Organisation de Coopération et de Développement Economiques
Organisation for Economic Co-operation and Development

DIRECTORATE FOR FOOD, AGRICULTURE AND FISHERIES
WORKSHOP ON MULTIFUNCTIONALITY
Paris, 2-3 July 2001

Synthesis of the evidence on the possible impact of commodity price decreases on land use and commodity production, and the incidence on the provision of non-commodity outputs

by
Alison Burrell
Associate Professor, Wageningen University, The Netherlands
Lead Speaker, Session 3.A

SYNTHESIS OF THE EVIDENCE ON THE POSSIBLE IMPACT OF COMMODITY PRICE DECREASES ON LAND USE AND COMMODITY PRODUCTION, AND THE INCIDENCE ON THE PROVISION OF NON-COMMODITY OUTPUTS

by
Alison Burrell[1]

1. Introduction

1. This paper has been prepared for Session 3 of the OECD Workshop on Multifunctionality to be held on 2-3 July 2001. Its aim is to synthesise and evaluate the evidence from country reports and other sources concerning the observed or possible impacts of commodity price decreases on land use and commodity production, and the incidence on the provision of non-commodity outputs. It also aims to identify approaches whereby policy makers could obtain additional relevant information.

2. The country reports on which this synthesis is based come from Austria, Belgium, Czech Republic, Finland, France, Greece, the Netherlands, Norway (food security), Norway (other non-commodity outputs), Spain, Switzerland, the United Kingdom, Australia and New Zealand, Canada, the United States (literature review), the United States (four selected non-commodity outputs), Japan and Korea.

2. Analytical framework

3. The analytical framework for this synthesis consists of two parts. First, the question of the possible impact of commodity price decreases on land use and commodity production can be investigated within the theoretical framework provided by neo-classical production theory. According to this approach, farm outputs are produced using variable (purchased) inputs and fixed factors (i.e. inputs that are operator-owned or controlled on a longer-term basis) using the most appropriate available technology. The producer is assumed to maximise the net return to the fixed factors, given the prices he faces.

4. In conventional applications of this framework, only those inputs and outputs that are under the control of the producer and for which he faces a price are specified. Second, therefore, in order to study the joint production of commodity and non-commodity outputs, it is necessary to incorporate the non-commodity outputs explicitly into the analysis. To do this, the relevant conceptual elements from OECD (2001) are used.

5. OECD (2001) (Figure II.5, p.39) offers a schematic representation of the economic activities on a typical farm. This figure shows physical linkages between fixed and variable inputs, and the outputs of commodity and non-commodity outputs. It also recognises that some of the fixed inputs available on the farm may be allocated to off-farm economic activity. In order to represent the reaction of a producer who faces a reduction in the price of an output, this diagram is adapted to reflect the fact that it is the price change that triggers the on-farm adjustments. The effects of a commodity price change are traced via different on-farm and inter-farm adjustments to their potential impact on non-commodity outputs.

6. We assume that, when the price of a commodity output falls, the producer will alter his supply of that output. This in turn implies adjustments to his previous allocation of variable and fixed inputs. In the

1. Associate Professor, Department of Social Sciences, Wageningen University, The Netherlands (Email: Alison.Burrell@alg.aae.awau.nl)

absence of any policies to remunerate the provision of non-commodity outputs, the producer's reactions will take into account only those inputs that have an opportunity cost for him. He will ignore repercussions on non-commodity outputs. The consequences of his adjustments for non-commodity outputs depend on the specific way in which the non-commodity outputs are *joint* with commodity output(s), the time horizon considered (i.e. the short or longer term) and the range of other technological and non-agricultural options available to the farmer.

7. OECD (2001) recognises that jointness between commodity and non-commodity outputs can result from (a) technical interdependencies, (b) the use of a non-allocable factor or (c) the presence of an allocable factor whose total quantity is fixed for the farm. The following examples clarify how these three types of jointness are accommodated in the above characterisation of neo-classical production theory.

8. Jointness due to technical interdependency implies that the level of the non-commodity output depends directly in the level of the commodity output. In the usual textbook example, the honey producer's output depends on the yield of his neighbour's fruit trees[2]. In the case of jointness due to a non-allocable factor, the producer's use of this factor (which may be variable or fixed) to produce commodity output automatically makes it available for the production of the non-commodity output. It is essentially non-rival for one output when used to produce the other. For example, using a particular cow to produce milk does not reduce its capacity to enhance a scenic alpine landscape. Moreover, the non-commodity output is either non-excludable, or excludable only at extra cost that the producer may have no incentive to incur. For example, pesticide residues are a non-commodity output produced jointly with the commodity output, by the variable input pesticides. Pesticide residues will be "de-linked" from the commodity output only if the producer faces appropriate incentives or sanctions.

9. Jointness due to an allocable fixed factor occurs because the allocation of a fixed input to one commodity output necessarily reduces the amount of that input available for other commodity outputs on the farm. If competing commodity outputs are associated with different non-commodity outputs, or different levels of the same non-commodity output per unit of the fixed factor, reallocation of a fixed factor between commodities will have an impact on the supply of non-commodity outputs. For example, if land is shifted to crops with a higher leaching potential, negative externalities associated with chemical run-off will increase.

10. Figure 1 shows the main linkages between a change in the price of a commodity and the provision of an associated non-commodity output. The link (1) $\rightarrow$ (2) $\rightarrow$ (3) represents a direct technical interdependency: as the level of the commodity output varies, so does that of the non-commodity output. We refer to this as a *direct output effect*[3].

2. In this example, the interdependency goes in both directions, since the level of the bees' activity (and hence the honey output) also influences the output of the fruit grower. Two-way dependency between the two outputs is not necessary in order to qualify for technical interdependence.

3. The terminology used here to denote the various effects of price on non-commodity outputs is not found in the literature. It is designed for the specific context of this paper and the issues under discussion here.

