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FARM STRUCTURE AND FARM CHARACTERISTICS - LINKS TO NON-COMMODITY OUTPUTS AND EXTERNALITIES

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NOTE BY THE SECRETARIAT

This paper investigates whether systematic links can be observed between certain farm characteristics and the incidence of either non-commodity outputs or negative externalities. As such, it is part of the body of work having to do with the multifunctional nature of agriculture, and specifically with the potential for there to be jointness of production of agricultural commodities and other non-commodity outputs.

The main author of this paper is Roger Martini, from the OECD Directorate for Food, Agriculture and Fisheries. Maria Rosander also contributed. Other colleagues from the Directorate and experts from OECD delegations have also contributed to or reviewed the document.

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TABLE OF CONTENTS

Boxes

EXECUTIVE SUMMARY

1. The changing structure of agriculture has implications for the design and effectiveness of policies that aim to tackle market failures in the provision of agriculture-related public goods. The potential exists to take advantage of or influence the structure of agricultural production in order to reach policy goals more efficiently. Whether this is possible depends on the following: Are particular types of farm characteristics associated with the generation of positive or negative externalities? And, can farms with specific characteristics provide positive externalities with public good features at lower cost?

2. This paper identifies a set of farm characteristics and their potential relationship to a list of non-commodity outputs (NCOs) and negative externalities, and searches the academic literature for research that identifies the linkages between the two. The focus is on the existence of jointness in production of an NCO rather than its desirability, which is a subjective matter.

3. Farm size, intensity of production, organic production, non-farm activities and commercial orientation, and the age and education of the farm operation were selected as relevant characteristics. Some of these are available as part of typical descriptive statistics of the sector, and it is of interest to see whether common farm classification systems are useful in this context.

4. These farm characteristics were related to the likelihood or intensity of environmental pollution, the maintenance of desirable landscape features, contribution to rural viability, and contribution to food security, food safety, or animal welfare. In general, there is no consensus in the research regarding the degree of jointness between the farm characteristics and the NCOs and externalities considered here. One reason for this may be that other factors, such as site-specific conditions, are more important.

5. It also seems likely that, of all the characteristics considered here, those related to the farm operator are most important. Farmers that are young, educated, and with a business-oriented approach to their operation appear most likely to take positive actions that would produce NCOs or reduce negative externalities. Other hypotheses that receive some support in the research considered here are:

- Economically larger farms are more likely to take positive environmental action and more frequently adopt conservation practices and join environmental schemes.
- Smaller farms tend to be more closely connected to the rural economy, even though they are more likely to be suppliers of labour rather than demanders of it.
- Farms using intensive production techniques tend to support less biodiversity.
- Organic farms tend to be associated with less environmental pollution and demand more labour per unit of output.

6. Given the weak evidence of jointness observed here and the lack of information regarding relative costs, directly targeting the desired NCOs is likely to be more efficient than targeting farms exhibiting specific characteristics thought to be associated with those NCOs and avoids the risk of introducing inefficiencies in farm production generated by interfering in the evolution of farm structures.

FARM STRUCTURE AND FARM CHARACTERISTICS
LINKS TO NON-COMMODITY OUTPUTS AND EXTERNALITIES

Background and motivation for the work

7. Activity 3 of the 2003/2004 Programme of Work and Budget of the Committee for Agriculture relates to the relationship between different policy instruments and objectives. One of the agreed outputs of this activity is an analysis of the implications of the changing structure of agriculture on the design and effectiveness of policies that aim to provide income support, adjustment assistance or to tackle market failures in the provision of agriculture-related public goods. Aspects related to income support and adjustment assistance are being taken up under other projects that are currently underway. The issue relating to market failures and agriculture related public goods arises from the on-going work on multifunctionality is the subject of this paper.

8. The demand for an analysis on this matter is driven by the assumption that certain farm systems or farm characteristics are superior at tackling market failure, at providing positive externalities or public goods, or result in less negative, in particular environmental, externalities. That is, farms of certain characteristics may be better equipped to provide a public good or positive externality, may produce less negative externalities for a given cost, or be able to reduce the emission of these negative externalities more cheaply than others. The varying degree of jointness in production between commodity and non-commodity production across the spectrum of farm systems and structures can explain this.

9. Possible approaches to tackling these issues were outlined briefly in a document discussed by the Committee for Agriculture at its meeting in November 2002 entitled Developing Policy Approaches to Achieve Shared Goals: Exploratory Note (AGR/CA(2002)4. This paper is a first attempt to pursue the ideas put forward there. The focus is on finding answers to the following questions:

- Are particular types of farm characteristics more associated than others with the generation of positive or negative externalities?
- Can farms with specific characteristics provide positive externalities with public good features at lower cost?

10. This paper takes a first step in this analysis by identifying a relevant set of farm characteristics[1] and their potential relationship to a list of non-commodity outputs (NCOs) and negative externalities, and searching the academic literature for research that identifies the linkages between the two[2]. The work to date on multifunctionality was developed around three themes or questions related to the nature of the production relationships (jointness and economies of scope), the existence or likely emergence of market failure in the case of reform and the extent to which identified NCOs exhibit public good characteristics

1. Hereafter, "farm characteristics" is taken to mean either farm production systems, farm characteristics, or the characteristics of farm operators.

2. In the work on multifunctionality (OECD 2003a) it was decided to use the term non-commodity output to describe the full range of positive effects that are listed as pertaining to the multifunctionality of agriculture.

and the resulting policy implications. Of these, the intent is to consider mainly elements related to jointness in the context of relative cost of provision or abatement.

11. It is impossible to be definitive in drawing a line between what is a desirable or undesirable outcome in an exercise such as this one. Different perceptions regarding the value of certain non-commodity outputs rule out characterising any particular set of characteristics as "good", or its absence as "bad". For example, reduced agricultural production might be seen as negative to some as it would reduce the open landscape, while an increase in the amount of "wilderness" might be perceived positively by others. Moreover, in addition to heterogeneous preferences regarding non-commodity outputs, for many of these outputs the relationship to agricultural structure is hypothesised rather than observed, and many contradictory but plausible hypothetical relationships exist.

12. It is clear that attention to differences in outcome preferences should be limited; such disagreements are perfectly acceptable. Having identified a potential or actual link between a particular farm characteristic and a non-commodity output, it is up to domestic policy makers to decide whether to promote or not the said output. Therefore, the focus will be on the connections between characteristic and NCO or externality, rather than the desirability of the outcomes.

13. Some consideration regarding the way in which we identify and classify farm characteristics is also valuable. Agricultural production is carried out in such a great variety of ways within and between OECD members that some are scarcely recognisable as being part of the same industry. A farm may be someone's weekend hobby, or an enterprise involving a large capital investment, employing many workers and carried out by publicly-held corporations. Making sense of these differences by defining them in a way that is helpful is critical to our task of finding the connections between farm characteristics and non-commodity outputs.

14. The following section discusses the classification of different farm characteristics, and identifies a system of classification that is both practical and useful in this context. After that, the cost side of the problem is touched upon. The paper then moves into the different postulated connections between categories of farm structures and NCOs and the empirical observations made in the literature. Conclusions are drawn based on the limited evidence available. Finally, the implications of the findings for any future work on this topic are explored.

Classification of farms

15. As noted above, farm characteristics refer to the scale and nature of the farm operation (farm system), the distribution of farm production resources, returns to producers, and the demographic characteristics of the farm operator. Standard classifications of farm characteristics in statistical data may be by farm size measured in value of sales or number of hectares, primary output (commodity specialisation) and geographic location. These commonly omit characteristics of interest to the questions posed in this paper. Additional information on characteristics required typically have to do with the farming system and must be found in specialised databases.

