Multifunctionality in Agriculture

EVALUATING THE DEGREE OF JOINTNESS, POLICY IMPLICATIONS

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Foreword

The Workshop on *Multifunctionality in Agriculture: Evaluating the Degree of Jointness, Policy Implications* took place in Paris, France on 30 November and 1 December 2006. Approximately 60 researchers and OECD country delegates participated in the discussions on the results of the latest research on the issue of jointness (as defined in earlier OECD work on multifunctionality). Three substantive sessions dealt with the issues of jointness in relation to rural development, to environmental externalities, and to food security. A fourth session dealt with jointness in the context of multiple non-commodity outputs occurring simultaneously in relation to the same agricultural production system. Professor David Abler of Pennsylvania State University in the United States, acting as rapporteur, closed the Workshop by giving an overview of the issues that had been discussed and the results that emerged.

The overview as further elaborated by Professor Abler follows. Almost all participants in the Workshop agreed to submit written papers in support of the presentations made during the Workshop and these papers are presented following the order of the agenda. Additionally, two papers submitted for the information of participants but not discussed during the course of the Workshop are included in the Proceedings in the appropriate sessions. These papers are *Evaluation of Agriculture's Contribution to Food Security* by Christian Flury, Gianlucca Giuliani and Simon Buchli, and *Evaluation of Jointness in Swiss Agriculture* by Christian Flury and Robert Huber. The views put forward in the Summary, and in the different presentations and papers are those of the respective authors and not those of any member government of the OECD, nor of the OECD Secretariat.

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Introduction and background

The primary function of agriculture is to supply commodity outputs such as food, fibre and other raw materials. However, agriculture can also be a source of several non-commodity outputs (NCOs) that are jointly produced with commodity outputs and that exhibit the characteristics of public goods or externalities. The term multifunctionality refers to this nexus between commodity and non-commodity output production in agriculture.

The Organisation for Economic Cooperation and Development has a long-standing interest in multifunctionality. In 2001 OECD published *Multifunctionality: Towards an Analytical Framework*, which presented the results of analytical work under a programme of work begun in 1999 on the production, externality and public good aspects of multifunctionality. A 2001 OECD workshop examined the empirical work available at the time for OECD countries on several topics: jointness between commodity outputs and NCOs; the relationship between commodity prices and the supply of NCOs; measurement of the demand for NCOs; alternative governmental and non-governmental arrangements for providing NCOs; and the role of transaction costs in policy design and implementation. A 2003 OECD report, *Multifunctionality: The Policy Implications*, provided guidelines for the development of optimal policy strategies according to the degree of jointness, the existence or likelihood of market failure, and the spatial and public good characteristics of various NCOs.

Following on these reports of a mainly conceptual nature, OECD has, in subsequent years, taken up different aspects of the multifunctionality debate, concentrating on issues that had been difficult to resolve in the earlier phases because of a scarcity of experience or data on the topics in question. A 2005 OECD report, *Farm Structure and Farm Characteristics – Links to Non-Commodity Outputs and Externalities*, examined the links between farm characteristics and NCOs and negative externalities from agriculture. A 2006 OECD report, *Financing Agricultural Policies with Particular Reference to Public Good Provision and Multifunctionality: Which Level Of Government?*, drew on the public finance and fiscal federalism literature to examine the appropriate level of government at which NCOs should be provided. A report entitled *Multifunctionality in Agriculture: What role for private initiatives?* explored, mainly in the form of case studies, the scope for non-governmental interventions in pursuit of multifunctionality, covering both the alleviation of negative externalities and the provision of positive externalities and public goods. One of the principal issues outstanding following the completion of the earliest studies – namely the issue of the role of policy-related transactions costs and the extent to which they might influence optimal policy choice across the spectrum from broad, undifferentiated measures to finely targeted measures – was taken up. This report (*The Implementation Costs of Agricultural Policy*) which tackled the issue from a more general agricultural policy perspective and not exclusively that of multifunctionality, was published in early 2007. Finally, continuing the effort to investigate outstanding issues, the purpose of the Workshop reported on here was to review the most recent research on jointness and to draw policy conclusions therefrom.

Jointness between commodity outputs and NCOs can arise due to technical interdependencies in production, non-allocable inputs into production, or inputs that are allocable but fixed or quasi-fixed in supply (OECD, 2001). Technical interdependencies refer to inherent features of the production process governed by biological, chemical, and physical relationships. Non-allocable inputs are those inputs that cannot be divided between commodity and non-commodity production. A non-allocable input contributes to multiple outputs simultaneously, so that it is non-rival for one output when used to produce another. If a non-allocable input is used in the production of an agricultural commodity and also in the production of an NCO, a change in the commodity output will lead to a change in the non-allocable input and in turn the supply of the NCO. An allocable fixed or quasi-fixed input is available to a producer in a fixed amount or along an upward-sloping supply curve, so that a change in one output leads to a change in the amount of the input allocated to that output, and in turn the amount of the input remaining for other outputs. If different commodities are associated with different levels of NCOs, then reallocation of fixed or quasi-fixed inputs among these commodities will alter the supply of NCOs from agriculture.

Jointness can lead to economies of scope, in which joint production of several outputs is less expensive than the sum of the costs of producing each output separately (OECD, 2001). There may be economies of scope between commodity outputs and NCOs, or among NCOs themselves. Economies of scope have ramifications for agricultural versus non-agricultural provision of NCOs (OECD, 2001). Some agricultural NCOs can also be provided by non-agricultural firms. If there are economies of scope between these NCOs and agricultural commodity production, then agricultural provision may be the most efficient option. Economies of scope also have ramifications for the geographical pattern of production (OECD, 2001). The costs and benefits of NCOs vary across geographic regions due to spatial differences in environmental and economic conditions. Under some conditions it may be most efficient to concentrate commodity and NCO production within a single region; under other conditions it may be most efficient to provide them separately in different regions.

Jointness has a number of policy implications. Some of the policy implications outlined by OECD (2003) are as follows. First, if jointness is weak, public policies should be targeted at an NCO itself and not linked to agricultural commodity production. Second, if jointness is strong, then it should be ascertained whether there is also a market failure in determining if policy action is required. Third, if there is both jointness and market failure, policies should be conditional on delivery of the NCO, and there should be monitoring to ensure that the desired outcomes are being achieved. Fourth, policy action should be targeted at the activity or input into production most strongly related to the NCO and should avoid unnecessary increases in the intensity of agricultural production. Fifth, policy action should be geographically targeted unless the NCO is associated with all or a large percentage of the production or agricultural land in a country. Sixth, transaction costs should be taken into account in policy design. Seventh, the level of government at which policy decisions are taken should correspond as closely as possible to the geographical occurrence of the demand for NCOs.

Cross-cutting themes among the presentations

One principal cross-cutting theme among the workshop presentations is that **the social demand for non-commodity outputs (NCOs) varies from country to country and from region to region**. In some cases this appears to be due to the different nature of the issues currently facing agriculture. Professor David Freshwater, in his presentation, emphasized that landscape preservation in North America is mostly an urban-rural fringe issue due to weak land use controls. In Western Europe, on the other hand, there are generally strong urban growth controls that limit the loss of farmland at the urban-rural fringe. Agricultural land abandonment and desertification are the key landscape preservation concerns in Western Europe. Japan appears to have policy concerns about both farmland conversion at the urban-rural fringe and agricultural land abandonment.

In other cases countries face similar issues but differ in whether the issues are viewed as important from a policy perspective. Professor Motoyuki Goda, in his case study of the socioeconomic viability of a small rural village in Japan, stated that Japan has concerns about the loss of small and often remote rural villages. Norway appears to have similar policy concerns. In the US, on other hand, there has been significant depopulation in many rural areas in recent decades, especially in the Midwest, and this has not raised any significant policy concerns at the federal level.

Professor Freshwater noted that historically a great deal of agricultural land has been abandoned in the US and allowed to revert to other ecosystems, principally forest. Unlike Western Europe, however, this has typically been seen as desirable because it means more wilderness. Western Europe has had human-managed ecosystems for millennia, so the concept of "wilderness" has much less public resonance. Professor Ian Hodge noted in his presentation that "ideal" landscapes for the public in England are generally "tamed, inhabited, warm, comfortable, [and] humanized." Views toward wilderness in Japan, as expressed during the Workshop, are similar to those in Western Europe.

A second cross-cutting theme among the workshop presentations is that **commodity outputs are complementary with NCOs in some cases but competing in other cases**. In his theoretical model and simulation analysis, Dr. Petr Havlík illustrated how grassland biodiversity can depend on farming intensity. At low levels of intensity, agricultural production can be complementary to grassland biodiversity by preventing land from reverting to forest. At high levels of intensity, excess nutrients from livestock or crop production can jeopardise nearby grasslands. Professor Ian Hodge and Dr. Eirik Romstad, in their presentations, also pointed out that there may be regions of complementarity and regions of competition between commodity outputs and NCOs, again depending on production intensity. Dr. Uwe Latacz-Lohmann's presentation illustrated how technological change can alter the relationship between commodity outputs and NCOs, and how agri-environmental policy may encourage the adoption of more environmentally friendly technologies by farmers.

Dr. Tristan Le Cotty, in his presentation, compared the cost efficiency of preserving open space in southern France through area payments to sheep farmers to graze lands versus payments to foresters to keep the coverage of bushes and shrubs below a certain percentage of land area. His theoretical model indicates that the marginal cost of open space preservation is less with payments to sheep farmers than with payments to foresters, although this result rests on the assumption that the marginal cost of open space preservation declines as sheep production increases. If there are regions of complementarity and regions of competition between commodity outputs and NCOs, as

Dr. Havlík's and Dr. Romstad's models suggest, then Dr. Le Cotty's results could be reversed at higher levels of sheep production intensity.

Robert Huber, in his presentation, compared the cost of landscape preservation in the Swiss lowlands through continued exploitation of grassland by grazing animals versus non-agricultural actors in order to determine whether there are economies of scope between agricultural production and landscape preservation. His results indicate that it is less expensive for non-agricultural actors to keep a landscape open through mowing than it is for a farmer to keep it open through grazing. However, non-agricultural actors face higher costs in disposing of the resulting biomass than dairy farmers—cows dispose of biomass as they eat it. Adding all costs together, farming is currently the less expensive form of landscape preservation. However, Robert Huber stated that future technological advances in the industrial use of biomass (*e.g.* bioenergy crops) could alter this picture.