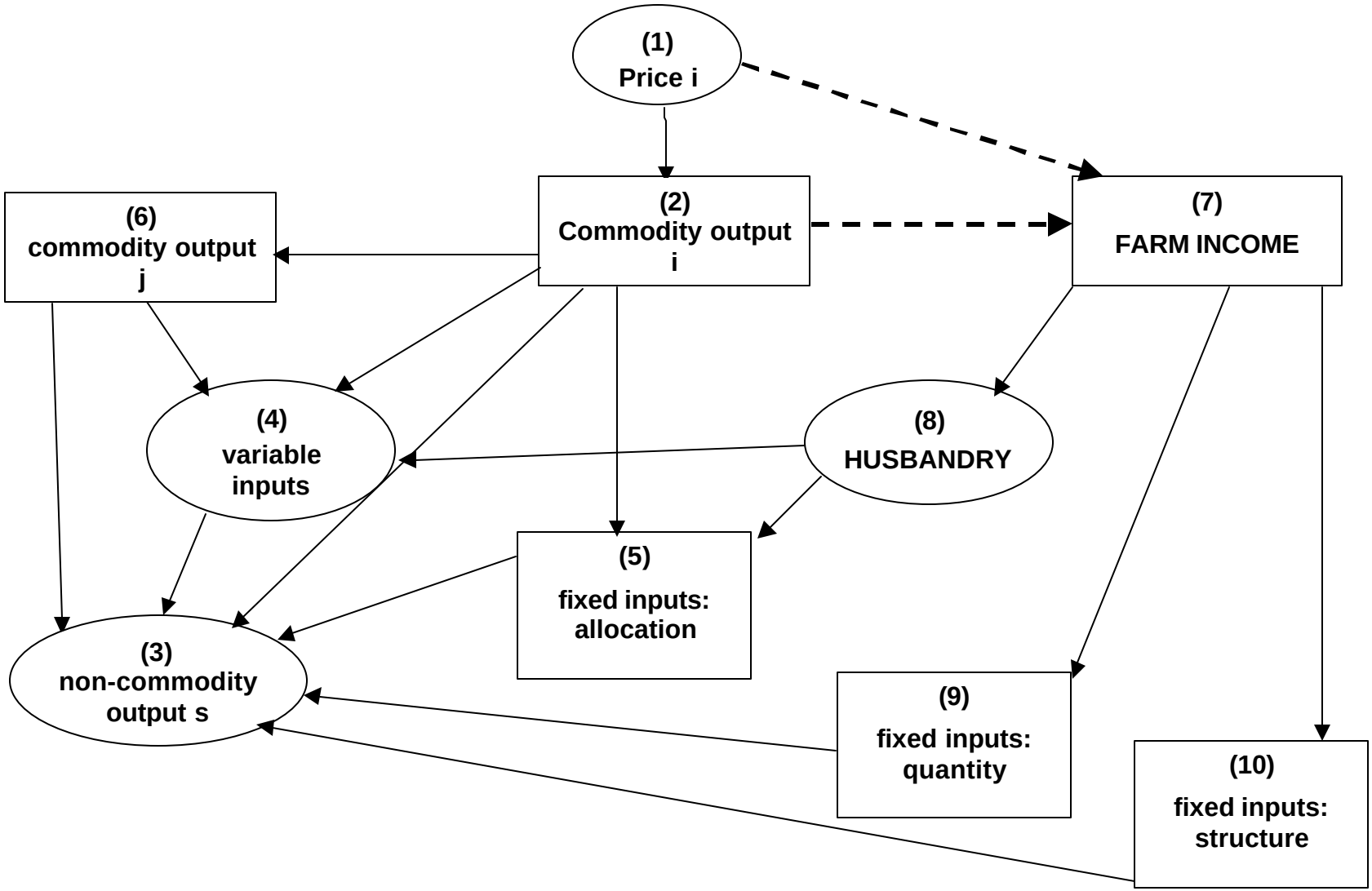

Figure 1: Main linkages between commodity price and non-commodity output

11. The link (1) → (2) → (4) → (3) operates via the jointness due to a non-allocable variable input. The arrow from (2) to (4) is shown as going in one direction only, in order to stress that the demand for the variable input is a *derived* demand, that is, the variable input is demanded in order to produce a desired level of the commodity output[4]. Therefore, its level adjusts when output price changes because the planned supply of the output has changed. We refer to the effect of this price change on non-commodity output via this link as a *direct variable input effect.* A fixed factor may also be non-allocable between a commodity output and a non-commodity output. That is, once it has been allocated to commodity output *i*, a certain level of non-commodity output *s* is also generated. In this case, we refer to a *direct fixed input effect.* This is shown by the linkage (1) → (2) → (5) → (3).

12. When the price of commodity *i* falls, there may be substitution away from commodity *i* and towards commodity *j.* This kind of adjustment is more likely if the price of only one output falls, or if output prices fall differentially, so that the relative prices of competing commodity outputs change. If the two commodities have different technical interdependencies with non-commodity outputs, or if their substitution causes adjustments in non-allocable variable inputs that jointly produce commodity and non-commodity outputs, then there will be consequences for the supply of non-commodity output(s). We refer to these links as *indirect output* and *indirect variable input effects* ((1) → (2) → (6) → (3) and (1) → (2) → (6) → (4) → (3) respectively).

13. Moreover, commodities *i* and *j* may both use the same fixed allocable input. If so, when production of commodity *i* falls, the fixed factors released may be re-allocated towards commodity *j*, and the link (1) → (2) → (6) → (5) → (3) is activated. This kind of fixed input reallocation may occur even in the short run. If the level of non-commodity output(s) per unit of the fixed input is different when the fixed input is used to produce commodities *i* and *j*, then there will be a change in the provision of non-commodity output(s). This is termed an *indirect fixed input effect.*

14. The case just described involves jointness of two *commodity outputs* due to a fixed allocable factor, and the consequences for associated non-commodity outputs of substitution between them. It is debatable whether a commodity output and a non-commodity output compete directly for a fixed allocable output. As long as non-commodity outputs are not remunerated, the profit-maximising producer has in theory no incentive to allocate any share of a fixed allocable input to the production of a non-commodity output as this reduces the amount available for the production of a marketable output. Therefore, it is more likely that when a non-commodity output is directly associated with the use of a fixed allocable factor, it involves jointness via some kind of technical interdependency[5].

15. On the right hand side of Figure 1 are three more links between price *i* and non-commodity output *s*, all of which operate through farm income. The link (1+2) → (7) → (8) → (4+5) → (3) reflects the fact that when income is reduced by the price and output falls, producers may attempt to boost revenue or cut variable costs by changing farming practices. This can involve reactions such as ploughing up field margins or substituting chemical pesticides for integrated pest management. These changes may have profound consequences for non-commodity outputs. We call this the *farming practices effect.*

16. Another chain of adjustment, (1+2) → (7) → (9) → (3), is stimulated by pressure on income and involves a reduction in the total amount of one or more fixed factors that are associated with a non-commodity output. Assuming that producers were already using profit-maximising combinations of variable inputs and commodity outputs, given their fixed input levels and the available technology, it is inevitable that a fall in one or more commodity price will reduce net returns to the fixed factors and the shadow prices of those factors will fall. This may trigger adjustments involving the quantity of one or more

4. Although, in theory, output and input levels are jointly determined.

5. This point is discussed further in OECD (2001, pp.118-119).

fixed inputs. Whether or not the farmer adjusts the quantity of the fixed factors available to the farm depends on the opportunity cost of continuing to use each fixed input in farming.

17. For example, following a fall in the shadow prices of both land and labour, a farmer may reduce his labour supply to his own farm and take up some part-time employment, if the off-farm wage is higher than the shadow return to his labour when used on his own farm. At the same time, he may keep the whole of his land in production if there is no alternative use for it that offers a higher reward. Even if no land is taken out of production, the *quality* of non-commodity outputs provided by that land (such as landscape features or wildlife preservation through more careful or time-consuming farming practices) may suffer due to its combination with a reduced labour input.

18. The extreme case of a reduction in fixed inputs involves the abandonment of the whole farm, with land reverting to wilderness or being sold for urban development. The fixed factors that disappear from agricultural use are a combination of land, labour and capital. The non-commodity outputs that were generated directly from the use of these fixed factors for agriculture will now cease. Therefore, the total quantity of non-commodity output will fall. This adjustment is unlikely to be activated in the very short term following a general reduction in output prices unless it is known that prices will not recover. However, in the medium term it becomes an active option, and is more likely to be irreversible than the other adjustments described so far. We refer to this as a *resource base effect*.

19. Finally, the linkage (1+2) $\rightarrow$ (7) $\rightarrow$ (10) $\rightarrow$ (3) on the right hand side of Figure 1 depicts the situation where the combination of a commodity price fall and the resulting cut in output puts unsustainable pressure on farm income, which triggers significant structural change. This change involves farm amalgamations, with land remaining in agricultural production but labour and human capital leaving the sector. Larger structures and a lower labour-land ratio offer new technological options that were not previously feasible, and which have implications not only for the way the remaining fixed allocable factors are used but probably also for the variable inputs. Such a technological switch could have major impacts on non-commodity outputs. This chain of adjustments is complex and may involve more than one of the effects already described. We refer to it as the *technology effect* since it is due specifically to technological change that brings new transformation possibilities between inputs, commodity outputs and non-commodity output. This effect usually depends on structural change, can involve major alteration to one or more fixed factors and is likely to be irreversible.