16. Before considering the classification of characteristics of use in this context, consider the following: the connection between farm characteristics and NCOs or negative externalities has three possible channels. First, there are those NCOs that are equivalent to or identified by the farm characteristic. For example, if people value the appearance of a small mixed farm, then the characteristic of being a small mixed farm is itself the NCO. A classification that is able to identify this characteristic automatically identifies the NCO. The second is when the observed characteristic identifies an element of the farm production system. Given a joint relationship of some degree between the production system and level of NCO or negative externality, identifying such a characteristic leads more or less directly and observably to

the NCO or negative externality of interest. For example if extensive production systems reduce environmental damage, then the characteristic (extensive production) and negative externality (environmental damage) are associated with an explicit functional relationship.[3]

17. It is also relevant to note that the connections between farm characteristics, NCOs and negative externalities can vary across the range of production within a given farm system defined by a set of characteristics. For example, there may be a complementary relationship between the provision of commodities and NCOs where there is a low commodity production - land ratio, whereas at higher ratios there is substitution between commodity production and NCOs, but also a complementary relationship between production and negative externalities (environmental pollution). (Hodge 2000; Harvey 2003)

18. The third channel is an indirect one, where the problem is discerning the likely decisions of the farm operator. The farm operator must make decisions regarding the operation of the farm, and more or less NCOs or externalities are produced because of these decisions. A classification system that identifies those characteristics of the farm operator that make specific decisions more or less likely provides some information regarding the amount of NCOs or negative externalities that farm will produce. It is recognised that this will always be a question of probability. For example, a farm operator with a high net income is less financially constrained in deciding to invest in improvements that reduce waste run-off from his farm, but this does not ensure that such investments will be made, only that they are more likely. Classifications based on the age of the operator, his income, education, or the size of his operation reflect this approach, identifying likely behaviours based on observable characteristics. Box 1 reports the key conclusions of an OECD workshop on the linkages between farm management, practices and the environment.

Box 1. Farm Management and the Environment

Farming practices and systems play a critical role in seeking to achieve an environmentally sustainable agricultural industry. They are constantly evolving and their impacts on the environment are complex and depend on specific agri-ecological conditions. Three key elements are vital to better understand the cause-and-effect linkages between policies, farming practices and environmental outcomes:

- *People:* farmers' decisions and responses determine the farm practices that lead to environmental outcomes.
- *Perspective:* environmental outcomes from agriculture are based on the way in which specific environmental issues are perceived by interest groups and the wider public, which exerts a major influence upon decision makers to influence environmental outcomes.
- *Policy:* farm management decisions are made in the context of a wide range and mix of policy measures and market approaches across countries, from regulatory dominance to regulatory direction; public support payments (tax) to market responses; cross compliance to voluntary and cooperative actions; and public agency verification to audited agri-food industry quality standards. This range and mix of policies and market approaches reflects agri-environmental priorities and institutional arrangements in each country.

There are impediments and incentives to increasing the uptake by farmers of environmentally effective farming practices and systems. The receptiveness of farmer uptake of new practices operates at two levels:

- *Farm and farming community level,* covering farm management capacity (*e.g.* farm financial resources, farmer education, technologies), input industry and customer perspectives (*i.e.* food chain).
- *Policy and market level,* depending on the relative "push and pull" of overall farm support programmes, policy mixes, regulatory frameworks and demands of the market.

Farm management indicators (FMIs) can be used as a tool to better inform decision makers of the linkages between policies, the adoption of new farming practices and environmental outcomes, by helping to:

3. Though the ability to quantify this relationship is not obvious. Indeed, the purpose of most of the papers reviewed in this report is to quantify this relationship.

- *Analyse the effects of policies,* through monitoring progress towards reaching policy goals and targets.
- *Track farmers' practices,* through providing key information on the extent to which farmers are responsive to environmental risks by, for example, revealing the number of farm management plans implemented in areas where significant risks exist.
- *Develop scenarios,* by using indicators in modelling future policy scenarios and showing agri-environmental trends to offer an early indication of potential environmental pressures and risks.

An OECD expert meeting on farm management indicators in New Zealand contributed to understanding the linkages between farm management and environmental outcomes. A diverse range of issues were covered, which addressed both farming systems (environmental farm management plans, and farm management capacity) and farm practices (nutrient management, pest and pesticide management, soil and land management, water and irrigation management, and biodiversity management). Experts recommended a list of indicators that can be used by OECD Member countries, and also identified indicators requiring further development, especially in terms of their analytical soundness, outlined in the Proceedings of the meeting.[1]

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The Box draws on OECD (2005), ***Farm Management and the Environment: Developing Indicators for Policy Analysis,*** joint publication with the New Zealand Ministry of Agriculture and Forestry, New Zealand. See www.oecd.org/agr/env/indicators.htm

19. There exist some helpful examples of farm classification systems that make use of these types of characteristics. The ERS uses a classification system (Hoppe, Perry, and Banker 1999), emulated to a significant degree in Canada (Niekamp and Zafiriou 2000) that defines exclusive categories based on a dominant characteristic (retirement, limited-income, lifestyle, or some gradation of size) (Box 2). This system puts each farm classified into one and only one category and makes use of many important characteristics related to both the farm operator and the farm enterprise.

20. In a review of approaches taken in Member countries, OECD (1995) summarises the various criteria for defining what is or is not a farm household, a somewhat more primal problem in classification. It is noted that the widespread practice of part-time farming and the importance of off-farm income makes drawing a sharp line between farmers and non-farmers difficult. According to the report, the following three criteria were commonly used:

- *Income source*: the definitions of an agricultural (farm) household range from "narrow", in which the household's main income is derived from independent activity in agriculture, to "broad," in which the household receives income from independent activity in agriculture even though the amount is only a minor part of the overall household income.
- *Labour input into agriculture*: the definitions similarly range from "narrow", where a substantial minimum quantity or proportion of labour input goes into farming, to "broad" where a small farm labour input is required; and
- *Farm ownership and size*: it is often stipulated that a given classification of ownership or management operate a farm of a minimum size. Size is defined in terms of an acreage or sales requirement. This classification is typically "broad": with small thresholds, large numbers of households are often included, even if only a limited part of income or labour input is related to farm activities.

21. The factors put forward in the OECD survey and the ERS typology are clearly important to include in any classification system, but there are others that are also likely to be important. Distinctions based on the nature of the production process itself, such as the level of intensity of the production as well as the use of organic or conventional agricultural production techniques, are included as potentially important elements of farm structure.

22. Another major factor is the type of production the farm pursues-crops, livestock, or other types of production. The type, nature, and intensity of any NCO or negative externality produced is certainly related to farm type in this sense. However, this is a topic of a different nature, and the effects of farm characteristics included here are ideally irrespective of the type of production on the farm, even if in the research reviewed some correlation is inevitable.

Box 2. The ERS Farm Typology

The Economic Research Service (ERS) of the USDA has developed a farm typology that divides [U.S.] farms into eight groups based on the occupation of the operators and the sales class of farms. These eight groups can in turn be divided into the following three categories:

- **Rural residence farms**. Includes *limited-resource* (gross sales less than USD 100 000, total farm assets less than USD 150 000 and total operator household income less than USD 20 000 and reporting "farming", "non-farming", a non-farm occupation, or "retirement" as major occupation), *retirement*, and *residential lifestyle* (operators report having a major occupation other than farming) farms.
- **Intermediate farms.** Includes *farming occupation/lower-sales* (sales less than USD 100 000 with farming as the major occupation) and *farming occupation/higher-sales farms* (sales between USD 100 000 and USD 249 999 and farming as major occupation).
- **Commercial farms.** Includes *large* (sales between USD 250 000 and USD 499 999), *very large* (sales of USD 500 000 or more), and *non-family farms* (organized as non-family corporations or cooperatives, or operated by hired managers).

According to the ERS, a family farm is defined as any farm organized as a sole proprietorship, partnership, or family corporation. Family farms exclude farms organized as non-family corporations or cooperatives, as well as farms with hired managers. Family farms are closely held (legally controlled) by their operator and the operator's household.

Costs and potential gains from the relationship between farm characteristics and NCOs

23. While this paper does not examine the relative costs of farms with different characteristics, providing a brief discussion of the issues helps to place the findings here in their proper context. Relative costs of production are important if the interest is in whether NCOs or externalities related to agriculture may be more efficiently provided in light of this association. Whether this association results in actual cost savings relative to alternative means of provision of these NCOs depends on the relative costs of alternative means of provision of the NCO in question.