A third cross-cutting theme is that **some NCOs are complementary with each other but there are competing relationships in other cases**. The presentation by Dr. Pierre Dupraz, based on a study of 1770 farmers in eight EU countries, found statistically significant cost complementarities between water quality protection, biodiversity preservation, and landscape maintenance. In other words, the provision of any one of these three NCOs by farmers lowers their marginal cost of providing the other two. Dr. Dupraz suggested two possible explanations for his findings. First, the farm characteristics that facilitate provision of one NCO may facilitate provision of the others (such as more land area per farmer and more woods and hedges on a farm). Professor Hodge also emphasized this point in his presentation. Second, a farm's previous experience in seeking out information about environmental programmes and negotiating with public authorities with respect to one NCO may lower its transaction costs with respect to committing to supply other NCOs. More generally, complementarities offer possibilities for economizing on transaction costs in policy design and implementation because multiple goals can be addressed simultaneously. Professor Erling Vårdal, in his presentation, stated that food security and landscape preservation are complementary objectives in the case of Norway.

Competing relationships among NCOs arise in other cases. The presentation by Professor Markku Ollikainen and Dr. Jussi Lankoski discussed the trade-off between promoting biodiversity and employment in agriculture and rural areas, on the one hand, and minimizing negative environmental externalities from fertilizer usage on the other hand. They also discussed policies, such as a tax or quantitative limit on fertilizer usage, which could reduce negative externalities while still preserving biodiversity and agricultural employment. Other negative environmental externalities mentioned in discussion during the workshop that may conflict with agricultural employment or food security goals include greenhouse gas emissions from agriculture, pesticide runoff and overspray, and overuse of water for irrigation.

A fourth cross-cutting theme is that **a dynamic perspective on NCOs is needed, not a static perspective**. This theme emerged during the sessions on rural development and food security. Dr. Franz Sinabell, in his presentation, emphasized that agricultural employment is declining at both national levels and within rural regions of OECD countries. A statistical analysis by Dr. Sinabell using data for 328 rural regions in the EU over the 1995-2003 period found no relation between the growth rate of agricultural value added and the growth rate of rural GDP. Discussion during the workshop brought out the point that the rural nonfarm share of the US population has been relatively constant since 1900 in spite of a major decrease in farming's share of the US population. If agriculture had been a linchpin of the rural economy, the rural nonfarm share of the population should have declined as a result of decline in the farm share of the population. Discussion during the workshop also pointed out that the Japanese village in Professor Goda's case study is comprised mainly of old people and students, and that demographics and the labour market are working against the prospects for survival of this village regardless of what happens to agricultural policy.

In his presentation on food security, Dr. Stefan Mann concluded that neither theoretical analysis nor empirical experience (*e.g.* Germany and Japan during World War II, Indonesia and Serbia more recently) demonstrates a strong degree of jointness between food security in times of crisis and public support for agriculture in normal times. He also noted that precautionary food security policies tend to over-focus on a single commodity, such as rice in Japan and Korea, milk in Norway, or potatoes in Switzerland. Results from Professor Vårdal's model of Norwegian agriculture indicate that substitution among food commodities in production and consumption would permit a "crisis menu" to be produced with only 29% of the current amount of labour and 56% of the current amount of land. A paper submitted by Switzerland but not presented during the Workshop concluded that short term food security is not or only weakly dependent on domestic production. However, in a crisis that persisted over the medium or long term and that affected both domestic production and imports, food security would be jeopardised if the initial levels of domestic production were lower than current levels.

A fifth cross-cutting theme is that **the appropriate level of government at which to address an NCO varies and is not necessarily the national level**. A separate report by the OECD (2006) addressed this issue recently, and indeed the concepts of federalism, subsidiarity and devolution are well-known among OECD member countries. As a general principle, Professor Hodge in his remarks recommended starting from the bottom up, at the local level of government, and seeing where that leads in terms of policy. In his presentation, Dr. Sinabell noted that there is a wide range of regional heterogeneity within OECD countries that makes a one-size-fits-all approach to regional development inappropriate. Christian Flury, in his presentation, emphasized the difference between agriculture-dependent regions and rural regions where the share of agriculture is small and the economy is diversified. He indicated that jointness between commodity outputs and rural development is weak in regions with more diversified rural economies.

Other NCOs may require action at the international level. Dr. Mann stated in his presentation that the nation state may not be the most appropriate level of government for dealing with all threats to food security in an age of multilateral collaboration and linkages through international trade. For example, one can ask whether it makes sense to think about food security in the case of Switzerland outside of food security for Western Europe as a whole. Dr. Mann also mentioned potential worldwide threats to food security such as world war or global warming.

A sixth cross-cutting theme is that **targeted policies are generally superior to broad-based policies, bearing in mind policy-related transaction costs**. In fact, as the theoretical model by Professor Ollikainen and Dr. Lankoski illustrated, policies in the absence of transaction costs should actually be parcel-specific. While this degree of specificity is unrealistic, several workshop participants recommended area payments targeted at particular regions and policy objectives as an intermediate option that balances precision and transaction costs. Robert Huber, in his presentation, recommended site-specific area payments for landscape preservation. Dr. Le Cotty, in his presentation, recommended area payments for sheep farmers to graze lands in order to preserve open space in southern France. The US Conservation Reserve Programme (CRP) was cited as another example of payments targeted at environmentally sensitive acreage. Professor Hodge, in his remarks, stated that area payments that are widely distributed among farmers are too blunt an instrument to address specific NCO issues. He recommended targeting area payments to specific locales.

It was noted that transaction costs with area payments need not be excessive. In their presentations, Dr. Romstad and Dr. Per Kristian Rørstad stated that area payments have relatively low transaction costs compared to many types of agri-environmental programmes. Dr. Mann noted that Switzerland has payments based on biodiversity counts (such as the number of flowers per hectare) in which transaction costs are less than 10% of total program costs. Dr. Rørstad indicated that there are economies of scale with respect to the size of a policy scheme; transaction costs per farm or per hectare of land decline as the number of farms or hectares of land covered by the scheme increases. Many agri-environmental programmes to date have been small in scope, meaning that fixed administrative costs are relatively large when expressed on a per farm or per hectare basis. A related issue is learning-by-doing and the potential for transaction costs to decline as farmers and government program administrators gain experience with these programmes. Also, unlike broad-based policies, targeted agri-environmental programmes can have the advantage of incurring transaction costs for only those farms where NCOs are most important.

A seventh cross-cutting theme is that **broad-based policies may economize on transaction costs but can fail to achieve their objectives in the first place**. Professor Hodge, in his remarks, stated that commodity price support may achieve some objectives but work against others. He felt that price support was unlikely to promote improvements in land management practices such as hedge management or buffer strips. Dr. Dupraz indicated that biodiversity protection requires particular patterns of land use, not just a certain amount of land in agriculture regardless of what is being produced on it. Dr. Osamu Koyama, in his presentation, noted that self-sufficiency rates in Japanese agricultural production have decreased significantly over time in spite of Japanese agricultural policies and opinion polls showing that the Japanese public is concerned about food security.

A number of speakers observed that broad-based policies may encourage more intensive agricultural production and therefore worsen negative environmental externalities such as excess nutrients from crop or livestock production, greenhouse gas emissions, pesticide runoff and overspray, and overuse of water for irrigation. The presentation by Professor Ollikainen and Dr. Lankoski contained empirical results in this regard for fertilizer runoff.

An eighth cross-cutting theme among the workshop presentations is that **the provision of NCOs involves more than agriculture and agricultural policy**. As noted above, a statistical analysis by Dr. Sinabell using data for 328 rural regions in the EU over the 1995-2003 period found no relation between the growth rate of agricultural value added and the growth rate of rural GDP. On the other hand, his statistical analysis showed a strong positive relationship between the growth rate of value added in the services sector and the growth rate of rural GDP. Professor Ollikainen stated that four different types of policies interact in rural development: regional policies, general employment policies, general agricultural policies, and agri-environmental policies. He noted that unemployment may be best addressed through general employment policies. The Canadian delegation commented that in many parts of Canada the question is not how agriculture affects rural development but how rural development affects agriculture — how the availability of schools, hospitals and other infrastructure influences the viability of agriculture.

With respect to food security, discussion during the workshop brought up the point that modern agriculture is critically dependent on fuel and fertilizer, and that domestic agricultural production capacity would be of little help to countries dependent on fuel and fertilizer imports if those import supplies were cut off. Modern agriculture is also highly dependent on hybrid seeds, pesticides, commercial livestock feed and replacement parts for farm machinery, inputs that many countries do not produce themselves.

Key unanswered questions

Two key unanswered questions emerging from this workshop relate to food security. First, what are likely to be the most important future threats to food security? Second, how do those threats fit into the broader picture of national and international security? As Dr. Mann emphasized, we know essentially nothing about the likelihood of future disruptions to imported food supplies or what shape those disruptions might take. The same can be said with respect to disruptions of imports of essential inputs into agricultural production. The fact that many countries dependent on food imports are also dependent on imports of agricultural inputs suggests that food security should be part of a larger discussion about threats to national and international security. This discussion should include consideration of the vulnerability of domestic agricultural production capacity relative to the vulnerability of imports or stockholding.

A third key unanswered question emerging from this workshop is how far can policy-makers go in targeting programmes to specific regions and policy objectives while still economizing on transaction costs? There was a consensus among workshop participants that a relatively high level of targeting is superior to broad-based policies, but it was not clear exactly how high a level is desirable. There was little discussion among participants about precisely where the point lies at which policy-related transaction costs outweigh the efficiency gains from greater targeting.

Conclusions

This workshop set out to examine the nature and strength of jointness between commodity production and non-commodity outputs (NCOs) in three areas: rural development, environmental externalities, and food security. The degree of jointness between commodity production and rural development was questioned. Little association between changes in agricultural GDP or employment and changes in overall rural GDP or employment was found. Regarding environmental externalities, the different research results showed commodity outputs as complementary with NCOs in some cases but competing in other cases. It was noted that there may be regions of complementarity at low levels of production intensity and regions of competition at high levels of intensity. With respect to food security, workshop participants indicated that experience during World War II and since then does not demonstrate a strong degree of jointness between food security in times of crisis and public support for agriculture in normal times.