20. The resource base effect and the technology effect are medium-term phenomena. If widespread in the sector, they can have a large impact on non-commodity outputs such as landscape preservation, biodiversity, rural employment (in areas where farm employment still plays a role) and water resource management (in countries where this is currently a non-commodity output of farming). These two effects are easily overlooked in the theoretical discussion of jointness, since the standard theory of producer decision-making is based on a single producer who remains in business, considers one planning period only and assumes that technology is fixed. The disappearance from the sector of resources which are not replaced by the creation of new businesses falls outside the scope of the theory of the individual firm. Similarly, discrete technology switches pose a challenge to microeconomic theory. Such switches can, however, alter established patterns of jointness between commodity and non-commodity outputs in a radical and discontinuous way.

21. In this section, we have identified nine different routes whereby the fall in a commodity price can affect the provision of a non-commodity output. They are summarised in Table 1. Each link is characterised by one of three kinds of jointness. In theory, the impact of a fall in output price on an associated non-commodity output could be positive or negative. Therefore, there are potentially eighteen different classifications possible. The next section attempts to classify the impacts reported from each member country in this framework.

Table 1: Classification of potential impacts on non-commodity outputs due to a price cut for a commodity output

Classification	Reference to Figure 1	Example	Time frame	Reversible ?	Incidence
On-farm effects					
Direct output effect	$1 \rightarrow 2 \rightarrow 3$	Rice price $\downarrow$, $\rightarrow CO_2$ absorption $\downarrow$	SR	Y	(*)
Direct variable input effect	$1 \rightarrow 2 \rightarrow 4 \rightarrow 3$	Crop price $\downarrow$, crop output $\downarrow$, fertiliser use $\downarrow$, nitrate contamination of surface and groundwater $\downarrow$	SR	Y	****
Direct fixed input effect	$1 \rightarrow 2 \rightarrow 5 \rightarrow 3$	Fruit price $\downarrow$, orchard area $\downarrow$, landscape diversity $\downarrow$	MR	Y	***
Indirect output effect	$1 \rightarrow 2 \rightarrow 6 \rightarrow 3$		SR	Y	-
Indirect variable output effect	$1 \rightarrow 2 \rightarrow 6 \rightarrow 4 \rightarrow 3$	Crop price $\downarrow$, potato area $\uparrow$, pesticide contamination of water system $\uparrow$	SR	Y	*
Indirect fixed output effect	$1 \rightarrow 2 \rightarrow 6 \rightarrow 5 \rightarrow 3$	Beef price $\downarrow$, grazing land converted to cropland, soil erosion $\uparrow$	SR/MR	Y	**
Farming practices effect	$(1+2) \rightarrow 7 \rightarrow 8 \rightarrow (4+5) \rightarrow 3$	Falling farm income forces cost-savings, farmer replaces integrated pest management by chemical pesticides	SR	Y	**
Sector effects					
Resource base effect	$1 \rightarrow 2 \rightarrow 5 \rightarrow 3$	Farm incomes $\downarrow$, land and labour leave agriculture, food security and rural employment $\downarrow$, total provision of landscape amenity and habitat preservation $\downarrow$	MR	N	****
Technology effect	$(1+2) \rightarrow 7 \rightarrow 9 \rightarrow (4+5) \rightarrow 3$	Farm incomes $\downarrow$, farm amalgamation $\uparrow$ permitting new "industrialised" farming technologies, landscape amenity and habitat preservation deteriorate	MR	N	***

Last three columns: **Time frame** refers to the speed of the farmer's adjustment, not the time taken to affect the non-commodity output. SR=short run, MR=medium run. **Reversible?** refers to the farmer's decision. Y=yes (but reversing the decision may not be costless). **Incidence** refers to the frequency and/or importance given to the corresponding effect in the country studies. This is a subjective judgement.

3. Summary of the evidence

22. This section summarises the evidence provided by 18 country studies on the possible impact of commodity price decreases on land use and commodity production, and the incidence on the provision of non-commodity outputs. To avoid the intrusion of repetitive references, the reader should assume that the evidence relating to a specific country is drawn from the corresponding country study, unless it is otherwise referenced.

3.1 Supply response

23. As a preliminary, we consider the evidence on the reaction of commodity output to a fall in its own price (the link (1) → (2) in Figure 1). There is a reasonable consensus in the reports, and much additional empirical evidence in the scientific literature to support it, that commodity supply is positively related to its own price. Therefore, when price falls so too does commodity output[6].

24. The supply elasticities quoted in the literature are usually for particular categories of output. They measure *ceteris paribus* changes in supply of one type of output, following a change in its price, on the assumption that prices of other outputs remain unchanged. Although these individual elasticities are likely to overstate the reduction in total agricultural output in a scenario where all output prices fall together, all the evidence (not to mention the rhetoric about trade-distorting support prices) suggests that agricultural output generally will fall if output prices decline.

25. Only one possible counter example was found. Evidence was quoted from New Zealand of a slump in wool prices leading to over-grazing, which resulted in destruction of landscape and loss of biodiversity. This example suggests disequilibrium behaviour that is likely to be unsustainable in the long run. If all profit-maximising options were being exploited before prices fell, and appropriate husbandry techniques for the long-run management of fixed factors were in use, intensification as a response to a price fall involves the deterioration of a fixed resource over time. A few European studies refer to increasing intensification over time accompanied by falls in real prices. It is true that, as real prices have fallen in Europe, farmers have kept pace with new cost-reducing technologies that, in some sectors, have led to intensification. However, there seem to be no grounds for arguing that this has occurred as a direct response to price falls. Without falling prices, the impact on output of technological change is likely to have been greater[7].

3.2 Direct output effects

26. As long as commodity price reductions cause a fall in the corresponding commodity output, the nature of the links between output price and non-commodity output can be investigated by considering the

---

6. For econometric evidence on positive output supply elasticities for on individual agricultural outputs within a supply system, see for example Guyomard et al (1996) (France), Sckokai and Moro (1996) (Italy), Reziti and Ozanne (1999) (Greece), Williams and Shumway (2000) (USA). The surplus changes due to price decreases in Korea under the Uruguay Round Agreement reported by Lee *et al* (1999) indicate positive supply elasticities for all outputs. For evidence on supply response when commodity prices fall together, see for example Sandrey and Reynolds (1990).

7. Ozanne (1992) has shown that an apparent backward bending supply curve is compatible with rational decision-making only when the presence of intermediate farm inputs blurs the traditional distinction between input and output, or when a fall in own-price is accompanied by a sufficiently large reduction in price risk.

links between commodity outputs and non-commodity outputs. We turn now to the first linkage identified in Figure 1, that is, a direct technical interdependence between a commodity and a non-commodity output.

27. Leaving food security issues to one side, only two countries offer evidence of a link between the level of commodity output *per se* and the provision of non-commodity outputs. Korea provides the winter habitat of 15% of the world's population of cranes, a bird species that is threatened with extinction. The preservation of cranes is correlated empirically with the yield in rice grains of paddy fields. The capacity of paddy fields to absorb carbon dioxide is also positively related to rice yield. In Austria, there is a relationship between intensity of grassland management (number of nutrient applications plus cuttings) and bio-diversity: the number of species is maximised when production is semi-intensive, but the number of rare species is maximised at lowest levels of intensity[8].