24. In the following discussion, which is intended only to be illustrative, it is assumed that the production cost differences between farms of different characteristics can be described by differences in average cost per unit of production. It also presents a case where there is only one NCO of interest. Reality is in fact quite different, as a number of NCOs or negative externalities may be of interest to policy makers, and any given farm structure would produce these in differing levels and proportions.

25. In the OECD work on multifunctionality (2003a), it was shown that the degree of jointness may be varied by changes in farming technologies and practices. By discriminating according to relevant farm characteristics, different technologies used by the farm are identified, each with a unique commodity-NCO relationship. Thus a set of actual or probable[4] production systems are identified by reference to farm characteristics, each one generating a specific level of a given NCO or negative externality for a given level of commodity output. As such, farm characteristics describe the degree of jointness by identifying

4. Probable in the sense that for farm characteristics based on such things as operator demographics, we are identifying only a likely relationship between this type of farm characteristic and the underlying operating structure that actually brings about the NCO or negative externality.

variations in the underlying technology. Since each of these farm technologies not only displays its own particular commodity-NCO relationship, but also a specific cost structure, both must be examined to evaluate the potential to utilise this relationship in the provision of NCOs.

26. A useful measure of the cost of providing (avoiding) a NCO (negative externality) is the unit (average) cost of production of the output (AC) divided by the quantity provided of the NCO (negative externality) per unit of output. Since we are expressing everything in terms of per-unit of commodity output, cost differences between farms of different characteristics reflect the incremental (marginal) cost of the NCO or negative externality only. That is, if we were unconcerned with anything besides commodity output, there would be no reason to prefer any farm system other than the one with lowest unit costs. Conversely, if there were an effective market for the NCO,[5] the farm system that could provide the NCO for the smallest increase in unit cost of output would be chosen.

27. If it were desired to provide more NCO than is provided through agricultural production, the cost of doing so, by taking advantage of its joint provision with agriculture, would be

$$\frac{AC(i) - AC(alt)}{NCO(i) - NCO(alt)} = \frac{\Delta AC_i}{\Delta NCO_i},$$

where *alt* is the alternative production system, which would prevail in the absence of intervention or market for the NCO, and *i* is any other candidate production system. Choosing the production system *i* that minimizes this ratio yields the most cost-effective means of providing the NCO via agricultural production. This ratio defines the cost of increasing the amount of NCO provided by converting one unit of output from the alternative production system to production system *i.* This is the private cost of provision, in that they are incremental costs faced by the producer in opting for different production systems, and not a total social cost, which would involve such matters as program transactions costs, for example.

28. If an alternative means of provision of the NCO exists, then this must be compared with the cost derived above. Only in the case that the cost of alternative provision of the NCO is greater (or unavailable) than that derived above is there potential for policy intervention directed at farm characteristics to be an effective means of provision.[6] Why is this only a potential? At this point, only the differential cost of provision to the producer has been identified. Any policy that influences the choice of farm system used by producers will result in additional cost to taxpayers or consumers having to do with the transfer efficiency and other efficiency losses in the implementation of the policy. These additional losses must also be taken into account in determining the optimal approach to provision of the NCO.

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5. That is, if the NCO did not possess public good or non-internalised externality characteristics.

6. The potential efficiency gain from taking advantage of the joint production of the NCO via agriculture as compared to providing the NCO directly, should such an alternative be available, is $\frac{\Delta AC_i}{\Delta NCO(i)} * NCO(Q) - C(NCO)$, where NCO(Q) identifies the functional relationship between primary output (food or fibre) and the NCO in question. C(NCO) is the cost of providing the NCO through alternative means. This difference equals the potential cost savings per unit of NCO, in terms of actual realised economic costs. This must be compared with any additional losses incurred in implementing a policy of providing the NCO through influencing producers' choice of farming system. A similar result holds for reduction of negative externalities.

29. In summary, the following points should be borne in mind when considering the results that follow:

- The farm type whose characteristics indicate the strongest relationship with a particular NCO may not be the most cost effective means to provide that NCO.
- In particular, other types of farm system may be more cost-effective if they have lower associated production costs, but lack of markets for the NCO may preclude farmers from adopting an alternative farm type.
- Even considering this, the presence of jointness in production of food and fibre with a NCO of interest does not automatically imply that any farm system is the best means to obtain it, so the cost of alternative (non-farming) provision of the NCO should also be considered.
- Finally, if the policy mechanism chosen to obtain the desired NCO also provides an incentive for farm operators to adopt different farm systems, the total policy implementation and farmer compliance cost may be greater than the increase in operating costs faced by the farm operator, due to efficiency-related losses. This total cost must be considered in evaluating the potential to exploit jointness with commodity production to provide a NCO.

Farm size

30. There are many ways to define farm size, but generally classification of small and large farms is established based on economic measure of size (*e.g.* gross farm sales or European Size Unit) or on the physical measure of size (*e.g.* the number of hectares). Size, however, can also be defined according to the number of working hours or number of employees used in the agricultural production. Farm size is often correlated with the production process used on the farm, including for example the intensity and diversity of production. Such process differences will be treated separately; only size itself is considered in this section.

31. The use of physical size as the basis of a classification system has some appeal particularly if the sector under consideration is quite homogenous with respect to what it is producing. However, as a sector becomes increasingly diverse, it becomes more and more difficult to use in a meaningful manner. Classification according to economic size, while not without problems, makes more sense for cross-sectoral and international comparability of results. To avoid effects of inflation and productivity growth a relative classification system, for example quartiles or deciles, to define the structure of the sector is preferred. In previous OECD work, OECD (1996), it has been recommended that classification be based on economic size and within the context of relative size classes rather than absolute size classes.

Environment

32. The effects of farm size on the surrounding environment has been relatively well studied in the literature. Potter and Lobley (1993) conducted a review of the literature regarding farm size and the environment, focusing on the United Kingdom. They conclude that there is little evidence supporting a "functional" relationship between the economic or physical size of a farm and its environmental sensitivity (in the sense of the second channel defined above). However, they find it likely that certain small farms contain conservation assets that deserve to be protected. They also conclude that there is little evidence that people managing physically or economically small farms are more conservation-minded. Small farms as a group emerge as somewhat reluctant to join conservation programmes, though it is unclear if it is because they are unwilling to carry out conservation activities or simply unable.

33. In a study of the Massif Central region of France, Callois *et al.* (2002) found a mixed relationship between farm size and environment. Large farms (in terms of area) did more landscape maintenance and

contributed to landscape openness and had lower pollution risk. However, they also reduced landscape diversity and biodiversity, and contributed to a lower rural population. The correlation between area-based measures of farm size and farm type (livestock vs. arable), especially in a specific region such as in their study, is noted by the authors. Indeed, the authors conclude that there is no systematic relationship between farm size and multifunctional characteristics. The same conclusion is reached by Piot-Lepetit *et al.* (2003) for pig production in France.

34. Potter and Lobley makes reference to research indicating that those farmers who are more committed to carry out conservation practises tend to be those who have the means to carry it through, *i.e.* farmers with larger businesses. However, at the same time, there is evidence that part-time small farmers are among the most environmentally aware members of the farming community. This increased environmental awareness on the part of smaller producers does not seem to translate into increased environmental investments.

35. Similarly, Gould, Saupe and Klemme (1989) found that in their sample of Wisconsin farmers, large farms were more likely to adopt conservation tillage technologies, even though smaller farms had a greater perception of erosion problems on their farms. Tavernier and Tolomeo (2004) apply the ERS typology to a US survey to examine farm size and sustainability. While they conclude from their study that smaller farms are likely to be more sustainable, they do so on the basis of survey responses regarding the importance of sustainability, rather than actual farm investments or activities. Thus, their result is more likely to support the idea that small farmers are more aware of environmental issues. Their work is an example of the potential utility of farm typologies such as that of the ERS. Featherstone and Goodwin (1993) find that large farms and corporate farms in Kansas, United States are more likely to make conservation investments, which would confirm that firms with a longer planning horizon are more likely to make these kinds of investments. Fuglie and Kascak (2001) in a study of nation-wide U.S. data find that larger farms adopt conservation technologies (conservation tillage, nutrient testing, integrated pest management) more readily than smaller farms, though there are significant regional differences.

