.13		-0.14		-0.18		-0.03
Consumer price index			-0.08		-0.09		-0.13		-0.01
Price of investment goods			-0.12		-0.16		-0.22		-0.05
Terms of Trade			-0.06		0.01		0.01		0.02
Nominal wage rate			-0.25		-0.33		-0.44		-0.11
Price of agricultural land			0.34		9.55		14.07		-17.75

Comparing the two subsidy scenarios (*Sub-A* and *Sub-B*), it is clear that the cost in terms of real GDP is higher the more land is shifted into organic production. The reason for this is of course that more land is being used in a less productive sector, thus lowering the total production possibility of the economy. Lower productivity results in lower returns to capital and labour and thus also lower income and lower consumption possibilities. For the agricultural sector as a whole though, the subsidies increase the returns to land resulting in increase land price of (9.6 and 14.1 percent).

The tax scenario results in exactly the same reduction in the total use of pesticides and nitrogen as subsidy scenario B (*Sub-B*) but at a lower cost. In terms of GDP the cost of the *Tax* scenario amounts to 0.01 percent of GDP. Achieving the same reduction in nitrogen and pesticide use by using subsidies (*Sub-B*) costs almost seven times more.

The reason for this difference is that in the tax scenario the majority of farmers (namely the conventional) face the imposed environmental tax and they only reduce their use of the taxed input by approximately 3 percent. These first units of input are relatively easily substituted with other inputs, and total production is only affected slightly. Society can thus achieve the same overall reduction in the use of pesticides and nitrogen by using two different policy instruments. Imposing environmental taxes that affect the majority of farmers turns out to be the most cost-effective instrument.

There is a small increase in real consumption in the *Tax* scenario. This is not a generic result of taxing pesticides and fertilizers. Real consumption increases because the income loss in this scenario is so small that the falling consumer prices allow for this small increase in real consumption. If the scenario was specified with higher taxes or taxes that applied to a larger part of the economy, the income loss would dominate and result in a fall in real consumption. Real public spending also increases. This is a result of the model closure where the percentage change in real public spending is set equal to the change real private consumption.

The consequences of the scenarios for landowners are also shown in table 5.1. In the subsidy scenarios land prices increase while in the *Tax* scenario the price falls.

6. Concluding remarks

This paper has analysed the economy wide implication of two different policy instruments targeted at reducing the overall use of pesticides and fertiliser. The analysis shows that in absence of consumer preference changes, subsidies (*Sub-A* and *B*) can be used effectively to change the relative profitability between organic and conventional production, thereby resulting in a shift of land into organic production of the same magnitude as that resulting from changed consumer preferences. Yet although the aggregate land use is the same, the increase in production is almost five times higher in the *Preference* scenario compared with the *Sub-B* scenario. The results also show that subsidising the organic sectors leads to a situation in which the conventional sectors use pesticides and fertilisers more intensively.

The implications for land prices are also different in the two scenarios. While the land subsidies result in land price increases and thus higher returns to land owners, the *Tax* scenario results in lower prices of land.

Even though the macroeconomic consequences of the analysed scenarios are small, the relative magnitudes are clear. In terms of real GDP, the cost of reducing the aggregate use of fertilizers and pesticides is seven times higher when using subsidies to organic farming compared to taxing the use of these inputs.

If society is concerned about the overall use of environmentally harmful inputs these inputs should be taxed or regulated in a similar way. The size of the organic sector should be determined by the consumers' willingness to pay.

Cost analysis such as the one presented could be compared with expected economy-wide benefits of the introduced policies. These benefits have not been a part of this analysis and only if the benefits are calculated or assumed to exceed the cost should such policies be introduced.

Naturally, the results found should be evaluated in light of the assumptions applied. Compared with other more partial economic analysis the present analyses takes into account the economic linkages between the individual agricultural sectors and between the agricultural sectors and the industrial sectors, consumer preference or willingness to pay. Furthermore, the analysis has taken into account the derived cost and price effects and the implications of explicitly representing the overall macroeconomic budgetary restrictions. The simulations have also been undertaken with a national AGE model assuming unilateral Danish policy initiatives.