28. In more countries, it is the presence of agricultural production *per se* rather than the level of output that is important for maintaining landscape values and to an extent biodiversity (although beyond a certain level of intensification biodiversity is harmed). For example, in Swiss alpine areas, some species and habitats are linked to agricultural cultivation and would be lost if a pure conservation strategy were adopted. In Austria, there are some semi-natural areas in different parts of the country that are considered to be of high ecological value. In 60% of these areas, agricultural provision was found to be a pre-condition for achieving conservation goals. Rice production in the upland Japanese paddy fields requires continuous management to regulate water levels, and to maintain terraces and canals. The paddy fields perform their non-commodity functions of flood control and landslide prevention best when rice is actually produced. By contrast, it is suggested that there is no apparent evidence in the US of jointness between agricultural production and the open space amenities of agricultural land[9].

29. Regarding food security, it is clear that the level of food production is directly and positively related to a country's food self-sufficiency status. Japan, Korea and Norway are concerned to maintain or increase existing self-sufficiency levels in order to improve their food security. One could therefore argue that the perceived level of food security in these countries is directly associated with the level of food production.

30. However, the Norwegian study on food security as a non-commodity output focuses more specifically on food security in a crisis situation, where the key issue is the amount of productive farmland and relevant human capital that can be mobilised at relatively short notice. The emphasis is on the need to maintain production capacity as an insurance policy rather than on raising domestic production levels in non-crisis periods. Safeguarding current output levels is seen as a means of preserving this capacity.

31. The same perspective on food security is found in the study from Japan, which states that "To continue rice production not only provides the food supply for the present, but also enhances it for future food. General rice production activities have been accumulating human resources, as well as playing a role in properly maintaining and updating the land foundation for paddy fields" (p.8). The Korean contribution points out that the conversion of domestic agricultural resources to other uses has, in Asian countries, been an irreversible process. Korea considers that maintaining domestic production capacity is desirable not just as insurance against a global food crisis but also to ensure basic rice supplies in the event of reunification with North Korea.

---

8. Grass is not a final commodity output but rather a produced input, so its inclusion in this category is debatable.

9. Yet Kline and Wichelns (1996) report that residents of Rhode Island, the US state with the second densest population, attribute significant environmental amenities to farmland, which compares favourably alongside other types of non-development land use.

32. This perspective on the food security issue makes it more appropriate to treat the link between output price and food security as working through the resource base effect, i.e. through changes in the total amount of fixed factors that are available for agricultural production, rather than as a direct output effect.

3.3 Direct variable input effects

33. Direct variable input effects occur when a non-allocable variable input produces both a commodity output and a non-commodity output. A number of countries (including Japan, Korea, Finland, Switzerland, Austria and the USA) report a strong correlation between negative externalities associated with variable inputs, principally chemical fertilisers and pesticides, and output intensity. A tendency by producers to over-use or misuse these inputs is suggested[10]. In many countries, large spatial variations in the incidence of these problems are also observed. The incidence of these externalities depends on the interaction between factors like soil type, crops grown, climate and indigenous pest populations, farming practices and farmers' attitudes.

34. The Netherlands occupies one end of the intensification spectrum: supplementary feeding of dairy cattle to achieve high yields has created a huge problem of manure disposal and other negative effects of agriculture include fertiliser run-off, methane production and land dehydration due to excess drainage. Yet even here, it is predicted that these externalities would be reversed with lower production per hectare. Indeed, after the policy reform in New Zealand, there was a significant reduction in nutrient and pesticide run-off[11]. However, a recent report on EU pesticide policy (Oskam *et al.*, 1998) calculated that a large fall in output price would be required before demand for pesticide would fall in the EU. Nitrate pollution is a less important problem in Spain than over-exploitation of groundwater and coastal aquifer salinity.

35. At the other end of the spectrum, negative externalities related to pollution by agriculture are reported to be small in Norway due to the small farm structure that restrains intensification, and stricter regulation in recent years.

36. In general, however, there is a broad consensus that variable input use is associated with significant negative externalities, and these externalities are likely to be reduced following a cut in output prices.

3.4 Direct fixed input effects

37. These effects involve non-commodity outputs associated with the use of a fixed input in the production of particular commodity outputs. Many instances of non-commodity outputs generated by fixed inputs are reported, ranging from the flood control functions of Japanese and Korean paddy fields and the insect and bird habitats provided by these paddy fields, to the role of traditional olive groves (with low levels of agricultural intensification) for pre-Saharan migratory birds in Spain, the preservation of orchard eco-systems in Belgium, traditional types of landscape (vineyards, chestnut orchards etc) in Switzerland and landscape features such as hedgerows and drystone walls associated with small-scale or upland livestock farming in various European countries. The non-commodity outputs generated by the use of fixed

10. Yadav *et al.* (1997) show that in Minnesota, a state with high nitrate levels in groundwater, farmers use nitrogen above profit-maximising levels and that recommended levels are too high, when residual nitrogen in the soil is taken into account.

11. The elasticities of fertiliser and pesticide use with respect to output prices estimated for the US by Williams and Shumway (2000) are mainly positive and significant.

factors by agriculture are largely positive, but many countries indicate that these non-commodity outputs have been declining in recent years due to output intensification.

38. As already mentioned in Section 2, there is discussion about the kind of jointness that is involved here. The fixed factors involved may indeed be allocable separately to the commodity and non-commodity outputs so that the outputs are joint because the factors are fixed on the farm. Alternatively, although the factors are allocable between commodity outputs (the same land cannot grow wheat and grass simultaneously), they may be non-allocable between a commodity output and a non-commodity output (the same land grows grass *and* offers habitat to insect species). Since virtually none of the joint commodity and non-commodity output pairs reported in the country studies involves a (negative) trade-off, the jointness seems to be due to a non-allocable fixed input.

39. Regarding labour use, the picture is less clear-cut. In a rare study of this question, McInerney *et al* (2000) have quantified the costs of countryside management tasks carried out on their farms by farmers in England and Wales. The implicit assumption here is that "countryside management" (a non-commodity output) is joint with commodity output through the use of an allocable fixed factor, farm labour. However, some of the tasks also contribute directly to the production of commodity output. The study estimates these costs at £23 per hectare, which should be compared with the £208 per hectare of external costs imposed by UK agriculture (Pretty *et al.*, 2000).

40. Whether the non-commodity outputs generated by fixed factors would be reduced if output prices fell depends on the type of adjustment followed. If the only consequence of the price fall is that output intensity falls whilst fixed inputs continue to be allocated in their traditional roles, the level of non-commodity output generated by fixed factors, particularly land, may actually increase.

41. However, this assumption may in many cases prove unrealistic. The maintenance of non-commodity outputs related to fixed factor use is under threat from the last four effects that we discuss below: the indirect variable/fixed input effects, the farming practices effect, the resource base and technology effects. Each of these effects characterises a scenario in which non-commodity outputs related to fixed factor use are at risk.