36. The fact that small farms are more reluctant to enter into management agreements and conservation programmes is supported by studies carried out by Dupraz *et al.* (2002) using European data, and in the United Kingdom by Wilson (1997) and McNally (2002). Wilson shows that larger farms are more likely to participate in Environmentally Sensitive Areas Schemes (ESA) due to the fact that larger farms are more likely to have larger areas of non-intensively used farmland, *i.e.* land eligible for ESA. Farm size thereby proves to be the strongest factor explaining participation in ESA. According to Potter and Lobley there is some evidence that the smallest farms tend to be less likely to join an ESA-type scheme compared to larger ones. The reason would be that the total expected returns to the farmer are not sufficient on a very small farm. This effect is also found in the Castilla y Leon region of Spain, where Oñate Rubalcaba and Álvarez Guillén (1997) observe that large farms were more likely to participate in the “cereal steppe programme”. They note that since payment is based on land size, and the whole farm must be enrolled in the programme, a large farm has a greater incentive to participate. A study in the same region investigating voluntary set aside schemes, where the farmer may choose the amount of land to set aside, was not able to find a relationship between farm size and amount of land set aside (Castillo Quero *et. al.* 1996). Entering into an environmental management scheme does not by itself, it should be noted, provide environmental goods or reduce negative externalities.

37. McInerney *et al.* (2000) also concluded that large farms were noticeably more involved in agri-environment schemes and projects to maintain the countryside than the average farm. Allen *et al.* (1993) confirms that larger, more highly capitalized farms are more likely to make conservation improvements. A U.K. farmer survey carried out by the Land Use Policy Group (2001) also found that the interest in participating in agri-environmental schemes was progressively greater as farm size increased. The results were especially clear for arable farmers; arable farmers on 200 hectares or more were approximately twice

as likely as the average farmer to be planning an increase in agri-environmental scheme participation, use of field margins, hedge and wall management and an increase in woodland. The survey also indicated that expanding farmers did not tend to increase the intensity of farming on land they take on, although a minority of dairy expanders and a much smaller minority of cattle and sheep expanders tend to increase stocking rates.

38. In a study based on interviews carried out in 1989 and 1990 with West German producers, Nieberg (1994) investigated whether farm size and employment status (part time or full time farming) effect the environmental impact of farm operations. Generally, no significant relationship was found between farm size and the environmental indicators used in the study, though larger farms were found to be more likely to apply economic thresholds in pest management, use soil testing to determine fertiliser application rates, and to participate in agri-environmental schemes.[7] Münchhausen (1994), using the same survey for the new federal states of the former East Germany also found no clear-cut relationship between farm size and environmental impact. The author finds no size correlation for most indicators, but does observe that larger farms appear to have more intensive pesticide regimes but are also more likely to apply environmental management measures. In particular, managers of larger farms make more frequent use of soil and manure testing, use economic thresholds for pesticide applications, and other environmental techniques.

39. Why do larger farms make more environmental investments despite a lesser degree of environmental awareness? Increased financial capacity and investment in management seem to be factors. In addition, differentiation in regulatory stringency based on farm size may play a role, if it is the case that larger farm operations are required to adhere to a more strict set of environmental regulations that require increased investment, planning, and oversight to implement. Related to this is the potential for size bias to exist in programme design, where large farms are better rewarded for participation. Large farms may also face lower costs on a per-hectare basis or be otherwise better suited to bear transactions costs of programme participation (MAPAAR, 2003, Dupraz and Rainelli, 2004)). Further, if it is the case that larger farms generate larger volumes of polluting effluent or have altered landscapes in the process of becoming larger, then such investments could be in compensation for this (Potter 1985). In OECD (2003b), it is observed that many environmental technologies are not scale neutral, becoming more cost-effective for larger farms to adopt.

Landscape

40. Farm size may provide an example of what was earlier termed an equivalence between characteristic and NCO. For many, a rural landscape composed of many small sized farms provides greater landscape amenity value than one composed of fewer large farms, by increasing the variety and charm of the countryside, say. Others may find the openness of the landscape a compelling feature.

41. In a study on structural change and impact on the rural environment, Knickel (1990) finds that the relationship between landscape quality and farm size is not clear.[8] In many regions there appears to be a correlation between the predominance of small farms and landscape quality. But contrast this with, for

7. Indicators studied include overall nitrogen balance, months of manure storage capacity, number of fall manure applications, frequency and quantity of pesticide applications, use of benign pesticides, share of arable land in cash crops, presence of structural landscape elements on farmland (hedges, trees, ponds), and active creation of such landscape elements in the past two decades.

8. Landscape is defined as the aesthetic and functional qualities of areas that are inhabited or visited by people. This is not an environmental issue. Environmental issues are concerned with the health of air, water, and soil resources plus the ability of the ecosystem to support a healthy level of biodiversity. Valued landscapes can be natural or modified by human activity. Indeed, they may be natural, rural, or urban.

example, the large farms in southeast England, which are also believed to contribute to an attractive landscape. Moreover, as was noted above, economically large farms are not necessarily large spatially, and a large farm may operate across a number of smaller, disconnected areas, thus appearing the same visually as a number of smaller farms.

Employment and rural viability

42. Rural viability does not depend primarily on agricultural demand for hired labour, as is often assumed. Labour may either be imported to or exported from a rural economy; it is not obvious that the direction of the net flow is a critical determinant of the sustainability of rural communities.[9] The level of economic activity in a rural region, and access to services on the part of rural residents will ultimately determine its viability. Whether agriculture is a net supplier or demander of labour with respect to rural communities depends on the structure of farm operations. The productivity of labour in agriculture has increased greatly, and a high proportion of farm operators pursue off-farm employment, supplying labour to the local economy. As part of the rural population, the economic well-being of farm households is as much a part of rural viability as is their effects on rural labour markets.

43. Flaten (2002) has studied the implication of structural change in dairy farming on rural employment in Norway. He confirms that large farms decrease farm employment substantially, and that rural areas lose most employment since they represent a large share of the total milk production and many of the smallest farms are located there. The farm employment loss in regions located closer to urban centres was seen as less significant since dairying in these areas form a smaller part of the local economy, the labour market is larger, and there exist greater opportunities for alternative farm enterprises.

44. Flaten finds many studies to support the hypothesis that smaller farms are better for the rural and national economy. He refers to studies showing that small-scale farming stimulates more activity in rural communities than large-scale farming. These studies also indicate that enlarged and merged farm fields, *i.e.* larger farming systems, can result in losses of habitats and a decline in biodiversity. This is partly confirmed by Henry *et al.* (1987). Heady and Sonka (1974) show that increased farm size results in higher income per farm (and lower prices to consumers), but lower total income in rural communities and less farm employment. This result is driven by the lower efficiency of labour use by small farms.

45. In OECD (2003) it was shown that a population of small- and medium-sized farms can support a healthy infrastructure and provide employment opportunities for rural communities, though it was not concluded that this was the lowest cost means of providing this. A preference for more small farms that use labour less efficiently than fewer large farms implies that the number of people in rural areas is more important for rural viability than the income of those rural residents.

46. The increased importance of off-farm income as part of total farm household income demonstrates that the farm sector can be either a supplier or demander of labour in rural areas, depending significantly on the size of the operation. The degree to which farm households (or their employees) participate in local economies, will determine the local multiplier effect of farm operations. Harrison (1993) observed that smaller farms tended to sell to and purchase from rural areas in greater proportion than did large farms. Harrison uses spatial evidence in central-southern England to support her theory that this is explained in part by the fact that the transactions of larger farms tend to be larger, and therefore decided more on price of commodities and inputs than transport cost. The opposite is true of small farms, who may not find it worth their while to travel long distances to obtain farm inputs. Wilson (1995) found

9. Nor is it automatically clear where the people that are supplying and demanding that labour reside; labour does not equal demographics. An individual may supply their labour to a farm, in a small town, or to a big city and still come to the same home at the end of the day.

in the case of the town of Gore, New Zealand that declines in farm incomes resulting from policy changes in the mid-80s significantly reduced local economic activity. Wilson notes that post-restructuring, farms tended to act in a more efficient and competitive manner, replacing purchasing patterns characterized by loyalty to local businesses with a price- and service-oriented approach.