Among NCOs, workshop participants identified some complementary relationships but there are competing relationships in other cases. Complementarities were found between water quality protection, biodiversity preservation, and landscape maintenance.

Trade-offs were found between promoting biodiversity and employment in agriculture and rural areas, on the one hand, and minimizing negative environmental externalities from fertilizer usage on the other hand. Complementarities offer possibilities for economizing on transaction costs in policy design and implementation and on direct programme costs because multiple goals can be addressed simultaneously.

This workshop also sought to examine the policy implications of jointness. There was little support expressed for the view that broad price- or production-based supports are the best policy solution to jointness between commodity outputs and NCOs. On the contrary, several speakers noted that broad-based policies are too blunt an instrument to address NCO issues such as landscape and biodiversity preservation, which are often region-specific or even site-specific. They instead recommended area payments targeted at particular regions and policy objectives as an intermediate option that balances policy precision and policy-related transaction costs. Broad-based policies can encourage intensive agricultural production methods that cause commodity outputs to compete with NCOs. In so doing broad-based policies may economize on transaction costs but fail to achieve their objectives in the first place.

Another policy implication emerging from the workshop is that provision of NCOs involves more than agriculture and agricultural policy. It was noted that rural non-farm employment in general, and employment in the service sector in particular, are key to rural economic growth. It was also noted that rural unemployment may be best addressed through general employment policies rather than agricultural policies. With regard to food security, many countries are dependent on imports of production inputs such as fuel, fertilizer, hybrid seeds, pesticides, commercial livestock feed, and replacement parts for farm machinery. Domestic agricultural production capacity would be of little help to these countries if imported input supplies were cut off.

Three key unanswered questions about jointness remain following this workshop. First, what are likely to be the most important future threats to food security? Second, how do those threats fit into the broader picture of national and international security? We know essentially nothing about the likelihood of future disruptions to imported food supplies or imported inputs into agricultural production, or what shape those disruptions might take. Third, how far can policy-makers go in targeting programmes to specific regions and policy objectives while still economizing on transaction costs? There was little dissent from the view that a relatively high level of targeting is superior to broad-based policies, but it was not clear exactly how high a level is desirable.

Ultimately, the only solution to information gaps on multifunctionality is policy experimentation and experience. Policy experimentation and economic research are joint products in a dynamic sense. Theoretical economic models can help focus our thinking but will not settle policy debates. Empirical models applied to real-world data are needed, and the only way to acquire real-world data is to observe what happens in response to policy experiments. Results from these empirical models can then inform the policy debate. As it has in the past on many issues, the OECD can be highly valuable as a forum for exchanging information among member governments about success and failures in policy experimentation related to multifunctionality.

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To What Extent is Rural Development a Joint Product of Agriculture? Overview and Policy Implications

by
Franz Sinabell

In 1998, at the Ministerial meeting of the Committee for Agriculture, OECD Agricultural Ministers acknowledged that the role of agriculture is *going beyond the provision of food and fibre [...] by contributing to rural development and generating environmental and amenity services for which there are often no or very imperfect markets* (OECD, 1998). The Ministers used the term "multifunctionality" to describe this role.

This term had been used already at the EU council meeting in Luxemburg when the European model of agriculture was presented. Apart from its production function, the agricultural sector must contribute to *maintaining the countryside, conserving nature and making a key contribution to the vitality of rural life, and must be able to respond to consumer concerns and demands regarding food quality and safety, environmental protection and the safeguarding of animal welfare* (Council of the European Union, 1997).

At a multilateral level, multifunctionality was discussed in the context of "non-trade concerns" of Article 20 of the Uruguay Round Agreement on Agriculture (discussed by Burrell, 2001 and Anderson, 2000). It is clear, however, that the meaning of this concept has changed over time. Originally, "multifunctional aspects" of agriculture addressed issues such as food security and sustainable development in the UN Agenda 21 (UN *2004*). Multifunctionality seems to represent a set of issues (environmental and rural development concerns) that is understood to be a sub-set of "non-trade concerns" which encompass food security, environment, structural adjustment, rural development, poverty alleviation, and so forth (WTO, 2004).

Within the international scientific community the notion of multifunctionality has been controversial. Some authors warned of the abuse of the term before it was widely used (Bohman *et al.*, 1999), and by 2000, many research papers and conferences (reviewed by van Dijk, 2001) had already dealt with this concept.

An OECD study (2001) which built on expertise from outside the organisation (*e.g.* Boisvert, 2001) placed multifunctionality within the context of external effects and market failure. According to this concept, agriculture produces two types of output: commodity outputs (food and fibre) and non-commodity outputs (NCOs) which represent various aspects of multifunctionality. A follow-up publication (OECD, 2003) provides a coherent framework to evaluate various types of multifunctionality outputs related to agricultural activities, including environmental benefits, food security, and rural viability.

This study applies the OECD methodology to analyse the effects of agriculture on rural viability. To narrow the scope of the analysis, some definitions are necessary. The starting point is to differentiate between two types of external effects; these are pecuniary and technological external effects. Such a distinction is crucial because technological externalities are relevant for welfare purposes, but pecuniary externalities are not (Scitovsky, 1954). Pecuniary externalities affect prices and costs of other firms via markets. Technological externalities affect the profitability of other firms via their production function and affect market outcomes only indirectly. By addressing technological externalities, policy intervention can correct market outcomes and contribute to a better allocation of resources.

Agriculture is the production of food and fibre as defined in the system of national accounts. The present analysis focuses on a sector in which enterprises seek to make profits by selling food and fibre to the market. Subsistence farmers and hobby farmers involved in farming activities are not considered in this study.

There are two factors that make agriculture special from the viewpoint of this study: demand for food is inelastic with respect to changes in income and technological progress makes farmers more productive (Mundlak, 2005). Given that this observation from the last century holds for the foreseeable future, we have to expect that the level of non-commodity outputs (NCOs) will be affected by these factors. The development of agriculture will have different consequences for NCOs depending on the way they are linked. NCO levels may either be dependent on the level of commodity outputs or on the levels of factors used in production (OECD, 2001). Technological change will make it difficult to conserve a given mix of agricultural outputs, inputs, and NCOs that are found optimal at a given point in time.

This dynamic aspect is important because viability is understood to have two connotations: the ability to live and to develop. Multifunctionality in the context of rural viability has both a static and a dynamic component. Such a view is consistent with the objective of rural development: "an overall improvement in welfare of rural residents and in the contribution which the rural resource base makes more generally to the welfare of the population as a whole" (Hodge, 1986). Development and improvement means change. The consequences for rural development are "structural and institutional changes in the rural parts of the wider economy" (Thomson, 2001).

The analysis of rural viability makes it necessary to differentiate rural from non-rural areas. Otherwise it would not be possible to make a distinction between the contributions of agriculture to the development of welfare in rural areas and the whole country. There are many possible ways to define rural areas and none of them is universally accepted, but two characteristics are relatively undisputed in the literature (Ward and Hite, 1998): rural areas are characterised by "remoteness" (distance to urban centres) and "low population density" (few inhabitants per square kilometre). Using such a definition helps to overcome "the difficulty of defining boundaries and reference systems" (Knickel and Renting, 2000) which became a major challenge in many studies on multifunctionality. The focus in this analysis is on rural regions while acknowledging that NCOs of agriculture are also relevant in urban and intermediate regions.

The analysis is structured as follows. A short review of the literature on regional growth is presented in order to identify the factors that are considered to be relevant for welfare enhancing changes. One result of the survey is a small set of key indicators of rural viability that can be affected by agriculture in a positive way. In the spatial analysis which is then presented, an attempt is made to provide an overview of the links between the agricultural sector, the development of rural regions relative to other ones, and the level of supply of those NCOs for which direct observations in the market place exist. A survey of studies dealing with NCOs which are associated with agricultural production is presented next. Only such NCOs which are considered to be relevant for rural viability are covered in this section. Those which affect food security or environmental protection are only briefly mentioned. After establishing the set of NCOs relevant for rural viability, the methodology developed by OECD (2002) is applied to identify the sources of jointness, to explore the possibilities of de-linkage, to identify the spatial factors associated with the supply side, to identify potential market failures and the characteristics of the goods in question. Finally, institutional arrangements that stimulate the production of NCOs and enhance internalisation of external effects are addressed. The findings are summarised and conclusions for the design of policies aimed at fostering the contribution of the agricultural sector for rural viability are discussed.

Rural viability in the context of regional development

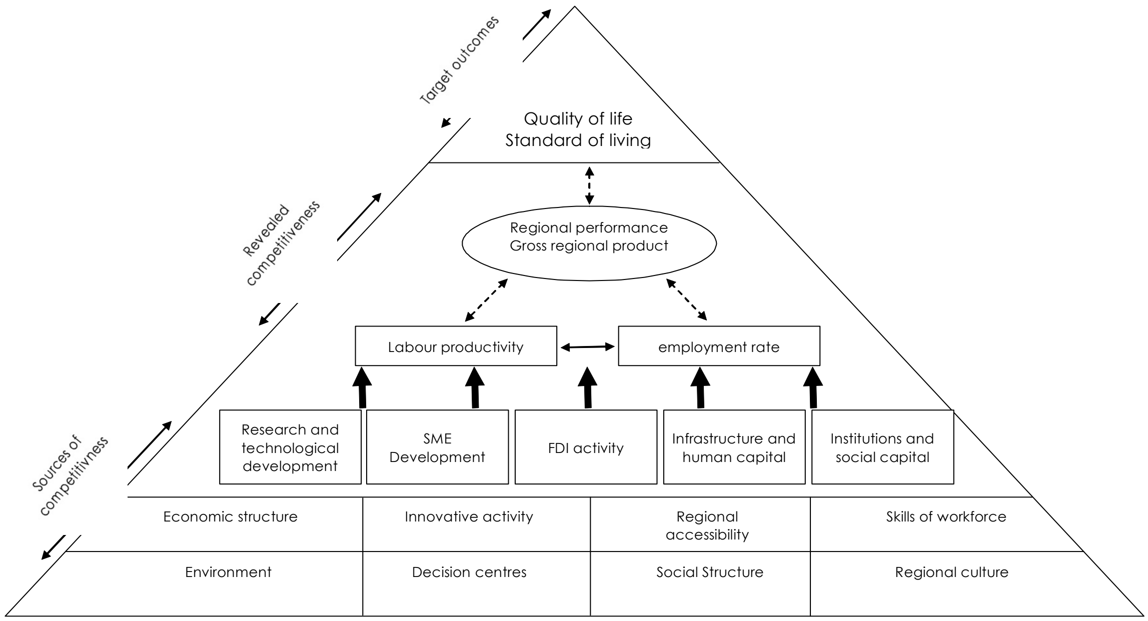
Measuring rural viability and NCOs of agriculture

According to the OECD framework, rural viability is a function of agricultural employment and measuring its share in rural employment indicates whether there is jointness or not: “If that share is low, there is no jointness in practice' (OECD, 2003). There are many countries with farm employment in rural regions of less than 10%. Nevertheless, authors from such countries claim that the multifunctional role of agriculture is important. There is no consensus on what “low” actually means. One approach to specify threshold levels of low agricultural employment is therefore to measure the significance of rural employment for the rural economic performance in a dynamic context: Increased levels of productivity and falling agricultural employment “could be further evidence of weak jointness” (OECD, 2003).