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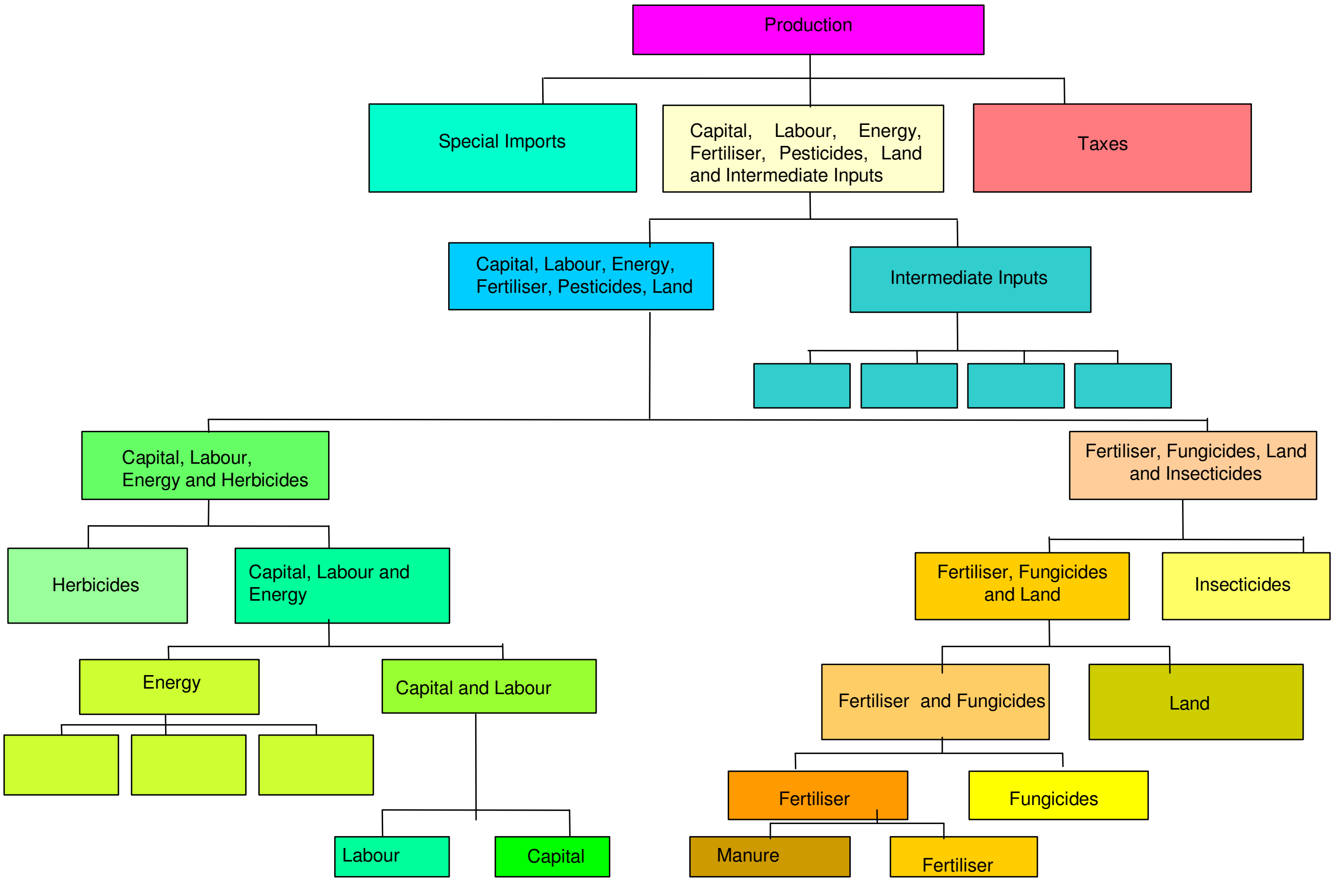
Appendix A

Table A.1 Industries and commodities in Organic-AAGE.