3.5 Indirect variable or fixed input effects

42. If two commodities *i* and *j* both use the same fixed allocable input and the production of commodity *i* falls, the fixed factors released may be re-allocated towards commodity *j.* If the level of non-commodity output(s) per unit of the fixed input, or the use of an externality-generating variable input is different in the production of the two commodities, then there will be a change in the provision of non-commodity outputs. There is a considerable literature on the differences in elasticities of chemical run-off with respect to output price for different crops typically used in US cropping systems. In the Netherlands, potatoes (an unsupported crop) are a pesticide-intensive crop and responsible for over-drainage of farmland. If relative prices of competing outputs change in favour of an output with higher (lower) negative externalities associated with either variable or fixed input use, then the level of negative non-commodity outputs generated could rise (fall). This is less likely in a scenario where all output prices are reduced at the same time, although as the situation of potatoes within the CAP demonstrates, there are some anomalies in existing patterns of relative prices that would probably be modified in a scenario involving reductions in support prices.

3.6 Farming practices effects

43. When income is reduced by the price fall, producers may attempt to boost revenue or cut variable costs by changing farming practices. These changes may have consequences for non-commodity outputs.

44. Various farming practices (such as split nitrogen applications, soil-conserving crop rotations, use of buffer strips along watercourses or around field margins, conservation tillage, integrated pest management, soil nitrogen and moisture testing and so on) are carried out by responsible farmers who are concerned to reduce their production of negative externalities or to avoid over-use of expensive inputs. A number of country studies expressed the view that, in order to boost falling incomes, farmers may abandon their use of such practices either to cut variable costs, or to reduce their on-farm labour supply and thereby increase their availability for off-farm work. Whether this is expected to be more than a short-term reaction is not clear. However, it signals the possibility of a worsening balance of positive and negative externalities generated by farming.

45. In a recent paper, Komen and Peerlings (2001) analyse the reactions of Dutch dairy farmers to various combinations of restrictions on nitrogen emissions, abolition of milk quota and price cuts. They use a model in which two "dirty" technologies and one "clean" technology are distinguished[12]. The clean technology uses less feed per cow, more capital and agricultural services, and produces N emissions/output that are 33-41% below those of the dirty ones. In a benchmark scenario (no milk quota, manure regulations in place) 89% of milk output is produced by the less dirty of the two dirty production methods, and 9% by the clean one. After a 15% reduction in intervention milk prices, milk output is lower, the share of the clean technology has fallen to 4% and 10% of milk output is now produced by the dirtier of the two methods. Interestingly, Reinhard (1999) demonstrates that simple correlations between intensification and negative externalities can be misleading. He shows that more intensive farms (with intensity measured as cows per ha) are also more N-efficient Reinhard (1999, p. 95).

46. When predicting how farming practices might change if farmers come under increasing income pressure, it is important to know what agri-environmental restrictions and incentive programmes are concurrently in operation. A number of studies in the US demonstrate that without incentives, many best practice farming techniques will not used by farmers. However, if restrictions or incentives are in place farmers' technical choices are significantly modified.

47. It is clear that changes in husbandry techniques with the aim of reducing costs could be a significant route whereby output price changes impinge on the provision of non-commodity outputs. The policy implications of this are discussed in Section 4.

3.7 Resource base effects

48. A number of country studies predict that, if output prices reduce significantly, the pressure on returns to farm-owned resources will cause the total quantity of land and labour available to agriculture to fall. This will lead to a reduction in the total amount of non-commodity outputs provided, despite the fact that demand for them is perceived to be growing.

49. This trend is already underway in most countries. Out-migration of labour and disappearance of land from agriculture are reported in virtually every study. For example, Japan has provided evidence on the increasing rate of abandonment of paddy fields in upland areas, and the threat it poses for traditional flood control systems. In lowland areas and especially around the three major metropolitan areas, much previous paddy-growing land has already been converted to urban use. Similar trends are reported for Korea. Although some alternative flood control infrastructure has been created to offset the conversion of paddy fields, it is becoming increasingly difficult to find good sites for the construction of multi-purpose dams and there is evidence of increasing flood damage.

12. The clean technology is based on a farming system currently in operation on a Dutch experimental farm.

50. In the Czech Republic, abandonment of land is also seen as the main threat to agriculture's positive non-commodity outputs. Current trends would be exacerbated by a reduction in farm prices, affecting the landscape preservation function of grazing land and causing erosion problems if marginal arable land is abandoned. In the Netherlands, there is currently an active debate about the future of agriculture as a major user of land, which is under strong pressure of demand for housing, road construction and so on. Non-agricultural provision of land-based positive externalities is well advanced in the Netherlands, with about 18% of rural areas (including shallow waters) either directly owned or managed under some kind of conservation agreement so as to provide landscape, wildlife habitat or recreation[13]. If, however, total returns to farming fall further and there is a massive withdrawal from farming, it is unlikely that non-agricultural provision can be increased sufficiently to satisfy demand for these non-commodity outputs.

51. In Norway, loss of land for agricultural use would lead to its abandonment or to afforestation. This would mean a significant loss of agricultural landscape. Unlike the situation in the Netherlands, population density is low and agricultural production is so scattered that non-agricultural provision of non-commodity outputs is seen as unrealistic. In Finland, where agriculture occupies only 8% of the land area, many traditional biotypes would be threatened if land were withdrawn from agricultural use on a large scale or in a fragmented way. In Norway and Finland, agriculture and forestry are not considered substitutes in the provision of non-commodity outputs, especially habitat and landscape diversity[14]. A survey in Finland found that agricultural land incorporating buffer zones along watercourses is the most valued landscape, whereas afforestation and land abandonment are the factors that most decrease the scenic value of landscape. In Spain, land abandonment in the interior of the country has negative effects on landscape provision, wildlife habitat and preservation of ecosystems, and fire risk.

52. The evidence that withdrawal of agricultural labour would significantly affect rural employment is much weaker. For example, rice growing in Japan contributes little to rural employment although horticulture and farm produce processing do help to sustain or increase employment levels. By contrast, in a study of employment patterns in a Korean rural county, crop production and agricultural services are estimated to have the highest total employment multipliers (Kim and Yoo, 1988). In Norway, farmers in remote rural areas are highly dependent on farm incomes, and thus these areas are more threatened by a potential rural exodus if output prices fall. In Austria, agriculture accounts for over 20% of employment in more than 10% of districts. On balance, it appears that rural employment effects could be significant in some regions of certain countries.

53. In all the countries referred to above, loss of land and labour from agriculture are long-run trends that have been observed over decades. The reports quoted above suggest that significant falls in output prices would accelerate these trends to the point where major and irreversible losses of non-commodity outputs may occur, and where the scale of provision within the country could fall short of demand. It is remarkable that few quantitative studies of these phenomena are reported. A recent report from Finland (SUSAGRI, 2000) calculated that if domestic support fell by 40% in 1999, by 2001 over 500 thousand hectares of land would be abandoned (compared with 3.3 thousand in 1995) and the number of farm holdings would fall by one quarter.

54. It was mentioned above that the food security concerns of Norway, Japan and Korea seem now to focus more on maintaining the potential (in terms of productive capacity - i.e. agricultural land and skills) to feed the domestic population in a crisis situation. Clearly, the permanent retirement of land and farming

13. In addition, water management and flood control functions are provided by the public authorities.

14. However, Plantinga (1996) analysed the effects of a reduction in milk price support in south western Wisconsin and found that the provision of non-commodity outputs increases as marginal agricultural land is shifted to forestry.

expertise from the sector reduces the scale on which domestic production could be geared up to meet this need.

55. In contrast to the above-quoted studies, in the United States the loss of fixed factors from agriculture is generally considered unimportant for the provision of non-commodity outputs. Impacts of a declining farm workforce on rural employment are considered to be negligible [15]. As for agricultural land, one of the country studies states that open space is valued as providing wildlife habitat and slowing down development, and these functions are independent of (or even competitive with) agricultural production. Moreover, there is evidence that land sales for development are motivated by capital gains and are largely independent of current income.