From an economic perspective, rural productivity can be analysed in the context of “regional development”. A starting point to understand factors affecting rural viability is to analyse the factors affecting rural development, a special case of regional development. Rural regions are special because of low population density and remoteness but the aim of rural and regional development is the same: economic growth and employment. Regions with a high growth potential have the ability to attract profitable firms that employ highly skilled workers with high incomes. The population in such regions has high living standards and the regional performance is measured by its GDP. Programmes addressing rural viability should aim at fostering such capacities.

In Figure 1, the target outcome of regional development, high quality of life and high standard of living of the population of a region is at the top of the pyramid. A measure of this outcome is the regional gross domestic product which gauges the economic performance of a region. The regional GDP is an indicator of the well-being of the population and changes reveal how well a region is adjusting to the changing environment.

Figure 1. A model for growth



Source: Gardiner, B. *et al*, "Competitiveness, Productivity and Economic Growth across the European Regions", *Regional Studies*, Vol. 38.9, pp 1045-1067, December 2004.

Regional productivity can be measured by two other indicators: labour productivity and employment. The first indicator is essential because "a country's ability to improve its standard of living over time depends almost entirely on its ability to raise its output per worker" (Krugman, 1992). However, labour productivity and employment must change in a balanced way in order to sustain a good regional performance.

If regional productivity (output per unit of labour) grows but employment (hours of labour) drops because the least efficient firms close and workers are laid off, productivity growth may not be associated with any overall increase in output. Output matters because it determines the level of the living standard. In such circumstances, "employment reduction is a negative route to raising regional productivity, and is to be contrasted with regions that have both high productivity and employment" (Gardiner *et al*., 2004). Productivity measures the output per hours worked. Employment (the number of hours worked) is a function of the employment rate, the dependency rate and the work-leisure trade off of the population in a region. (Gardiner *et al*., 2004).

Productivity and the factors determining employment are indicators which can be measured on a regional scale and are therefore measures of "revealed competitiveness." The concept concentrates on very few variables and does not capture all the complexities of a given economic situation in a region. Factors of production other than labour are not accounted for directly, the flows of goods and capital are not considered, and net balances of commuting workers between regions are not calculated. The simplicity of the model has the advantage that data are relatively easy to obtain and they are sufficient to describe the economic performance of a region in a longer term perspective.

Using this concept of regional performance, measuring the contribution of agriculture to rural viability can be conducted in a straight forward manner by measuring agricultural output, hours worked in the sector, the working population and the whole population of farm households. Evaluating the contribution of agriculture in such a way shows how significant farming is in a given region, but such a calculation is nevertheless not sufficient.

By definition, multifunctionality of agriculture goes beyond the production of farm commodities. Nevertheless, the output of food and fibre in a region is important because it is contributing to the regional value added. If agriculture enhances rural GDP due to its multifunctionality character, there must be at least two channels.[1]

- **Direct channels:** Agriculture produces not only food and fibre, but also other outputs (products or services) which are a direct component of rural GDP. Among these outputs are community services or farm tourism. Activities of farms have consequences on the profitability of other rural firms via input and output relationships. According to the definition presented above, such effects are pecuniary externalities.

- **Indirect channels:** Agriculture produces other NCOs that have an influence on the productivity of other sectors, the employment rate, the work-leisure trade off or the size of the population. They are either due to positive or negative technical external effects. They affect either production decisions of other firms or consumption choices of households.

The regional well-being is determined by productivity and the level of employment. An unproductive farm sector with respect to food and fibre does not contribute in a positive way to rural viability. Maintaining farm employment at high levels diminishes rural viability unless it is contributing to rural GDP directly or indirectly. If that is the case, we should be able to measure this contribution because it materialises at the regional level. We would expect that regions with similar characteristics but different shares of agriculture have different levels of GDP or different growth rates.

To measure the contribution of agriculture that goes beyond commodity production may be relatively easy as far as direct channels of NCOs are concerned. But it may be very difficult, when indirect channels are the source of additional GDP. The difficulty arises because the pathway of influences has to be identified in the first place and its particular type (either a pecuniary or technical externality) has to be identified.

Figure 1 presents a model of such pathways. It suggests that labour productivity and employment rate are determined by five factors. Only few farms are involved in R&D. SME development is concentrated on manufacturing and services and FDI activities are generally not controlled by agriculture. Indirect channels therefore could come from human capital (spillovers from well educated farmers) or special roles farmers play in the formation of social capital.

Social capital can be defined as “the shared knowledge, understanding, norms, rules, and expectations about patterns of interactions that groups of individuals bring to a recurrent activity” (Ostrom, 2000). This is seen to be a prerequisite to solving social dilemmas or coordinating collective-action situations based on trust. Improving social capital in rural areas is viewed as one option to strengthen such positive effects for rural society as a whole (Ruben and Pender, 2004).

1. Sallard (2006) distinguishes not just direct and indirect links, but also complementary and competitive linkages.

Indirect NCOs such as positive spillovers from agriculture to other sectors or to the well-being of the population in rural areas can be expected to come mainly from the base of the pyramid of regional growth, and its role of maintaining and providing an environment that attracts people to living in a given region (population), that helps people to stay healthier (total hours worked), or makes other sectors more productive (GDP/total hours worked).

A traditional cultural landscape provided by agriculture could be an important factor because productivity is not limited to just efficiency: "It depends on the value of the products or services that a region's firms can produce, as measured by the prices they can command, not just their efficiency in producing standard items" (Porter *et al.* 2004). For the tourism sector in rural areas, the characteristics of their environment may be the factor which allows it to differentiate itself from other destinations. For food processors, marketing food with regional attributes or special types of traditional processing can be important marketing attributes.

A government may be concerned by sparsely populated regions and try to maintain a given minimum level of population. Even under such a policy the framework of wealth creation in a region such as that outlined above will not change because the government would choose a targeted policy that obtained a given level of population while simultaneously trying to maximise regional GDP. In comparison to a situation without such a policy, relatively more agricultural activities can be a consequence of this.

Review of theories to explain regional development and clusters of economic activity and value chains in rural regions

There is no dominating theory in the economic literature which can explain the development process of regions. Consequently, no single "theory of rural development" providing a framework to analyse all phenomena exists (Ward and Hite, 1998).

One of the first authors to attempt to explain the disparity between urban centres and rural areas was von Thünen (1826). His model explains how land rents are related to transportation costs. In the first half of the 20th century, Lösch (1940) and Christaller (1933) made important contributions to regional economics: the concept of central places and peripheral areas, and explanations for factor mobility and migration and international trade. However, these approaches cannot explain why economic structures like cities evolve in a market environment characterised by welfare maximising households and profit maximising firms (Krugman, 1998). Neoclassical theory, urban economics and new economic geography are the economic approaches that attempt to overcome this limitation (Martin and Sunley, 1998).

In the neoclassical growth theory regional differences in productivity are due to different factor endowments (differences in the capital/labour ratios) and prevailing technologies. Productivity growth (measured as output per unit work) depends on the accumulation of capital per worker and an – exogenously given – rate of technical change. In the standard neoclassical growth model technology exhibits constant economies of scale and diminishing returns to factors of production. An important assumption is that factors are free to move and the same technology is available in all regions. One theoretical result of this model is that lagging regions should catch up with highly productive ones. Regional convergence in productivity is therefore the outcome of economic growth. The fact that natural factors (like mineral deposits, transport conditions along rivers) are not the same everywhere can explain the concentrations of some industries. Empirical evidence does not support this theory unambiguously because one major result, regional convergence, is not observed everywhere. Policy conclusions derived from this model are that barriers to factor mobility should be removed, open access to markets should be guaranteed, and structural change should be facilitated. A necessary condition for an efficient flow of goods and services is an adequate transport and information infrastructure.

As well as the neoclassical growth theory, the endogenous growth theory also assumes that regional differences in productivity are due to differences in capital/labour ratios. But it takes account of the knowledge base and explains regional heterogeneity by different proportions of the workforce in knowledge producing industries. Technical change is considered to be subject to variations. Endogenous growth is a function of the number of knowledge workers. Places with a large number of highly skilled workers benefit from concentration due to positive external effects of knowledge (Quigley, 2002). The development of regions with predominating low-tech industries depends on how they are able to attract high-tech firms and high knowledge workers. Contrary to the neoclassical model, greater divergence may be an outcome of regional development. The more knowledge spillovers are localised, and the more knowledge workers move to leading technological regions the more productivity differences between regions will persist or even widen. Regions that have fallen behind will grow at slower rates or even lose population due to migration. Policy conclusions consistent with this model are that growth can be stimulated by investing in human capital and that knowledge spillovers are an additional growth stimulus. Evidence from Sweden where higher education policy has emphasized the spatial decentralization of post-secondary education suggests that there is a positive effect upon the average productivity of workers (Andersons *et al.,* 2004).