Food security, food safety, and animal welfare

47. In compiling this paper, the following conceptions of food security were encountered:

- Food security as **quantity**, where national **self-sufficiency** of major staples is at issue.
- Food security as **quantity**, where **total supply** potential for the world population is the concern.
- Food security as **quality** and **diversity**, where access to a varied, fresh, and local diet is valued.
- Food security as **resiliency**, where the robustness of the food supply system to disturbance is of concern (this is related to the first bullet item, where self-sufficiency may improve resiliency).
- Food security as **sustainability**, where the ability to produce into the future is assured.

Food security as a policy issue seems to be evolving away from a post-war focus on production to qualitative and longer-run concerns reflective of more affluent societies. The value of providing food security and animal welfare is defined by the demand for such things, as expressed through the actions of national policy-makers who represent their citizens' interests. In the case of animal welfare, demand is also expressed through animal protection charities and trusts. In this sense, these concepts are best defined in terms that reflect the preferences and intent of citizens. This approach is complicated by the fact that these preferences can and do vary within and between countries. For this reason, in most cases this paper uses these terms in the same sense as do the papers referring to them.

48. With respect to farm size and food security, food safety, and animal welfare, few studies have addressed this topic, and the relationship is likely to be mediated by other factors. For example, for quantity-based conceptions of food security, farm size may have an impact through economies of scale in production.

Summary

49. The evidence presented in this review paints a mixed picture of the relationship between farm size and NCOs and negative externalities. On environment, the clearest observation is that large farms are more likely to participate in environmental programmes, though this does not guarantee beneficial environmental outcomes. Large farms are also thought to be both more able and more often required to make defensive environmental investments, while some small farmers appear to have more environmental awareness. On rural viability, large farms are more likely to demand rather than supply labour, and thus may support local employment, but participate less in local economies and carry out economic interactions over larger distances.

Organic Production

50. Organic production systems comprise a broad possible set of production approaches. Progress in standards-setting in organic marketing and labelling have offered some clarification in defining organic production in recent years. Conventional alternatives are equally varied, including minimum-input, low-till, no-till, or many other possibilities. While other definitions go further, a simple definition of organic agriculture is food that is produced without artificial fertiliser or pesticides using instead only organic-based fertilisers and natural pesticides. It uses antibiotics and other animal health products only to cure sick animals and not to enhance yields (OECD 2003). The USDA National Organic Standards Board has

defined organic agriculture as an ecological production management system that promotes and enhances biodiversity, biological cycles and soil biological activity. It is based on minimal use of off-farm inputs and on management practices that restore, maintain and enhance ecological harmony.

51. According to the International Federation of Organic Agriculture Movements (IFOAM) organic agriculture is based on a number of principles, including compatibility with natural cycles and living systems, maintaining and increasing long-term fertility and biological activity of soils, maintaining and encouraging agricultural and natural biodiversity and promoting conservation of water. The principles also include producing sufficient qualities of food, allowing animals to express the basic aspect of their innate behaviour and providing good quality of life to those involved in agriculture.

52. Work by the OECD has contributed to examining the developments in organic production from a policy perspective. These include, for example, the Wageningen workshop on sustainable farming systems (OECD 2001a), the organic agricultural workshop in Washington in November 2002 (OECD 2003), and considers aspects of organic agriculture in its work on agri-environmental issues, in particular developing indicators (OECD 2001d) (Box 3).

Box 3. OECD Wageningen Workshop on Sustainable Farming Systems

The workshop on Adoption of Technologies for Sustainable Farming Systems, hosted by The Netherlands's Ministry of Agriculture, Nature Management, and Fisheries, was held in Wageningen on 4-7 July 2000*: Regarding organic production, the following conclusions were drawn:

- Organic farming generally requires a higher level of labour input than more conventional forms of farming, mainly due to the substitution of chemical inputs by labour, and a higher proportion of labour intensive activities. The growth in organic farming to date has not generally had a significant effect on employment levels in rural regions in Europe due to the small scale of organic production. However, it has been observed that there may be more substantial benefits arising from the positive image associated with organic farming for tourism and for small business closely related to organic farming.
- Some evidence exists indicating that organic standards have had a positive impact on animal welfare, although animal health on organic farms is not better than on non-organic farms.
- In terms of food safety, empirical evidence suggests that organically grown foods have fewer and generally lower pesticide residues than conventionally grown food. The possible nutritional value of organic food has been difficult to substantiate but recent studies have identified two possible exceptions; higher vitamin C content in organic vegetables and lower nitrate content in organic crops.

* OECD, (2001a).

Environment

53. Evidence from research, field trials and farm experience suggests that organic agricultural practices are generally more environmental friendly than conventional agriculture, particularly with regard to lower pesticide residues, a richer biodiversity and greater resilience to drought. The use of manure as the primary source of nutrients can pose problems of balancing the requirements for different nutrients, which raises the potential for over-use of certain nutrients, especially when manure disposal capacity is an issue.

54. Reduced productivity in organic agriculture, depending on the product and the location, could lead to less land being available for non-agricultural land users such as wildlife habitat and green, non-farmed space and thus greater negative impacts on the environment. While organic systems may have better environmental performance on a per-hectare basis, the difference when measured in unit of output may be substantially reduced (OECD 2003).

55. Stobbelaar *et al.* (1999) evaluated the performance of organic and conventional farms on Crete and concluded that the organic farms cause less erosion, provide higher biodiversity, demand additional labour and offer higher landscape diversity. McLaughlin and Mineau (1995), in a review of primarily Canadian research, evaluated a number of agriculture activities (tillage, drainage, fertilizer and pesticide inputs, intercropping, grazing, and crop rotations) and found that chemical pesticides are detrimental to biodiversity, especially for birds. They point to a study in Denmark which showed the songbird carrying capacity of conventional tilled areas to be less than half that of organic areas.

56. Studies carried out in France and Switzerland find that organic production is superior to conventional in terms of water pollution, soil quality, and biodiversity, and that organic producers carry out more environmental practices (APEX scientific group 1996, Bourdais, 1998, Freyer *et al.* 1996. But while Basset-Mens and Van Der Werf (2004), who study organic pig production in Brittany, confirm these benefits on a per-hectare basis, they calculate that considering all elements of production using life-cycle analysis, organic production can be more polluting on a per-unit of output basis. Whether the per-hectare or per-unit of output measure is more appropriate depends on the environmental issue at hand.

57. A study of the effects of organic farming in Europe was carried out by Stolze *et al.* (2000). This study combined a survey of experts in 18 European countries with a review of literature in order to characterise the relative impact of organic versus conventional farming on the set of environmental indicators developed by the OECD (OECD 2001d). The results are synthesized in a qualitative manner including possible ranges of relative effects. The authors find that organic farming is equal or superior to conventional farming for all the indicators considered; only for erosion and nitrate leaching was organic production possibly inferior according to the confidence ranges placed on those indicators. Other indicators encompass ecosystem diversity and landscape, soil, water, and air quality, and use of farm inputs. The authors note that despite the broad positive impact over a wide array of indicators, large differences exist between various indicators. They also observe that results are sensitive to measurement on a per-hectare or per-unit of output basis.

58. OECD (2003*b*) assessed the environmental impact of organic compared with conventional dairy farming against a selected range of OECD agri-environmental indicators (Table 1). This assessment indicates mainly relatively positive environmental impacts when compared with conventional dairy, with the exception of methane (a greenhouse gas) emissions. Some indicators, particularly nutrient leaching could potentially be relatively worse in organic production when compared with conventional approaches.