56. Both Australia and New Zealand have rural areas from which agriculture has nearly disappeared, and in New Zealand native (and regenerated?) bush is now seen as the most desirable landscape. In these countries as in the US, land retirement is considered a desirable policy to deal with various kinds of negative externalities from agriculture. Indeed, most US agri-environmental expenditure has gone on land retirement schemes.

57. In Canada, there have been no studies evaluating agricultural landscape but many evaluations of wilderness. The Canadian study supports the idea (Batie, 1997; Hodge, 2000) that "New World" countries, in contrast to Europe and Asian countries, attach more value to a natural ecosystem than to a managed or specifically agrarian landscape.

58. As the North American and Oceanian countries are net food exporters, they are not concerned by any food security implication of withdrawing productive resources from agriculture.

59. In summary, those countries that value highly the non-commodity outputs of farmland, preservation of open space and non-developed areas, rural employment or food security, view with much greater concern the disappearance of resources from agriculture. These countries tend also to attach higher probability to the acceleration of current trends if commodity prices fall.

3.8 Technology effects

60. This effect occurs when the combination of a commodity price fall and the induced fall in output puts unsustainable pressure on farm income, triggering structural change involving farm amalgamations. Land remains in agricultural production but labour and human capital leave the sector. Larger structures permit new technological options for exploiting the land that were not previously feasible. This section investigates the likelihood of such a development, based on the country studies.

61. In Norway, half the farms have disappeared in the last 30 years, but most land has been taken over by neighbouring farms. Although farm size in Norway still remains very small compared to most European countries, regional specialisation (encouraged by policy measures aimed at exploiting comparative advantage) is already giving cause for concern within this small-scale structure. Thus, Norway is seen to have already started on the path leading to specialisation and the associated deterioration of non-commodity outputs like landscape variety and habitat diversity, which are negative aspects of large-scale farming. Structural change, regionalisation and intensification, leading to loss of landscape diversity, are also observed in Finland.

62. Although labour-saving technologies are gradually being introduced into paddy field management in Japan, there are no predictions of significant structural change being triggered by local

15. Farm income accounts for less than 4% of total personal income in non-metropolitan US counties and the share of agricultural employment was just 8% in rural counties in the mid-1990s.

labour shortages. As already mentioned, land abandonment and unplanted paddy fields are a more typical phenomenon in Japan. Apparently, the scope for larger-scale technology for larger-scale paddy production is so far limited.

63. In the Netherlands, nearly half of dairy and arable farmers are over 55 and have no successor. These farmers control about 1 million hectares (30% of the rural area including shallow waters). Thus, there is scope here for major restructuring and the adoption of large-scale technology in the coming years. According to the report, however, the real danger is that land will be nibbled away from agriculture by "diffuse urbanisation".

64. Structural change with large increases in farm size is one of the possible scenarios following a fall in prices in Spain's extensive dryland agriculture. The loss of crop diversity that is expected to follow from the new technologies introduced on larger new farms would have negative effects on bird habitats. Rural employment in economically vulnerable areas would also suffer.

65. There are apparently very few studies explicitly analysing the impact of price-induced structural and technological change on non-commodity outputs. Potter *et al.* (1998) surveyed farmers in three very different regions of the UK to examine the impact of trade liberalisation on environmental management. Farmers were presented with a number of scenarios involving different degrees of liberalisation. A key finding was that, in upland areas, amalgamation of farm holdings would encourage a "ranching" system of management to the neglect of marginal land and with stocking levels too low to maintain biodiversity. A very low labour-land ratio would mean a lack of resources for countryside management tasks.

66. Moreover, in Belgium, economic models have predicted that output price reductions would lead to an increased scale of farming, with "larger-scale" landscapes (loss of landscape features) and more uniform cropping systems.

67. The reports mentioned in this section highlight the negative landscape and wildlife effects that massive technological change would bring, and to a lesser extent the rural employment effects. The assumption is invariably made that larger-scale technology would lead to a more industrialised agriculture. If this permits more intensive production and higher output per hectare, the implications for food security are ambiguous. Self-sufficiency may improve, other things being equal. If, however, the true food security objective is to maintain food-producing capacity for times of crisis, the security offered by more industrialised technologies that rely more heavily on purchased (imported) inputs may be illusory. Other possible consequences of restructuring and technological development, such as loss of countryside access to the public, animal welfare aspects and so on are not mentioned in the country studies.

Table 2. Summary of impacts on non-commodity outputs of changes in fixed factor availability following a fall in output prices

Labour	Land	
	Remains	**Is withdrawn**
Remains	Farm incomes fall, rural poverty increases. Deterioration in farming practices possible. Consequences for non-commodity outputs hard to predict.	Not realistic
Is withdrawn	Farm amalgamations, restructuring → new technology Greatest threat to landscape preservation, biodiversity. Also rural employment. Effect on food security ambiguous.	Land abandonment or conversion, outmigration. Reduction in the total provision of landscape, biodiversity; loss of flood and disaster prevention, food security and rural employment (where relevant).

68. Table 2 summarises the different scenarios involving the disappearance of land and/or labour from agriculture. The top left-hand box represents a scenario that inspired much agricultural policy in the first half of the twentieth century but is unlikely to fit OECD countries in the twenty-first century. The bottom left-hand box corresponds to the technology effect, whereas the bottom right-hand box represents the resource base effect. They differ according to whether or not land leaves the sector along with labour. In either case, the consequences for agriculture's current provision of non-commodity outputs could be significant. For countries whose agriculture is already characterised by large-scale structures and low labour-land ratios, and where unused land can revert easily to an ecologically sound pre-agricultural state, both the scenarios in the bottom line may seem inevitable and desirable. Countries whose current non-commodity output provision is based on smaller-scale, more labour intensive agriculture and where high population density creates heavy demand for non-commodity outputs from agriculture, these developments are viewed with more concern.

4. Conclusions

69. This section summarises the general trends and patterns that emerge from the country studies. It then identifies areas in which additional information would be useful for predicting the impact of commodity price decreases on commodity production and on the provision of non-commodity outputs.

4.1 General trends, points of convergence and divergence

70. There is general consensus that producers would respond to commodity price reductions by reducing their supply of commodity outputs. This indicates a normal supply response. There are also, however, predictions of increased production intensity as a response to price falls. It is not always clear whether this is intended to imply an increase in total quantity supplied or in supply per hectare. The previous section has presented a framework for decomposing producers' reactions so that more clarity can be achieved on this question.

71. Almost no cases are reported where the level of a non-commodity output is directly related to how much of a commodity *output* is produced. Therefore, reduction of output supply *per se* would not

affect the provision of non-commodity outputs. However, non-commodity output provision would be affected because of adjustments in input use. The way in which non-commodity outputs will change depends strongly on *how* producers adjust their input use in order to achieve the desired reductions in supply.

72. There are divergent views on whether the presence of at least some agricultural production is necessary for the provision of certain land-based non-commodity outputs such as landscape or flood control. Even where agricultural production is not necessary, so that a price-induced cessation of production would not automatically lead to a cessation of non-commodity output provision, it is not guaranteed that this provision will continue. Whether land abandoned by agriculture continues to provide non-commodity outputs depends crucially on how it is subsequently managed, and in particular whether it is converted to another use.

73. There is strong consensus that agriculture's use of certain variable inputs generates negative externalities, and that these externalities are likely to be reduced if output prices fall. The country studies refer to a large body of empirical literature analysing these linkages. There is major spatial variation, even within countries, in the quantitative importance of the impacts of commodity price changes on externalities generated by variable input use.