The New Economic Geography is a relatively young branch of regional theory (Krugman, 1991). General equilibrium models are used to explain what factors lead to patterns of economic concentration similar to those that can be observed in the world. This theory attempts to discover factors that can explain why, for example, 19% of the French population live in the metropolitan area of Paris on 2,2% of the area of France and produce 30% of the national GDP. The same theory tries to explain why most of the population does not live in Paris.

Two important assumptions in such a model are technologies with increasing returns and imperfect competition. Spatial agglomeration (specialisation and clustering) is a source of externalities with increasing returns (due to knowledge spillovers and specialised suppliers). Factor flows and trade increase the tendency of spatial concentration of economic activities, leading to “core-periphery” equilibria of persisting regional differences in productivity (Fujita and Mori, 2005). Among the factors explaining such outcomes are transport costs, workers that are not equally mobile, and the fact that agglomeration allows specialised firms to attract workers with special skills. Producers of intermediate goods have an incentive to locate close to downstream industries where they have the largest market. Producers of final goods want to be close to their suppliers and close to high income consumers, those with high skills and high wages who work in specialised industries. However, agglomeration has not only benefits but also cost (*e.g.* congestions, high prices of land). Therefore centripetal and centrifugal forces are in balance and peripheral regions remain productive, however, at lower rates.

Highly stylised models of the New Economic Geography are capable of explaining economic phenomena which are relevant for agriculture. Murata (2005) showed that the theory is consistent with Engel's "law" (the demand shift from agricultural goods to other goods) and Petty's "law" (the reallocation of labour from agriculture to non-agricultural activities). The causes for such phenomena in Murata's model are 'substantial improvements in transportation technologies' which give rise to structural transformations that eventually 'create new varieties of manufactured goods'. Due to the complexity of the models of New Economic Geography there are only a few empirical studies that are specific to this theory (a survey is provided in Fujita and Mori, 2005). Empirical papers addressing various aspects of such models are difficult to compare (Head and Mayer, 2004). The existence of localised externalities and the limited geographical range of knowledge spillovers may be due to a range of factors. Owing to the lack of empirical findings, it is hard to derive concrete policy recommendations from the theory. Its value for policy analysis is identification of factors that matter in regional growth.

An alternative approach to analysing the productivity of regions is based on the analysis of clusters of firms and value chains (Bergman and Feser, 1999, provide an introduction). Three recent studies (Munnich *et al.,* 2002; Porter *et al.*, 2004; and Feser and Isserman, 2005) used this approach to analyse U.S. rural regions. While Porter *et al.* (2004) did not account for the agricultural sector in rural areas, clusters that include agriculture and forestry are covered by the analysis of Feser and Isserman (2005).

Bergman and Feser (1999) see the value of the industry cluster concept in its capacity to assist analysts and policymakers to 'see the regional economy whole'. Industry cluster analysis is a comprehensive approach for understanding regional economic conditions and trends. The statistical analysis helps to identify policy challenges and opportunities those conditions and trends portend. Munnich *et al.* (2002) conclude that cluster analysis is an approach to learning from successful regional economies.

In their analysis of clusters in rural areas, Feser and Isserman (2005) aimed at separating two dimensions, the economic interrelationships between sectors and the geographical concentration of related sectors. They found that while rural economies specialize in natural resource- and agriculture-based economic clusters, they also play a significant role in a number of manufacturing and non-manufacturing clusters. According to their analysis, 14 of 15 geographic clusters of the motor vehicles value chain in the U.S. consist partly of rural and/or mixed rural counties. This result highlights the diversity of activities in rural counties. Only in a few clusters do agriculture and other resource based industries add significantly to the value chains.

All three analyses on clusters in rural areas (Munnich, 2002; Porter *et al*., 2004; Feser and Isserman, 2005) draw the same conclusion: More research is necessary to better understand the determinants of rural economic performance. These conclusions suggest that the cluster approach has not yet provided sufficiently reliable results for well established policy conclusions (see also Martin and Sunley, 2002).

The long-run trends that the theoretical models imply are not simply of academic interest (Gardiner *et al*. 2004). The neoclassical model predicts that regional productivity (or GDP per person) should converge as integration proceeds. The endogenous growth and New Economic Geography models predict increasing regional specialisation and spatial concentration of economic activities. Convergence does not necessarily need to happen.

Empirical studies by Gardiner *et al.* (2004) on the process of convergence among regions in Europe provide mixed results. Many low productivity regions have improved their relative position but the degree of convergence "has been disappointingly slow".

Leonardi (2006) finds that the rate of convergence of the poorest regions (many of them rural ones) is acceptable and his results show that cohesion policy has "favoured the convergence of less-developed regions towards the EU mean." One conclusion of these findings is that policies aimed at improving regional productivity may work but there is no guarantee that the objective will be achieved quickly or at all.

The role of rural regions in OECD countries and the role of agriculture for rural development – a quantitative overview

An attempt is made in this section to provide an overview of the role of agriculture in OECD economies as a whole and in rural regions in particular. In a descriptive approach various elements of regional growth as derived at the beginning of the previous section, are presented. After introducing the concept of defining rural regions, the role of agriculture in the whole economy will be briefly summarized. Next, rural areas in OECD countries are described and a set of indicators is presented which are considered to have an impact on regional (rural) growth.

Rural regions are characterised by remoteness and low population density. The OECD has developed a classification that takes account of both attributes (see definition in annex). This classification differentiates between predominantly rural, predominantly urban, and intermediate regions. By taking other attributes, adding more of them or delineating regions in another way, rural regions can be defined differently (an example is the ESPON classification; Bengs and Schmidt-Thomé, 2005). Therefore it should be kept in mind that "rural regions" according to one classification are sometimes 'non-rural regions' according to another classification. Depending on the territorial level, not all types of regions (predominantly rural, predominantly urban and intermediate) are present in all OECD countries. At a higher territorial level (TL2), there are no predominantly rural regions in the Netherlands, in Ireland no intermediate regions, in Canada no urban regions, and in Luxembourg there are only intermediate regions. In the remainder of this section, data will be presented that are based on the territorial definition of the OECD; the terms "rural" and "urban" will be used, however, instead of "predominantly rural" and "predominantly urban".

Statistics at the country level (Table 1) show that the contribution of agriculture to national incomes (GDP) is relatively small in most OECD countries. The share of GDP of the food processing sector is similar to that of agriculture (on average agriculture accounts for 2% cent of GDP, food processing for 1.9%) in many countries. In almost all OECD countries the share of the agricultural workforce is larger than the share of GDP. Large discrepancies can be seen in Austria, Japan, Mexico, Poland and Turkey.

In OECD countries rural regions account for 13% of GDP, urban regions for 43% and intermediate regions for 44% (Table 2). In many small OECD countries rural regions contribute significantly larger shares to national GDP (Ireland and the Scandinavian countries).

In almost all OECD countries the level of rural GDP per person is below the country average. In OECD countries, regional GDP in rural areas is only 82% of the average levels. In almost all countries, rural GDP is below average (Table 2). This does not necessarily mean that people living in rural regions are worse off, because they may have lower expenditures for the same standard of living.

Table 1. Main agricultural indicators for OECD countries (in %, latest available year)

	Agriculture in GDP**	Food processing in GDP	Agriculture in total civilian employment	Food processing in total civilian employment	Agriculture commodities in total exports	Agriculture processed products in total exports	Agriculture commodities in total imports	Agriculture processed products in total imports	Food in total consumer expenditures	EAA share of NCOs relative to COs
Australia	3.4	.	4.0	2.1	12.7	4.2	1.3	2.8	10.5	
Austria *	1.3	1.1	4.9	.	.	.	.	.	.	11.5
Belgium *	1.0	0.8	.	.	.	.	.	.	.	1.2
Canada	2.3	2.0	2.9	1.6	3.9	2.2	2.9	2.7	9.9	
Czech Republic	2.8	3.5	4.5	2.6	1.4	1.7	2.2	2.2	17.5	4.4
Denmark *	1.6	1.5	.	.	.	.	.	.	.	6.6
Finland *	1.0	0.8	.	.	.	.	.	.	.	10.5
France *	2.0	1.7	3.8	.	.	.	.	.	.	8.8
Germany *	0.8	0.8	.	.	.	.	.	.	.	4.2
Greece *	5.3	4.2	14.9	.	.	.	.	.	.	8.9
Hungary	3.3	3.2	5.6	3.3	4.8	2.3	1.6	1.5	19.0	11.7
Iceland	9.2	.	3.9	7.8	0.7	0.2	2.4	5.0	14.1	
Ireland	2.1	1.6	.	.	.	.	.	.	.	
Italy *	2.3	2.0	4.8	.	.	.	.	.	.	7.8
Japan	1.3	2.3	4.6	2.8	0.0	0.2	5.7	2.5	14.4	
Korea	3.6	2.7	8.8	1.4	0.2	0.5	3.1	1.2	14.2	
Luxembourg *	0.5	0.4	.	.	.	.	.	.	.	6.3
Mexico	3.8	5.0	15.8	4.1	3.0	2.3	4.6	2.3	21.1	
Netherlands *	1.9	1.5	3.0	.	.	.	.	.	.	13.6
New Zealand	8.7	.	8.1	3.8	37.3	5.6	3.0	4.6	16.7	
Norway	1.4	1.5	3.7	2.4	0.3	0.3	2.8	3.2	12.5	
OECD	2.0	1.9	6.1	1.7	3.6	2.7	3.5	2.7	10.7	
Poland	3.0	3.6	18.4	3.4	3.7	3.6	2.4	2.4	19.4	4.1
Portugal *	2.4	2.0	.	.	.	.	.	.	.	5.5
Slovak Republic	4.0	4.0	5.8	.	1.3	1.6	1.9	2.2	21.1	13.9
Spain *	3.6	2.8	5.7	.	.	.	.	.	.	
Sweden *	0.7	0.5	.	.	.	.	.	.	.	10.1
Switzerland	1.3	.	4.1	1.6	0.6	1.6	2.5	3.0	11.0	3.9
Turkey	11.9	4.8	33.8	.	4.5	4.6	2.2	1.5	.	
United Kingdom *	0.7	0.6	.	.	.	.	.	.	.	11.4
United States	1.6	1.3	1.7	1.2	5.4	1.8	1.5	2.1	6.1	
EU-15	2.0	2.1	3.8	2.4	3.8	3.6	4.3	3.2	12.6	

* Own calculations based on EUROSTAT New Cronos; employment measured in full time equivalents; EAA (economic accounts of agriculture) share of NCOs (non-commodity outputs) relative to COs (commodity outputs) measures the sum of 'secondary activities (inseperable), item 17000' and 'agricultural services output, item 15000' relative to 'agricultural goods, item 14000.