Table 1. Assessment of organic dairy farming's impact on the environment compared to conventional dairy farming[1]

INDICATORS	++	+	0	-	--
Farm input and resource use					
Nutrient use		X			
Water use			?		
Pesticides	X				
Energy use		X			
Soil quality					
Soil organic matter		X			
Biological activity	X				
Structure		X			
Erosion			?		
Water quality					
Nitrate leaching		X			
Phosphorus leaching (Eutrophication)		X			
Pesticides	X				
Soil			?		
Air quality					
Carbon dioxide (CO_2)			X		
Nitrous oxide (N_2O)		X			
Methane (CH_4)				X	
Ammonia (NH_3)			X		
Biodiversity					
Genetic diversity			X		
Species diversity		X			
Habitat diversity			?		

Note

1. Organic dairy farming performs: ++ much better, + better, 0 the same, - worse, -- much worse than conventional dairy farming; where no data were available, the rating is shown by a "?". Borders indicate subjective confidence intervals of the final assessment, which is marked as “X”.

Source: OECD (2004) Agriculture, Trade and Environment: The Dairy Sector.

Employment and rural viability

59. Organic farming on average requires a higher level of labour input than more conventional forms of farming, mainly due to the substitution of chemical inputs by labour, and a higher proportion of labour intensive activities. Parra Lopez *et al.* (2004), in a study of organic vs. conventional olive grove farming, found that the experts surveyed agreed that organic farming was likely to generate more direct and indirect employment when compared with conventional production. Lower productivity implies a lower value-added per unit of labour in organic production (for a given output price), and therefore lower wages, though the increase in total labour use makes the effect of this on wage labour income ambiguous.[10] Organic producers compensate for this reduced productivity by obtaining a premium for their product in the marketplace. If such a premium is required for organic farming to be viable, it makes it less likely that organic production could expand beyond a certain market size, and therefore limits the extent to which

10. From an accounting perspective, for a given value of farm production, if total farm worker income increases, the income of the farm owner must decline. It is difficult to conceive of a case where reducing the productivity of labour would improve total economic performance.

organic production may be relied upon as a basis for a policy that exploits its potential jointness to provide NCOs or reduce negative externalities.

Food security and food safety

60. Organic production, using fewer inputs, usually results in a lower yield per acre in comparison with other approaches. This reduction in yield negatively affects food security if the concern is in terms of quantity produced rather than quality, diversity, or resilience of the food supply system.

61. Kouba (2003) studied differences in safety and quality between organic and conventionally produced food in a broad-based review. Kouba found that in the area of chemical residues some studies show lower (but not absent) pesticide residues in organic food, while other studies show no difference in pesticide levels. Contradictory results are found concerning contamination form natural fertilisers and bacterial contamination, *e.g.* E. coli and salmonella. Concerning mycotoxins a FAO study concludes that there is no evidence that organic food is more prone to this kind of contamination then is conventional food. Stolze *et al.* (2000) find it reasonable to assume that pesticide and nitrate residues would be lower, but find results inconclusive for mycotoxin, heavy metal and PCB contents, and radioactive contamination. The importance of any difference depends on how much risk is being reduced. That is, how much benefit is provided by additional reductions below a threshold already considered safe.[11]

62. For quality attributes, which include nutritional value and sensory properties, no major differences have been found in terms of nutritional composition between milk from conventional and organic production. Some differences have, however, been found in egg composition (Kouba 2003). Stolze *et al.* (2000) also find no significant different for vitamins (except possibly vitamin C), nutrients, and aromatic compounds, though they find that organic animal products may be superior in terms of BSE risk or effects of exposure to antibiotics. There is no clear evidence that there exists a significant difference between the two systems regarding sensory parameters.

Animal welfare

63. Lund and Algers (2003) have, through a broad but primarily European literature study, tried to examine differences in animal health and welfare in organic farming compared to conventional farming. The authors find that the small number of comparative studies in principle makes it impossible to draw any general conclusions but they make the cautious conclusion that except for parasite-related diseases health and welfare in organic livestock farming are the same or better than in conventional herds. Stolze *et al.* (2000) observe that animal welfare has been a low priority in organic production research. They report that there is some evidence that dairy cows in organic systems tend to have longer average productive life. The authors speculate that management routines for specific animal husbandry practices could become part of the organic farming framework in the future.

Summary

64. There is evidence to suggest that the reduction in use of chemical inputs on the part of organic producers results in a reduction in negative environmental externalities, even if the potential for damages from over-application of nutrients is not entirely eliminated. Organic farming substitutes these chemical inputs with, in particular, labour, potentially boosting the demand for labour in rural areas and contributing to employment and rural viability. However, the corresponding reduction in yields may reduce the value of labour and incomes for farm workers in the organic sector unless a sufficient premium for organic products

11. Though some may raise the question of whether current standards are appropriately safe; thus the debate between application of regulations based on scientific standards or the precautionary principle.

can be realised. This yield reduction also brings into question whether a predominantly organic agriculture sector could provide an adequate food supply (though this aspect of food security is of diminished importance-see above).

65. The increased cost for a unit of output observed in organic farming makes it ambiguous whether the association between this farm structure and NCOs observed here indicate that organic production is a lower cost means of obtaining these NCOs. That is, while organic production may be associated with lower negative environmental externalities, an equivalent effect may potentially be achieved more cheaply by modifying conventional approaches (such as through lower use of farm chemicals) when all costs are included. However, to the extent that this were to be a policy-induced result, the policy-related transactions costs involved in controlling and monitoring the individual elements of conventional farming, with a view to securing the intended environmental outcomes, may be rather high-at least some of these transactions costs may be avoidable in organic farming because of its system-based approach.

Intensive vs. extensive agriculture

66. Intensive farming systems are commonly characterised by high yield associated with a high use of inputs (agrochemicals like plant protection products and fertilisers, as well as resources such as energy and water) on a given area of land. In the distinction between farm structures characterized by intensive vs. extensive production, we expect the relationship between structure and NCO to be characterized by some kind of functional relationship, as per the second channel of effect mentioned above. In many cases, commentary on agriculture and its relationship with NCOs and negative externalities assumes a positive relationship between farm size and intensity.

Environment

67. It is commonly believed that extensive farming systems contribute positively to biodiversity, landscape and reduce nutrient run-off. Intensive agricultural production systems are seen as using applications of fertilisers and pesticides in a quantity and manner that negatively impacts the environment. On the other hand, higher yields imply that less land is required for a given output level, potentially leaving more land available for natural landscapes beneficial to biodiversity. Further, increases in efficiency and lower unit costs of production mean that when all costs are taken into account, intensive farming may still potentially be a lower-cost means of providing NCOs.

68. The OECD (2003*b*) in its study of the linkages between agriculture, trade, and the environment in the dairy sector cited the following works, concluding that operations that are more intensive appear to have a higher risk of environmental damage:

- In Florida, United States, the accumulation of phosphorus in soils on highly intensive dairy production was 20 times higher than on pasture dairy production (Graetz *et al*. 1999).
- A comparison in New Zealand showed that while nil and restricted grazing systems would reduce nitrate leaching compared to conventional grazing systems, the nil grazing system had higher overall N losses because of increased gaseous emissions (de Klein and Ledgard, 2001). The nil grazing system was also less economically viable, providing a negative return on capital, while the profitability of a restricted grazing system depended on whether an effluent application system was already in place (de Klein, 2001).
- A study of dairy farmers in the Netherlands concluded environmental efficiency is positively related to milk yield, but negatively related to the herd size and the quantity of feed that is purchased per cow. Other factors influencing environmental efficiency included agricultural education (positive), age (negative) and the type of soil on which the farm operated

(Reinhard *et al.* 2002). Another study of Dutch dairy farmers concluded that the main farmer characteristic explaining improved environmental management was education – better educated farmers could increase production and cope with the environmental consequences (Ondersteijn *et al*. 2003)

69. Donald *et al.* (2001) reviewed agricultural intensification in the United Kingdom and found that this was at least partly the reason for a decline in farmland bird populations. Reduction of the populations of farmland birds reduces biodiversity. Three Spanish studies investigating intensity and bird populations found mixed results; intensive production involving irrigation was good for cranes (Sánchez Guzman *et. al* 1999), but bad for eagles (Gonzalez et. al. (1990). De Juana *et al.* (1993) found increased use of pesticides reduce food availability (both seeds and insects) for birds and that intensive livestock production can reduce habitat suitability. McLaughlin and Mineau (1995) in a mostly Canadian literature review found that more intensive activities, such as drainage and habitat conversion are detrimental to biodiversity while activities such as rotational cropping patterns improve biodiversity when compared with monocropping. In France, Thenail (2002) found that intensive agriculture significantly affects landscape patterns: the more intensive the farms are, the less dense is the *bocage* (hedge pattern typical of Western France). The author concludes that the negative impact of intensive farming on the bocage has also negative impacts on biodiversity.