	Industries			Commodities	
*#	1-2	Cereal	*	1-2	Cereal
*#	3-4	Oil seeds	*	3-4	Oil seeds
*#	5-6	Potatoes	*	5-6	Potatoes
*#	7-8	Sugerbeets	*	7-8	Sugerbeets
*#	9-10	Roughage	*	9-10	Roughage
*	11-12	Meat cattle and milk producers	*	11-12	Meat cattle
*	13-14	Pigs	*	13-14	Milk
*	15-16	Poultry	*	15-16	Pigs
	17	Hunting and fur farming, etc.	*	17-18	Poultry
*#	18-19	Horticulture		19	Hunting and fur farming, etc.
	20	Agricultural services, etc.	*	20-21	Horticulture
	21	Forestry		22	Agricultural services, etc.
	22	Fishing		23	Forestry
	23	Extraction of coal, oil and gas		24	Fishing
*	24-25	Cattle-meat products		25	Extraction of coal, oil and gas
*	26-27	Pig-meat products	*	26-27	Cattle-meat products
*	28-29	Poultry-meat products	*	28-29	Pig-meat products
	30	Fish products	*	30-31	Poultry-meat products
*	31-32	Processed fruit and vegetables		32	Fish products
	33	Processed oils and fats	*	23-34	Processed fruit and vegetables
*	34-35	Dairy products		35	Processed oils and fats
*	36-37	Starch, chocolate products, etc.	*	36-37	Dairy products
*	38-39	Bread, grain mill and cakes	*	38-39	Starch, chocolate products, etc.
*	40-41	Bakery shops	*	40-41	Bread, grain mill and cakes
*	42-43	Sugar factories and refineries	*	42-43	Bakery shops
	44	Beverage production	*	44-45	Sugar factories and refineries
	45	Tobacco manufacture	*	46-47	Beverage production
	46	Textile, wearing apparel and leather		48	Tobacco manufacture
	47	Manufactured wood and glass products		49	Textile, wearing apparel and leather
	48	Paper products and publishing		50	Manufactured wood and glass products
	49	Oil refinery products		51	Paper products and publishing
	50	Basic chemicals		52	Oil refinery products
	51	Fertiliser		53	Basic chemicals
	52	Agricultural chemicals nec		54	Fertiliser
	53	Non-metallic building material		55	Agricultural chemicals nec
	54	Metal products		56	Non-metallic building material
	55	Machinery and non-transport equipment		57	Metal products
	56	Transport equipment		58	Machinery and non-transport equipment
	57	Electricity		59	Transport equipment
	58	Gas		60	Electricity
	59	Steam and hot water		61	Gas
	60	Construction		62	Steam and hot water
	61	Motor vehicles service		63	Construction
	62	Wholesale trade		64	Motor vehicles service
	63	Retail trade		65	Wholesale trade
	64	Freight transport		66	Retail trade
	65	Financial and property services		67	Freight transport
	66	Transport and communication services		68	Financial and property services
	67	Public services		69	Transport and communication services
	68	Dwelling ownership		70	Public services
				71	Dwelling ownership
				72	Coal imports
				73	Manure
				74	Fungicide
				75	Insecticides
				76	Herbicide

* Both conventional and organic product/production. # Land using industries

Appendix B Nesting structure



Appendix C, Detailed results tables

Table C.1 Organic share of land and value of production

	1995	Baseline	Preference	Sub-A	Sub-B	Tax
Production value	3.5	5.0	9.5	5.5	5.6	5.0
Production volumes	3.5	5.8	10.7	6.9	7.0	6.1
Agricultural land	2.8	4.8	8.7	8.7	10.2	5.3

Table C.2 Changes in production, percentage changes

	Baseline	Pct.pa.	Preferences	Sub-A	Sub-B	Tax
Conventional productio	20.6	1.3	-4.7	-2.3	-3.0	-0.4
Organic production	107.1	5.0	84.4	17.1	18.4	5.9
Total	23.6	1.4	-0.2	-1.3	-1.9	-0.1

Table C.3 Organic consumption shares.

	1995	Baseline	Preference	Sub-A	Sub-B	Tax
Bread, flour	4.4	4.9	13.2	5.1	5.1	5.0
Meat	1.1	4.7	14.2	4.9	4.9	4.7
Dairy	12.2	19.6	27.3	21.1	21.2	20.2
Other	5.1	8.9	16.3	9.0	9.0	9.0
Total	5.1	8.8	17.0	9.2	9.2	8.9

Other is mainly vegetable.