** Per cent of agriculture in GDP: National accounts gross value added for agriculture forestry and hunting as a percentage of Total Gross domestic product.

Source: OECD (2005), *Agricultural Policies in OECD Countries. Monitoring and Evaluation*, Paris.

Table 2. Regional GDP population, labour force and unemployment in OECD countries

	Distribution of GDP by sub-region			Share of rural regions			
	Rural	Urban	Intermediate	Population	Unemployment	Labour force	Per capita GDP in rural regions
	%	%	%	%	%	%	%
Australia	3	2	95	24	25	22	86
Austria	36	30	34	46	42	44	77
Belgium	2	88	11	2	2	2	70
Canada	9	0	91	30	36	28	83
Czech Republic	4	25	70	5	4	5	82
Denmark	34	39	27	39	43	40	87
Finland	53	35	13	62	88	60	84
France	25	39	36	31	28	30	79
Germany	16	67	17	20	25	20	81
Greece	39	38	23	40	34	37	96
Hungary	28	35	37	39	49	37	72
Iceland	.	.	.	38	43	38	.
Ireland	62	38	0	71	75	68	88
Italy	8	57	35	10	10	9	83
Japan	11	63	25	13	11	13	87
Korea	19	45	36	17	12	19	111
Luxembourg	0	0	100	.	.	.	.
Mexico	38	34	28	37	29	34	80
Netherlands	0	87	13	.	.	.	.
New Zealand	.	.	.	.	.	.	.
Norway	40	23	37	50	50	48	81
OECD	13	43	44	20	23	19	69
Poland	29	38	33	38	56	50	76
Portugal	19	62	19	25	24	22	73
Slovak Republic	21	25	53	26	29	14	84
Spain	11	52	37	14	15	13	78
Sweden	43	28	29	50	54	49	87
Switzerland	.	.	.	6	47	6	.
Turkey	23	43	34	32	28	36	73
United Kingdom	3	75	23	4	5	4	68
United States	9	28	63	12	13	11	82

Source: OECD (2005) *OECD Regions at a Glance*. Tables 3 (col. 1-3), 1.4 (col. 4), 3.3 (col. 5), 4.3 (col. 6), 11.8 (col. 7).

In OECD countries, 20% of the population, 19% of the labour force and 23% of unemployed persons live in rural regions. A lower level of labour market participation and a higher rate of unemployment (Table 2) are among the explanations why the regional per capita GDP is lower in rural areas than in other regions.

However, demographic factors, labour market participation and unemployment are not sufficient to explain why rural regions are lagging in many OECD countries. The following factors have an important influence on productivity: skills, infrastructure and — based on theoretical considerations — spillovers due to agglomeration. Analyses suggest that in several OECD countries agglomeration benefits are statistically significant (OECD, 2005). One consequence of these effects is that productivity in rural regions is below the country average in most OECD countries (Table 2). From a static perspective, low productivity and relatively high farm employment seem therefore to be linked.

The relevance of human capital to development and growth emphasises the role of education in today's knowledge-based economies. Skills are generally measured in terms of attainment of tertiary level education (including university-level education from courses of short and medium duration to advanced research qualification). In 2001, from a working-age population of about 770 million, about 150 million had a tertiary-level qualification. In most OECD countries people with high skill levels are living in urban regions and the relative share in rural regions is smaller compared to the share of labour force (Table 2). In countries like Finland, Canada and Belgium the shares of population in rural areas with tertiary education is high compared with the shares in other OECD countries (Table 2).

The share of the agricultural workforce in rural areas has been declining steadily in all OECD countries for which data are available (Bollman, 2006). Even in rural areas the share of agriculture in total employment is relatively low (Table 3; see also Figure 1 in Bollman, 2006). In most OECD countries, however, more than half of the workforce in agriculture is located in rural areas (Figure 2 in Bollman, 2006).

Population is growing in all types of regions, but rural regions are not developing in the same way in all OECD countries. In certain countries (Austria, Belgium, United Kingdom) population growth in rural regions is positive and higher than in the other regions (Table 4). In some countries, the rural population is declining in some regions while it is growing in others (in Scandinavian and Eastern European countries).

The growth rates of GDP in rural areas are relatively lower in almost all OECD countries. Only in Austria, Ireland and Turkey is the growth of rural regions higher than in urban and intermediate regions. This pattern suggests that in most countries growth tends to be higher in regions where economic activity is highly concentrated than in those where it is more dispersed.

In some countries, the GDP of intermediate and some rural regions is growing considerably faster than in urban regions (Table 4). Therefore, not all rural regions are trapped in a low-growth path. Even if agglomeration economies are low in intermediate and rural regions, the growth potential of these regions remains significant.

Table 3. Levels of education, relative labour productivity and unemployment and share of agricultural workforce in rural regions

	Distribution of population by levels of education in rural regions				Labour productivity in rural regions	Unemployment in rural regions	Agricultural workforce in rural regions
	Share of whole country	Share within rural regions					
	%	%	%	%	% of national level		% of total
Australia	15	49	39	12	101	98	13
Austria	.	.	.	.	85	105	10
Belgium	2	42	32	26	89	84	6
Canada	23	29	40	31	102	108	10
Czech Republic	4	25	65	10	85	89	12
Denmark	30	33	47	20	92	107	6
Finland	55	29	42	28	92	104	9
France	23	35	51	14	83	96	7
Germany	9	19	62	19	82	122	5
Greece	25	61	27	12	109	97	30
Hungary	36	50	41	9	79	118	11
Iceland	.	.	.	.	.	112	0
Ireland	45	44	41	15	93	104	11
Italy	5	59	32	9	91	120	9
Japan	15	22	55	24	84	91	11
Korea	12	78	8	13	115	70	.
Luxembourg	.	.	.	.	.	.	.
Mexico	20	82	11	7	90	94	30
Netherlands	0	.	.	.	.	.	.
New Zealand	2	32	57	10	.	.	.
Norway	39	17	60	23	90	103	5
OECD	20	40	43	17	83	102	.
Poland	28	36	56	8	82	113	37
Portugal	24	74	17	9	85	108	25
Slovak Republic	11	19	69	12	92	115	9
Spain	12	33	46	21	87	97	17
Sweden	29	21	57	21	91	102	4
Switzerland	0	19	54	27	.	79	.
Turkey	17	77	15	8	64	84	64
United Kingdom	12	19	51	30	70	101	12
United States	11	11	64	25	64	105	4

Source: OECD, 2005, OECD Regions at a Glance. Tables 6.3 (col. 1), 6.8 (col. 2,3,4), 12.5, 12.6, 12.7 (col. 5; unweighted averages), 13.5, 13.6, and 13.7 (col. 6; unweighted averages); own estimates based on OECD Territorial Database and ST.AT (for Austria) in col. 7.

Table 4. Regional growth in OECD countries, 1996-2001

Subregion	Average population growth			Average annual growth rate of GDP			GDP growth of fastest growing regions		
	Rural	Urban	Intermediate	Rural	Urban	Intermediate	Rural	Urban	Intermediate
	%	%	%	%	%	%	%	%	%
Australia*	0.6	1.3	1.4	3.0	3.5	3.6	7.2	3.5	3.9
Austria	0.3	0.2	0.0	2.8	1.9	2.6	4.1	3.1	4.3
Belgium	0.6	0.2	0.2	1.9	2.7	1.9	1.9	5.0	2.6
Canada*)	0.1	1.3	0.4	3.1	0.0	4.3	6.7	0.0	7.3
Czech Republic	-0.2	-0.7	-0.1	2.3	6.4	1.1	2.3	6.4	4.1
Denmark	0.2	0.5	0.4	1.9	3.1	2.4	2.4	3.7	3.4
Finland	-0.1	1.3	0.2	3.0	5.8	4.4	5.2	5.8	5.4
France	0.3	0.3	0.5	2.4	3.2	2.9	4.9	5.9	4.5
Germany	-0.1	0.2	0.0	1.8	1.8	1.8	2.9	4.0	2.8
Greece	0.0	1.1	0.6	3.4	4.4	3.5	5.8	4.4	3.6
Hungary	0.2	-1.6	0.5	3.2	4.9	5.3	4.8	4.9	9.2
Iceland*	-0.3	.	2.0	.	.	4.5	.	0.0	4.5
Ireland	1.1	1.2	.	9.6	9.2	.	11.7	9.2	0.0
Italy	0.0	0.3	0.1	1.9	2.2	1.9	4.1	3.2	3.3
Japan	-0.1	0.4	0.1	0.1	0.2	-0.1	1.1	1.1	1.4
Korea	0.0	0.2	2.4	4.4	2.3	8.2	7.2	5.4	11.1
Luxembourg	.	.	1.2	.	.	6.7	.	.	6.7
Mexico*	1.0	1.6	1.3	3.9	4.2	5.3	7.2	6.5	9.4
Netherlands	.	0.6	1.0	.	3.5	2.6	.	4.5	6.7
New Zealand	.	1.3	0.2	.	.	.	.	.	.
Norway	0.3	0.8	1.0	-0.3	3.6	1.5	2.1	3.6	2.1
OECD	0.2	0.6	0.7	2.8	3.8	3.5	11.7	10.0	11.1
Poland	0.1	-0.4	0.1	4.9	6.2	4.9	8.1	10.0	10.1
Portugal	-0.2	0.6	1.3	2.8	3.4	4.3	4.8	4.2	5.8
Slovak Republic	-0.1	-0.7	0.2	3.0	4.0	2.9	3.4	4.0	4.3
Spain	0.0	0.5	0.5	2.8	4.1	3.9	3.8	5.6	5.7
Sweden	-0.3	1.0	0.2	1.7	4.7	4.0	4.3	4.7	4.2
Switzerland	0.1	0.7	0.4	.	.	.	.	.	.
Turkey	1.2	2.8	1.6	3.7	3.7	3.2	7.6	4.8	5.8
United Kingdom	0.4	0.1	0.4	0.6	3.4	2.0	3.7	7.9	5.9
United States*	0.5	1.2	1.3	2.4	3.7	4.0	3.8	5.1	6.3

* GDP growth measured at TL2. *Source*:: OECD (2005), *OECD Regions at a Glance*. Tables 7.8 (col. 1,2,3), 8.8 (col. 4,5,6), 8.9 (col. 7,8,9).