70. Atkinson and Watson (1996), reviewing European research, confirm that intensive livestock production results in a potentially large environmental impact due to the imbalance between nutrient input and output. These results are confirmed by Knickel (1990), also in the European context, who states that the intensification of the use of fertilizers and pesticides is one of the major causes of ecological impoverishment in rural areas. In a study of intensive olive production in Spain, Garcia Brenes (2004) found reductions in biodiversity and increased pesticide and fertilizer contamination in intensive groves, and questions their sustainable water use. Vera *et al.* (1994) found that in the costal region of Aquilas-Mazarrón, overexploitation of aquifers led to salinization and desertification, and that intensive irrigated agriculture contributed to nitrogen pollution in water.

71. In a survey of German literature, Isselstein, Stippich, and Wahmhoff (1991) investigated evidence regarding extensive production systems and environmental impact. Their findings suggest that farms with low-intensity production systems are more likely to be environmentally friendly. This result is supported by de Haen (1985) and Seibert (1986). In particular, reduction of chemical inputs and more structural variety in the landscape are seen as important, though the authors argue that management changes should be targeted to specific environmental problems. In another literature review, Nischwitz (1996) also finds a consensus that intensive livestock holdings are likely to cause significant environmental pollution, even though it remains unclear whether less intensive production systems would pollute less. He finds regional concentrations of intensive operations to be more serious a problem than intensive operations as such.

72. Research in France also tends to confirm that intensive production can increase pollution (APEX scientific group 1995, Piot-Lepetit and Le Moing 2000). However, considerable variation in results are noted, and it is observed that impacts are strongly dependant on variations in climate and soil characteristics (Boiffin and Stengel, 2000, Piot-Lepetit and Le Moing 2000). The dominant role of regional characteristics is also observed in the United States by Caswell *et al.* (2001), who also note a complementarity between intensity (in the use of irrigation), and adoption of pest and nutrient management practices. Moreover, since water flows are more predictable under irrigated agriculture, the effectiveness of these management practices may be greater than when they are used in rain-fed agriculture.

73. Concerning intensity and participation in environmental programmes, Dupraz *et al.* (2002), in a study using data from eight European countries, found that farms using more extensive production techniques, in terms of labour or livestock per hectare, are more likely to participate in environmental

programmes, and are therefore somehow more suitable for agri-environmental participation. In Dupraz (2003), he notes that farms participating in environmental programmes in order to reduce negative externalities from intensification see a greater return to participation than do those who participate for the maintenance of landscape or biodiversity preservation. McNally (2002), studying the relationship between off-farm activity, production intensity, and participation in environmental schemes showed, using an European data set, that off-farm diversification was positively related to participation, but that on-farm diversification measures were not.

Other NCOs

74. It has been argued that extensive agriculture contributes positively to animal welfare, by providing animals more freedom and mobility. Higher yields from intensive production contribute positively to food security (in the adequate supply sense), but may raise issues regarding the sustainability of such production in the future. Regarding employment, rural development, and food safety there are no clear indications, except to point to the likely correlation between intensity of production and other farm characteristics considered in this paper. In a study of social transformation in the western Andalucia region of Spain, Cruces Roldán *et al.* (1997) point out that increasing intensity of production boosted the economy in the region, reduced unemployment rates, and increased the profitability of small farms, reducing the need for off-farm income.

Summary

75. Abler (2001), contributing to the OECD work on multifunctionality asserts that, with some exceptions, many of the non-commodity outputs are associated with the land being in farming rather than with the level of commodity production. This would imply that the level of intensity is more important in the context of negative externalities than for provision of NCOs. The results highlighted above indicate a typically negative relationship between level of intensity and many environmental indicators, though site-specific conditions may be the stronger determinant of environmental pollution.

Age and education of the farmer

76. Producers that are nearing retirement age may operate under a shorter planning horizon. Where this is the case, they would be less likely to make investments or adopt newer technologies if the payoffs from such actions are realized over a longer period. The intensity of this effect is likely related to farm size, as large, commercially managed operations may more easily be valued and sold as going concerns. This would eliminate the break in planning horizon caused by the farm owner's retirement, as the value of investments made are more easily recoverable in the sale price of the farm (see Featherstone and Goodwin, 1993). This is compared with a business plan where the farm operation is shut down upon retirement, and assets such as land and equipment sold separately. Accordingly, the presence of a successor or a succession plan could be the critical factor, and the age of the farmer picks up this effect.

77. Younger farmers are more likely to have obtained some formal education related to agriculture, and be more familiar with newer technologies and so be better placed to exploit them. Schur (1990) in a survey of German farmers found that young farmers were more educated, used advisory services more and attributed a greater importance to the management practices those services advocated. However, Niekamp and Zafiriou (2000) note that younger farmers that are just starting out may have a higher debt burden that could reduce their capacity to invest. Older farmers by contrast will have more experience, and may make better business decisions as a result (OECD 2001d). Studies in France by Piot-Lepetit and Le Moing (2000) and Le Goffe *et al.* (1996) find no clear relationship between farmer age and the effectiveness of the farm enterprise.

Environment

78. A reduced propensity to invest on the part of retirement-age farm operators would make adoption of new technologies offering improvements in environmental sustainability less likely, although they may shift practices to less labour intensive activities (e.g. from dairy to beef). Wilson (1997) has examined the reasons behind participation in Environmentally Sensitive Areas Schemes and found no correlation between age and participation. However, age may influence which specific habitats are included in the scheme: Younger farmers seem to join the schemes for conservation reasons while older farmers have more pragmatic objectives such as income or leisure. Dupraz *et al.* (2002) and Nieberg (2004) found a negative relationship between age and the probability of entering an agri-environmental scheme; older farmers seem to be less willing to participate. Castillo Quero *et al.* (1996) studied cereal farmers use of set-aside in a region of Spain and found that young farmers set aside more land (but no relation was found between set aside and education or part-time farming). It bears repeating here that participation in environmental schemes is not of itself equivalent to an environmental NCO or (reduced) negative externality.

79. Featherstone and Goodwin (1993) found that older farmers in Kansas were less likely to invest in conservation improvements. In a survey of Wisconsin Farmers, Gould, Saupe and Klemme (1989) found age to be one of the most important explanatory variables for adoption of conservation tillage; older farmers were less likely to adopt this (then new) technology, even though older farmers were more likely to recognise erosion problems. In their study, farmer education did not significantly influence adoption.

80. In the context of farm size, it was noted that larger farms made more environmental investments even though smaller farms had more awareness of environmental issues. This does not imply that environmental awareness is unimportant; many authors find a strong relationship between awareness and environmental practices, investments, and participation in environmental schemes (Meynard *et al.* 2002, Avilez Benitez 2001, Dupraz *et al.* 2000, Dupraz 2003, MAPAAR 2003).

81. Knickel (1993) investigated three farm categories—expanding, static, and reducing—to determine if these characteristics are connected with their environmental behaviour. He observed that young, well-educated farmers were more likely to manage expanding farms. Farms that are expanding, that is, making investments to increase the economic size of their operations, were found to be more likely to participate in environmental schemes, have rotations that are more diverse, use soil testing, and have knowledge of integrated pest management. They tend to farm more intensively, using more chemicals and having higher stocking densities, but they are more likely to have taken specific measures for protection of ground water and wildlife conservation and enhancement. Fuglie and Kascak (2001) find higher levels of education to be positively correlated with more rapid adoption of conservation technologies.