74. Non-commodity outputs provided directly by the use of fixed factors in agriculture are more typically related to commodity outputs by a relationship of technical interdependency than because they use the same allocable fixed factor as commodity outputs. The typical case is of a fixed input that generates a non-commodity output simultaneously with a commodity output, and not of commodity and non-commodity inputs competing for the rival use of a fixed input. However, it depends on the particular case as to whether this technical interdependency operates at the margin (i.e. the more commodity output is generated by the fixed factor, the higher (lower) the level of the non-commodity output) or whether the provision of the non-commodity output requires simply that the fixed factor should be used produce a particular agricultural commodity, regardless of the intensity of use. Thus, if commodity price changes alter the *intensity* of use of the fixed factor it is not always clear what the impact on non-commodity output would be.

75. There is significant scope for changes in the provision of non-commodity outputs following a commodity price fall if lower incomes put pressure on farmers to adopt cost-reducing farming practices that are less respectful of non-profit-oriented outcomes. The extent to which they do this will be conditioned by the regulations and agri-environmental programmes currently in force, together with the general package of property rights conferred by land ownership in their country.

76. Many countries perceive a major threat to non-commodity output provision due to the disappearance of land and labour from agriculture. If the total quantity of these resources in agriculture declines, even if those resources that remain in agriculture continue to be used as before, the total quantity of non-commodity outputs produced by agriculture will decline. In countries where agriculture already takes only a small share of total land area, it is suggested that the reduction in the quantity of land available for agriculture may force the total provision of non-commodity outputs below some kind of acceptable absolute threshold. With regard to the loss of labour from agriculture, the likely impact on non-commodity outputs, specifically on rural viability, varies much more between countries. Some country studies consider this impact to be negligible. Other studies indicate that the impact could be significant in some regions.

77. Moreover, the consequences of the disappearance of fixed inputs from agriculture following a fall in commodity prices depend on what the most likely alternative use for this land is. Depending on the country or region, former agricultural land may be used for construction or urbanisation, may revert to its natural pre-agricultural state or may lie unused in an ecologically unstable condition, possibly as a source of fire hazard or deteriorating through lack of maintenance. Regarding labour, one study refers to the possibility of increasing urban congestion due to a mass exodus of agricultural labour. Therefore, when

land and labour are withdrawn from agriculture, the loss of the associated non-commodity outputs from agriculture may in some cases be compounded by the negative externalities generated subsequently by alternative uses of these factors.

78. The question of what the most valued characteristics of land as a spatial medium are, and how land should be used if it is not used for agriculture, receives different answers in different countries. This means that, even where the impact of price reductions on land use is the same across countries, the way this impact is perceived and valued will differ. Real cultural divergences seem to be indicated here.

79. Studies from countries concerned with food security appear to describe agriculture's role in this respect as providing the *potential* for self-supply of food in times of crisis as more important than the actual level of food supply attained in non-crisis periods[16]. Currently, this capacity is maintained by a mixture of price incentives for current production and direct payments. It is implied that, if output prices fall, existing capacity for domestic food production cannot be guaranteed.

80. Countries whose current pattern of non-commodity outputs depends on small-scale production units and a more managed pattern of land use foresee that declining output prices would increase pressure for the industrialisation of agriculture into larger-scale structures involving new technologies. This would affect the provision of some non-commodity outputs. There are natural, country-specific limits to how much restructuring and technological change could be accommodated without major damage to non-commodity outputs. These limits depend, *inter alia*, on terrain and agro-climatic conditions, population density and pattern of settlement in the countryside, agriculture's current share of the total land area and total area of agricultural land available in the country. There seems to be a general uneasiness (see, for example, the studies from Belgium, Greece and the Netherlands) that, in a piecemeal restructuring and technological evolution driven by cuts in commodity prices, these natural limits may not be respected.

4.2 Recommendations

81. To answer the question concerning appropriate methodologies for obtaining additional information that would be useful to policy makers, a first step is to identity apparent gaps in the existing information base. Given that there are large differences between countries in the information available, the recommendations contained in this section will remain general and conditional. The country studies do not permit any assessment to be made of the costs of obtaining additional information.

82. The specific question addressed in this paper is the likely effect of commodity price cuts on the supply of non-commodity outputs. We assume that the purpose of having better information on this issue is in order to identify the types of agricultural activity likely to come under most pressure following reductions in output prices, and the specific non-commodity outputs that are most likely to be affected, so as to design mitigating policies. This would require being able to identify the most likely adjustment strategies adopted by farmers, and being able to predict the direction of likely changes to non-commodity outputs that their adjustments generate. To go further and construct quantitative models that could be used to predict the size of the impacts of commodity price changes would require a much deeper and more comprehensive information base than we envisage here.

83. With this relatively modest objective in mind, one can survey the evidence provided by the country studies in order to identify current information gaps. Some major areas for further study are listed below.

16. We acknowledge that there is a danger of over-interpreting certain passages relating to food security that appear in these country studies. The interpretation that what matters is the maintenance of production capacity for food rather than to routinely fully exploit this capacity may not represent the view of the governments concerned.

84. ***More information on fixed input use in agriculture is required***. One of the conclusions of this review of the country studies is that commodity price changes will impact on positively-valued non-commodity outputs largely through the adjustment of fixed factors. Therefore, more information is needed in this area. This includes information not only about how fixed inputs are allocated over different types of production, but also on the shadow prices of land and labour in different types of farming, rates of exit and entry of fixed inputs into farming, and the new uses of factors that leave farming.

85. ***More information is needed concerning the interface between farming practices and non-commodity provision.*** This information should be not only of a purely technical nature, but should also embrace economic constraints and producer incentives. The compilation of a complete database on agri-environmental interactions and farmer responses region by region is a daunting task, and most governments would be unwilling to incur the cost of setting up and maintaining such a database. However, it seems clear that the marginal return to additional studies examining particular questions of interaction between commodity and non-commodity output production is high, in terms of more imaginative and effective policy making[17].

86. ***Information about the interactions between different types of policies is needed in order to understand better the links between commodity price changes and non-commodity output provision.*** Policy makers need much more information about the interactions between different kinds of policies, and the complementarity between initiatives in areas like income support, environmental policy, structural policy and rural development. The country studies from Switzerland and Austria both express the view that the impact of commodity price changes on non-commodity output provision is likely to be small in these countries because mitigating policies are already in place. The evolution of Swiss policy over the last 10 years illustrates an integrated approach in which a progressive lowering of output prices was accompanied by the setting up of alternative payment systems with increasingly strong cross-compliance conditions. As a result, higher targets for non-commodity outputs have been achieved while minimising the effects on farm incomes, which may otherwise have created pressures for the reduction of non-commodity output supplies. In various other studies, likely impacts of falling commodity prices are discussed as if no other related, possibly offsetting policies were already in place. One wonders whether this is indeed the case, or whether insufficient information is available to take the possible role of these other policies into account.