Based on OECD territorial indicators and results presented by Bollman (2006), it is clear that rural regions are very important in many OECD countries. In some countries, rural population is declining and rural GDP growth is generally lower than in other regions. To attribute this solely to the decline of agriculture does not seem to be justified because in some countries rural regions grow faster even if the share of agriculture is declining.

For some OECD countries in the EU, sufficient data are available to compare growth rates of the agricultural gross value added (GVA) in rural areas with growth rates of rural GDP. Comparing growth rates of nominal agricultural GVA and the respective regional GDP between 1995 and 2003 in 328 rural regions gives the following result (Figure 2):

- agricultural GVA grows and GDP of rural regions grows: 55%;
- agricultural GVA grows and GDP of rural regions declines: <1%;
- agricultural GVA declines and GDP of rural regions grows: 42%;
- agricultural GVA declines and GDP of rural regions declines: <1%.

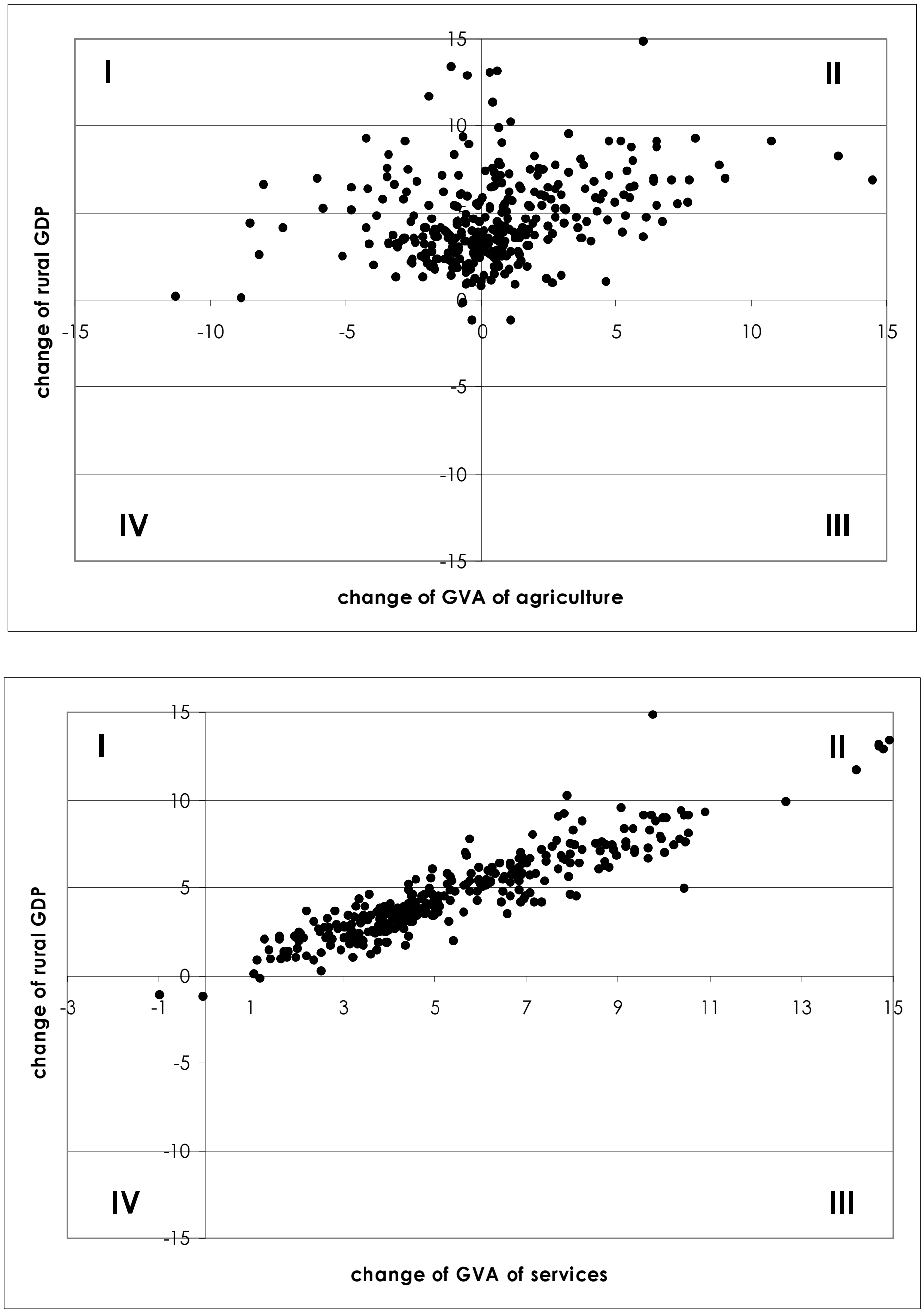
The statistical evidence shows that the contribution of agriculture to national income is low in many OECD countries. Frequently the share of labour employed in the agricultural sector is higher than its contribution to GDP. Elements of rural viability related to farm population are therefore expected to be higher than those related to outputs and inputs.

In rural regions, agriculture is more important than in intermediate and urban regions, but its share has been declining even in the most rural regions. They are now characterized by activities of industry or the service sector. Nevertheless, effects of the farm population on regional viability seem to be most important in rural regions. Regional productivity is generally low in regions with a relatively high share of agricultural workforce. In a static framework, farm employment in such regions is therefore important and indicates that jointness matters but it is hard to quantify the degree of jointness at aggregate levels.

Statistics from OECD countries show that in a dynamic context many rural regions grow even if the share of agriculture is low. Observations from EU member states show that many rural regions in which agriculture is declining have high positive regional growth rates. According to the OECD framework (OECD, 2003) this is evidence of weak jointness, at least for the regions in question.

Regional growth is definitively positively affected by growing agricultural output because it is an element of overall output. How much agriculture is contributing to rural growth due to NCOs cannot be measured by comparing the performance of rural regions alone because many factors have an influence on growth differentials. But a declining farm sector does not prevent growth in many regions. Therefore, NCOs of agriculture do not seem to be a necessary condition for rural productivity.

Figure 2. Rates of growth of gross value added of agriculture, services and GDP in rural regions of OECD countries in the EU



Source: Own results based on nominal regional GVA and GDP data from Eurostat New Cronos, 2006. In quadrant I there are regions with declining agricultural gross value added (GVA) and increasing regional GDP; in quadrant II are regions with increasing agricultural GVA and increasing regional GDP; in quadrant III are regions with increasing agricultural GVA and decreasing regional GDP; in quadrant IV are regions with decreasing agricultural GVA and decreasing regional GDP.

Evidence of non commodity outputs of agriculture relevant for rural development

Towards a systematic approach to measure rural viability

A stylised model of regional wealth creation was presented above. Elements having an influence on the target outcome, the well-being, and living standard of the population were differentiated into two categories:

- Effects via direct channels show up directly in indicators of the revealed competitiveness of regions. Some of them are due to pecuniary externalities. Activities in the market place of agricultural firms have consequences on other firms (increasing or lowering profits via price effects). From a welfare economic point of view, market outcomes need not be corrected if pecuniary externalities are present. Unlike technological externalities, they do not misallocate resources and are necessary for the market to work efficiently (Holcombe and Sobel, 2001).

- Effects via indirect channels that can be identified to exist but their significance is frequently not (yet) known in quantitative terms. They are consequences of either positive or negative technological external effects. Some authors claim that there are additional indirect effects that go beyond the concept of external effects.

The next two sections are organized according to this principle. Some of the NCOs listed in these sections are related to the methodology outlined above. Others are based on findings of authors who have established either in a descriptive or quantitative manner that linkages between agricultural activities and the welfare of a region exist via indirect channels.

Non-commodity outputs affecting regional performance via direct channels

Several variables of the equation to measure regional performance are well covered in standard statistics:

- agricultural population and agricultural workforce;
- agricultural products in an input-output context;
- non-agricultural products provided by agriculture.

In the general literature on agricultural multifunctionality, these elements were identified to be related to NCOs of agriculture. The population of agricultural households and farm labour is measured in censuses in many countries. The share of agriculture in the workforce of OECD countries is provided in Table 1.

According to OECD methodology, agricultural employment has potential positive effects on rural viability. However, NCOs related to population are problematic. Farm labour is an input and cannot be viewed as a non-commodity output (OECD, 2002). Several potentially positive NCOs related to rural population were suggested to exist: lower congestion and pollution in urban centres and lower average cost of rural infrastructure (OECD, 2003; see also Abler, 2001 and Smith, 2006).

Viability of rural areas can also be defined in broader terms related to the "attractiveness" of life in rural areas. Apart from agricultural employment, income generation and rural amenities can be associated with rural viability (OECD, 2001). Some authors use rural viability in such a broad sense and claim that there are more types of potential NCOs associated with farm population that go beyond farm employment:

- smaller farms buy more products from small local providers (Harrison, 1993);
- smaller farms use more labour per unit output (demonstrated for dairy farms by Flaten, 2002) and the same is true for organic farms (Fasterding and Rixen, 2005);
- in some countries farm families have more children than other ones and therefore the farming community contributes to society in an over-proportional way (Mann and Erding, 2005, analyse the Swiss case); rural areas therefore can provide employees for high wage urban-oriented industries (Isserman, 2001).

Agriculture was defined above as producing commodities (food and fibre). It is part of agri-business and buying materials and services from the input providers, and supplies outputs to downstream industries as well. These relationships are recorded in input-output tables which are available for most OECD countries.

- In a survey undertaken by OECD on evidence of jointness between commodity and non-commodity outputs, several country reports referred to the role of the agricultural sector for downstream and upstream industries (surveyed in Abler, 2001). The impact agricultural production has on other industries can be measured by input-output coefficients and inverse coefficients which measure the multiplier effects of changing outputs. A full accounting of all those linkages shows that agriculture is directly or indirectly responsible for about 23% of employment in non-metropolitan US counties (Gale, 2000).