82. In the study by Schur (1990), it was found that the level of education and knowledge was connected to environmental behaviours, though farmers with moderate levels of education were found most likely to pollute the environment. Meynard *et al.* (2003) in a European study found that general education is connected to the adoption of environmentally friendly practices, while vocational training in agriculture is not. Caswell *et al.* (2001) found that the farm operator's education had a significant effect on the adoption of information-intensive technologies such as biological pest control or nitrogen testing. Rau (1993) observed that full time and better-educated farmers were more likely to apply good environmental measures. It was also found that farmers that are more educated made more use of advisory services, were more likely to consider organic production as an option for their farm, were more willing to carry out environmental tasks as contractors to local governments, were more knowledgeable about environmental regulations, and were more inclined to take proactive environmental action at their own cost. This was true even though better-educated farmers were less likely to be aware of environmental problems and considered them less severe than did less educated producers.

Employment and rural viability

83. Many countries have both programmes that offer incentives for farmers to exit the agricultural sector as well as those to promote entry into the agricultural sector. This apparent policy incoherence may be seen as an attempt to alter the age structure of the farm sector, thereby promoting modernisation and efficiency by increasing the rate of adoption of new technologies. Such improved dynamism in the sector is seen as important to rural viability.[12]

Food safety, food security, and animal welfare

84. Little can be said on this topic, except to note that a reduced propensity to invest or adopt new technologies would have a negative impact on provision of these NCOs. Improved food security relies on sophisticated tracking and tracing systems and related technologies. If improving animal welfare involves significant investment, in animal housing systems for example, older producers may be reluctant to make them.

Summary

85. The age of a farm operator is an important determinant of willingness to invest in new technologies. Younger farmers have a longer planning horizon and are less reluctant to adopt newer approaches. Youth is an important positive indicator of the production of NCOs and reduction of negative externalities. In these matters, the higher propensity to invest seems to dominate relative lack of experience and potentially higher capital constraints. Farmers that are more educated are more likely to adopt better farm practices, especially when those practices are information-intensive.

Off-farm activities and commercial orientation

86. Participation by farm households in off-farm activities is strongly linked to farm size. Following Sadoulet, de Janvry and Benjamin (1998) referred to in OECD (2001*b*), farm households can be classified into the following groups or types based on labour on and off the farm:

- Farm households that have such a small endowment of farm assets that the marginal returns to farm production are much lower than the off-farm wage rate. Such farmers are not farmers per se, but are hired workers, either in farm production on others' farms or in other industries.
- Farm households where at least one family member works at least part-time outside the farm.
- Farm households that are self-sufficient in labour with no off-farm work and with no hired labour.
- Farm households that employ some hired labour. They are assumed to have no off-farm work since both kinds of work are assumed to be perfect substitutes. However, in a situation with imperfect substitutability, farms with both hired labour and off-farm work may well co-exist.

87. Whether being involved in off-farm activities contributes positively to non-commodity outputs or effects the level of negative externalities is not apparent. While these activities are likely intended to supplement farm income, it may also be the case that farmers with high off-farm income are hobby or lifestyle farmers who are less interested in maximizing profits from farm activities, but in providing NCOs. This raises the possibility that those operators would respond differently to market or policy changes than would business-oriented producers.

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12. See for examples EU Economic and Social Committee CES 1314/2001 ES/WGR/PM/ms, EU Council document 11486/03 "Employment in rural areas under the European Employment Strategy".

88. McNally (2002) used regression analysis to study the relationship between the pursuit of other gainful activities (OGA) and farmers' willingness to join environmental schemes. Other gainful activities refer in this case to time worked either in an off-farm job or in an on-farm diversification activity by the farmer and/or spouse. McNally's main conclusion is that even though there is a relationship between OGAs and his measures of environmental performance, it is much weaker than the relationship between farm size, the type of land use, the form of business and environmental improvement. McNally notes that OGAs are more often observed on farms with lower measures of agricultural intensity, a characteristic covered elsewhere in this paper.

89. Rau (1993) interviewed farmers in Germany to assess their perceptions and approaches related to environmental management practices. He found that part time farmers were more aware of environmental problems, but that this awareness did not translate into environmental action. While full-time farmers where more likely to use environmental practices such as soil testing, fertiliser and pesticide record keeping, regular checking of pesticide application equipment, part-time farmers hardly ever applied these techniques. The author attributes the difference in awareness of environmental problems to part-time farmers' greater exposure to information, critical views, and arguments outside agriculture, while lack of time and knowledge prevent them from translating this increased awareness to action on the ground. Similarly, part-time farmers were found to have less diverse arable rotations, while full-time farms tended to have "healthier" rotations. Nieberg (1994) found the same result regarding full-time farming and greater use of environmental practices and healthier crop diversity, also attributing this to a shortage of labour on part-time farms. On the other hand, she found that part-time farmers were the ones more likely to participate in agri-environmental schemes or set aside field strips for hedgerows at their own cost.

90. Ekman and Andersson (1997) assert that on-farm processing activities increase farm income and consequently strengthen the rural economy. Farmers pursuing off-farm activities may also contribute to rural viability by supplying labour to rural economies. Lehner-Hilmer (1999) surveyed farmers in Bavaria and found them open to the idea of alternative sources of income (such as tourism or landscape conservation) as a substitute for income from agricultural production. Farmers, and in particular full-time farmers, felt that this would contribute to rural viability.

Conclusion

91. The objective of this paper is to examine the relationship between farm characteristics and non-commodity outputs and negative externalities by choosing some observable characteristics and commonly mentioned NCOs and externalities, and assessing the results of empirical work in this area. Considered together, the research presented here allows few clear conclusions, and no formal assessment has been attempted regarding the quality of the research included in this review. While empirical support for many of the hypothetical relationships between farm structure and NCOs may be found, a concrete refutation of any proposition cannot be made.

92. Simple characterisations of the structure of the agricultural sector are unable to provide a satisfactory picture of the sector's ability to provide NCOs. However, there are some areas where evidence suggests a relationship between general farm characteristics and certain NCOs or externalities. These are:

- Farms of greater economic scale are more likely to take positive environmental action and more frequently adopt conservation practices and join environmental schemes. Farm economic size, by itself, may not be the major causal factor in every case; it is likely that this is often correlated with causal factors such as farm type or farmer characteristics.
- Younger farmers are more likely to invest in new technologies in general, and those related to conservation improvements in particular. Better-educated farmers tend to use better practices.

- Smaller farms tend to be more closely connected to the rural economy, even though they are more likely to be suppliers of labour rather than demanders of it.
- Farms using intensive production techniques tend to support less biodiversity on their land
- Organic farms tend to be associated with positive environmental benefits and demand more labour.

93. A key element determining the provision of NCOs seems to be the presence of a farm operator that has the inclination, knowledge, and capacity to make investments in his farm operation. Indeed, this single element may well dominate all the other characteristics considered here, and is important for several NCOs and externalities. According to the evidence presented here, such a farmer is more likely to be young, educated, and possesses a business-oriented approach to farming.

94. Site-specific characteristics, such as soil structure or moisture levels, will always be important, and often overshadow the effect of other farm characteristics. This is especially true for environmental externalities such as pollution from agricultural sources. The type of farm production, crops, livestock, fruit, or vegetables, is also a critical determinant of the type and nature of any NCO or externality produced. The importance of the type of farm characteristics considered here must be weighed against the influence of these other factors.

95. The studies considered in this paper do not provide strong empirical grounds to resolve the theoretical debates regarding farm structure and lower-cost provision of NCOs. Some results confirm, other do not, widely held *a prioris* regarding the relationship between certain farm structures and NCOs and negative externalities, but little can be said on the cost side of the equation. That is, even if a certain NCO can be identified with a particular structure of agricultural production, it cannot be said that the NCO is obtained at least cost by using policy to target support to maintain that structure. Directly targeting the desired NCOs is therefore likely to be achieved at lower cost than targeting farms exhibiting specific characteristics thought to be associated with those NCOs, while also avoiding the risk of production inefficiencies generated by interfering in the evolution of farm structures. While no further work is envisaged on analyzing the linkages between farm characteristics, NCOs and externalities, other work currently underway in the OECD, such as analyzing developments in the food economy, policy design for effective targeting, land mobility, and environmental cross-compliance for example may touch on some of the issues raised.

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