87. ***More information is required about producers' behavioural responses to declining farm income, and to programmes designed to promote non-commodity output provision***. The physical interactions between commodity-producing activities and non-commodity output provision are complex and their understanding requires a large input of information from various scientific disciplines. There is a danger that this strong need for technical data will obscure the need for equally reliable information, also derived in a scientific manner, on the behavioural responses of the farmers who make the decisions about the countryside. However, this is also a prime information need. In the United Kingdom, for example, where property rights distribution favours the landowner as opposed to the state, virtually all agri-environmental schemes are voluntary. Hanley and Oglethorpe (1999) raise the question as to whether the uptake of these schemes will suffer as CAP support shifts increasingly from price support to direct payments. If CAP direct payments, which carry almost no cross-compliance conditions, replace the risk-reducing function of the agri-environmental payments (which in the past has made these schemes attractive to farmers on a voluntary basis), there is a danger of reduced uptake of the agri-environmental schemes. Such a shift could indeed have an impact on non-commodity output provision. Whether or not it materialises depends crucially on farmers' perceptions of the incentives offered. Thus, where programmes

17. For example, see Wossink *et al.* (1999) for an analysis of the interaction between farmers' perceptions, economic incentives and spatial constraints in the adoption of wildlife-preserving farming practices. This study shows that more flexible design of wildlife-preserving policies can achieve wildlife targets at lower cost.

to offset the impact on non-commodity output provision are voluntary, it is important understand how farmers view their options and constraints, in order to design incentive-compatible policies. This example illustrates the kind of information about farmers' perceptions and motivation that needs to be expanded.

88. From the above observations, some challenges for improved information provision can be identified. Expanding the knowledge base needed to understand the impact and the direction of commodity price changes on non-commodity outputs, and to design effective policies for ensuring an appropriate provision of non-commodity outputs, will encounter at least three main difficulties. The first of these is the large spatial variation in these impacts within some countries. This variation is due primarily to agro-ecological differences, but also to differences in farming structure, local economic conditions and socio-demographics of farmers in different parts of the country. To predict regionally differentiated impacts and to design appropriately targeted policies may require an information base that is defined and maintained at a level of spatial disaggregation not currently available. Provision of this type of information requires considerable financial and human resources. Each country needs to find its optimal position along the trade-off between spatial disaggregation and cost.

89. The second difficulty arises from the fact that information on fixed factor use in agriculture is less easily available than data on output supplies, input demands and market prices. Traditionally, production analysis has concentrated on the farmer's short-run decision-making, involving output supply and variable input use, given the total amounts of fixed factors at his disposal. Data on marketable quantities is usually readily available, permitting estimation of output supply and input demand elasticities. However, information about how farmers use and adjust their fixed factors is not so easily obtained, and fixed factor adjustment has received much less attention from researchers. Some countries do not operate an annual agricultural census. In any case, census-type information only provides a snapshot of the farmer's resource position at a particular point in time, which merely serves as a reference point for inferences about how these resources are used and what drives their adjustment. One can conclude that a new kind of survey instrument is needed in order to provide information on fixed input use and its adjustment over time, and that the information gathered would require considerable analysis and interpretation by researchers before its full value could be exploited by policy makers.

90. A third challenge involves obtaining more information about farmers' choices and behaviour regarding non-commodity output provision. The model of producer behaviour that inspires most research on agricultural production and supply assumes the producer is driven by the goal of profit-maximisation. This has served well as a basis for analysis and prediction of short-run production decisions. However, it is also observed that some producers enter into voluntary management agreements whilst others do not, some producers observe higher standards of stewardship or respond to lower compliance incentives than others, and so on. To expand our understanding of non-commodity output provision, it would be desirable to know whether these differences can be explained in terms of factors such as the full economic status (including off-farm income) of the farm household, and farmer characteristics such as age and education. Here again, this kind of information can only be obtained by appropriately designed survey instruments.

REFERENCES

Batie, S.S. (1997). Environmental benefits of agriculture: non-European OECD countries. *Environmental Benefits from Agriculture: Issues and Policies - the Helsinki Seminar*. Paris: OECD.

Guyomard, H., Baudry, M. and Carpentier, A. (1996). Estimating crop supply response in the presence of farm programmes: application to the CAP. *European Review of Agricultural Economics* 23(4):401-420.

Hanley, N. and Oglethorpe, D. (1999). Emerging policies on externalities from agriculture: an analysis for the European Union. *American Journal of Agricultural Economics* 81: 1222-1227.

Hodge, I. (2000). Agri-environmental relationships and the choice of policy mechanism. *The World Economy* 23(2):257-273.

Kim, K.D. and Yoo, S.W. (1988). *An Evaluation of the Rural Industrilaisation Project: The Case of Hoenseong*. Korea Rural Economic Institute (in Korean).

Kline, J. and Wichelns, D. (1996). Measuring public preferences for the environmental amenities provided by farmland, *European Review of Agricultural Economics* 23(4):421-436.

Komen, M.H.C. and Peerlings, J.H.M. (2001). Endogenous technology switches in Dutch dairy farming under environmental restrictions, *European Review of Agricultural Economics* 28(2): 117-142.

Lee, J.O., Yim, J.B., Yim, S.S., Oh, S.I. and Shim, Y.K. (1999*). A Study on the WTO Agricultural Trade Negotiations*, Korean Rural Economic Institute research Report, C99-36 (in Korean).

McInerney, J., Turner, M., Barr, D. and McQueen, G. (2000). *What's the Damage? A Study of Farm Level Costs of Managing and Maintaining the Countryside.* Agricultural Economics Unit, University of Exeter.

OECD (2001). *Multifunctionality: Towards and Analytical Framework.* Paris: OECD.

Oskam, A.J., Vijftigschild, R. and Graveland, C. (1998). *Additional EU Policy Instruments for Plant Protection Products.* Wageningen: Wageningen Pers.

Ozanne, A. (1992). *Perverse Supply Response in Agriculture.* Aldershot: Avebury.

Plantinga, A.J. (1996). The effect of agricultural policies on land use and environmental quality. *American Journal of Agricultural Economics* 78: 1082-1091.

Potter, C., Lobley, M. and Bull, R. (1998). *Agricultural Liberalisation and its Environmental Effects.* Report for the Land Use Policy Group by the Environment Department, Wye College, University of London.

Pretty, J.B., Gee, C., Hine, D., Mason, R.C., Morison, C., Raven, J., Rayment, H., Van der Bijl, G. (2000). An assessment of the total external costs of UK agriculture. *Agricultural Systems* 65: 113-136.

Reinhard, S. (1999). Econometric analysis of economic and environmental efficiency of Dutch dairy farms. PhD thesis. Wageningen: Wageningen University.

Reziti, I. And Ozanne, A. (1999). Testing regularity properties in static and dynamic duality models: the case of Greek agriculture. *European Review of Agricultural Economics* 26(4): 461-478.

Sandrey, R. and Reynolds, R. (eds) (1990). *Farming Without Subsidies: New Zealand's Recent Experience*. Wellington: GP Books.

Sckokai, P. and Moro, D. (1996). Direct separability in multi-output technologies: an application to the Italian agricultural sector. *European Review of Agricultural Economics* 23(1): 95-116.

SUSAGRI (2000). *Sustainable Development in Agriculture: Indicators, Agri-Environmental Programme and Demonstrations*. Final Technical Report. Agricultural Research Centre of Finland.

Williams, S.P. and Shumway, C.R. (2000). Trade liberalization and agricultural chemical use: United States and Mexico. *American Journal of Agricultural Economics* 82: 183-199.

Wossink, A., van Wenu, J., Jurgens, C. and de Snoo, G. (1999). Co-ordinating economic, behavioural and spatial aspects of wildlife preservation in agriculture. *European Review of Agricultural Economics* 26(4): 443-460.

Yadav, S. N., Peterson, W. and Easter, K.W. (1997). Do farmers overuse nitrogen fertiliser to the detriment of the environment? *Environmental and Resource Economics* 9: 323-340.