- For the evaluation of regional policies input-output models have been developed for several regions (Ciobanu, 2004; Mattas *et al.*, 2006 and Psaltopoulos *et al.*, 2006). Such analyses show the consequences of different policies on the sector in question and its upstream and downstream industries, but also on all other sectors (including households).

Many farms produce not only farm commodities for the market but other products as well. Among these outputs are food which is processed on farm like cheese or oil (examples from Norway are presented by Lyssandtræ, 2006) and services for the elderly or persons with special needs, community services, or transport and machinery services for other farms or firms in the region and farm tourism (*e.g.* Park, 2006 for related activities in Korea).

In many countries, the value of these outputs and services is measured by the economic accounts of agriculture (EAA). In some countries these outputs are higher than 10% of the value of commodity outputs (Table 1).

Non-commodity outputs affecting regional performance via indirect channels

Agriculture generates environmental benefits that are well documented but not systematically measured. Since many studies have been carried out in this field and methodological advances have been made, the range of values of agricultural landscape attributes is well known (an extensive recent survey on valuation studies is provided in Idda *et al.*, 2005). Open landscape is particularly highly valued close to metropolitan areas (Boulanger, 2004). Providing access to land (Marsden *et al.*, 2002) is an important precondition for the consumption of such environmental benefits and countries have different rules on access to open land. Therefore not only the output levels and technology determine the agricultural NCOs, but also institutional arrangements and property rights matter.

Environmental amenities provided by agriculture as well as services related to flood prevention (Nakashima, 2001) are directly consumed by residents and visitors of rural regions. The rural population grows when more people become residents because of an attractive cultural landscape - consequently indirect channels of NCOs have measurable outcomes. In such cases positive external technological effects are causing the social benefits. When technological external effects are present, markets do not provide the price signals reflecting social opportunity costs. Policy intervention may enhance resource allocation in such situations.

The agricultural community and other inhabitants of rural areas are considered to contribute to rural growth via additional indirect channels which seem to go beyond the concept of external effects:

- the social capital of rural societies (Léon, 2005 and Mugler *et al*., 2006);
- the cultural heritage and traditional villages and architecture (Hediger, 2004 and Ohe, 2004);
- the territorial image of regions (Vollet, 2006);
- the social coherence of their communities and their traditional activities (Lim, 2005; Saika, 2006; Mann and Wüstemann 2005).

During the last ten years, the concept of social capital has been an ever expanding field of social science research. It has been used to explain a wide range of phenomena (political participation, institutional performance, health, corruption, performance of public services) and was found to be an explanation for regional growth (Helliwell and Putnam, 1995). Most analyses which focus on agriculture and rural social capital are dealing with developing economies and countries in transition. How agriculture contributes to the social capital in OECD countries is therefore not yet well understood. One reason for such a lack of evidence could be that measuring "social capital" is very difficult (Durlauf, 2002; Sabatini, 2006).

It is very difficult to evaluate the benefits society gains from characteristics listed above. Two proposals are found in the economic literature on how to deal with this problem. In both proposals, the authors suggest taking all elements together and identifying the value of a bundle of NCOs. The first approach is to consider that existing farming systems are formed by farm policies based on deliberate public choices as opposed to measuring the value in monetary terms. For the case of Switzerland, Mann and Wüstemann (2005) reported on a referendum of a farm bill in 1996 as an example of public valuation. An alternative to referenda are valuation studies similar to those carried out by Bennet *et al.* (2004). They estimate a willingness to pay for the maintenance of rural population levels in Australia by employing methods to measure environmental benefits. They did not distinguish between farmers and other citizens in remote areas and therefore the NCOs related to Australian agriculture are unknown.

Evaluation of the degree of jointness between agricultural production and non-commodity outputs that contribute to rural viability

Non-commodity outputs affecting regional performance via direct channels

Rural population and farm labour

In OECD countries, the share of the agricultural population has been declining over the last decade, while the economies as a whole have been growing. Most rural regions in these countries have a growing population, although there are several rural regions where the population, and particularly the agricultural population, is declining.

This problem is not associated with the agricultural sector alone. The number of people living in a specific region will determine the average cost of infrastructure services. Thus, where there is a declining population, the people who use existing infrastructure will have to pay higher costs per user. Concerning infrastructure, it is necessary to distinguish between capital costs and maintenance expenses. Investments for infrastructure such as streets, sewers, or telephones are sunk cost. They are not accounted for in decision-making at the margin and therefore it is not economical to attract more people into regions to lower averages of irrelevant costs. Preventing the population from dropping below a certain minimum is only relevant for maintenance expenses. Statistics on maintenance costs of infrastructure in rural areas at OECD level are not available.

There are several options to prevent certain services being shut down in rural areas. One is to increase competitiveness and review potential limitations on businesses (*e.g.* the operation of postal services by monopolies, restrictions on sales of pharmaceuticals). Community services can be provided collaboratively by co-operation between villages and not necessarily by each village. Such strategies help to keep average cost down.

Is there a benefit if people from rural areas do not move to urban centres and contribute to the problems of metropolitan areas (negative environmental effects, congestion)? To answer that question it would be necessary to estimate net welfare losses because residents in rural areas generate externalities as well. The first best approach to address environmental problems and congestion is to internalise external cost (by taxes or regulations). According to the theoretical models presented above, such a strategy can make rural areas more attractive because it introduces friction in the process of agglomeration. However, unintended side-effects may also result.

Equity concerns during the phase of policy reforms have to be considered as well. Blekesaune (2001) analyses such a scenario in Norway. He concludes that “if the subsidies are going to be more orientated to payments for rural settlement and landscape care, and less orientated towards farm production, it is more likely that farmers in urban areas will derive benefit from this arrangement because they are more likely to maintain farming.” He also mentions that specific regulations of the land market aggravate the problem. Brunstad *et al*., 2005, analyse the same situation not from a sector specific perspective but in a general equilibrium framework. Their suggestion is to address multifunctionality attributes with targeted instruments. Using such instruments, equity concerns can be directly addressed.

Agricultural outputs in a dynamic input-output context

Is agriculture contributing to rural viability because of the production effects in upstream and downstream industries? Multiplier effects clearly indicate that this is the case. In a dynamic context upstream and downstream linkages cannot be used as an argument to justify the maintenance of a given output level of an industry. As the I-O import tables of most countries show, domestic food processors use a considerable amount of imported farm commodities to produce food and other products.

In a dynamic context, food processors would expand the share of imported commodities if there were fewer domestic supplies. The example of Austria shows how fast and flexibly firms adjust to new situations (Hofreither *et al.*, 2006). After Austria's accession to the EU in 1995, prices of agricultural commodities dropped by 21%. Austrian firms in the food processing industry no longer had to pay an implicit input tax and became more competitive because they could choose between a larger variety of inputs. Ten years later, the value added has increased considerably and employment levels are rising again after a transition period of several years. The transition was not successful in every case. The fact that ten percent of firms in the downstream sector had to close shows that there were not only winners. However, the remaining firms are now more competitive and have better business opportunities.

Non-commodity outputs sold on the market

Economies of scope arise when a single firm can produce two outputs cheaper compared to a situation in which each output is produced by two separate firms. They can arise when indivisible inputs are used in the production of more than one good.

Community services which can be carried out with farm machinery (like clearing streets of snow in winter) give rise to economies of scope because fixed costs can be spread over more services. In this particular case, farmers are competing with other firms with adequate machines (like trucks) which are not operated at full capacity during winter. In many cases farmers are owners and operators and therefore can supply these services very flexibly. Communities in rural areas definitely benefit if they get the same service cheaper.

Many consumers have a preference for goods and services which are provided by local farmers. Farm tourism and food processed on farms are typical examples (several case studies are provided in OECD, 2005b). The production of such goods and services is typically on a small scale. Many consumers prefer this to industrial products. Unit production costs are relatively high because there are less scale economies. Nevertheless many consumers are paying the premium price of the attribute "made on a small farm." One important reason why consumers pay premium prices is that they can directly check the credibility of the attribute either because of direct sales or – in the case of farm tourism – because the good is consumed where it is produced.

Many farmers produce commodities and highly differentiated products, because of economies of scope. If farming is no longer profitable this may disrupt the other business as well. Closing the farm and giving up both product lines is only one alternative. The other is to expand the branch with the highest margin and the best opportunities to reap economies of scale.

In such a scenario some goods and services previously produced together with farm commodities will no longer be supplied in the region. Owing to the fact that there are close substitutes to practically all these farm specific outputs on the market (*e.g.* food processed in small butcher's shops, tourist services supplied by bed and breakfast operators) potential losses of rural GDP do not seem to be very high in such a scenario.

Non-commodity outputs affecting regional performance via indirect channels

In the previous section it was found that there are profound reasons why those factors which are at the basis of the pyramid of regional competitiveness are hard to quantify. We know very little on how social capital, regional culture, social structure and the other factors contribute to the economic performance of regions. This lack of knowledge is not limited to rural areas but to others as well.

Should we know more? Concerning environmental amenities which are linked to the production of agricultural commodities, it seems worthwhile to promote research with an agricultural focus, because we know relatively little on how institutional arrangements can contribute to the stimulation of these outputs and the technology of providing landscape amenities separate from agricultural outputs (*e.g.* the case studies on tourism in OECD, 2005b).

Concerning the other elements listed above, it is necessary to increase knowledge more as well. However, it does not seem promising to focus on agricultural NCOs alone. The whole rural population (including non-farm households, small medium sized firms, and local non-governmental groups) has some effect on the wellbeing of rural communities.

In a comparison of successful communities versus less successful ones, Mugler *et al.* (2006) found some factors which contribute to fostering job creation and growth in rural communities: adequate infrastructure, good governance of regional policy, accountability of local public decision-makers, a climate of competition and innovation, no subsidies for the prolongation of uncompetitive operations, local institutions for the creation of trust and networks, and a unique regional vision which allows firms to differentiate their traded products (Mugler *et al.*, 2006). Some of these factors are just good governance, others are very closely related to the NCOs discussed above. Using such studies and approaches like those proposed by Feser and Isserman (2005) or Porter *et al.* (2004) may contribute to a deeper understanding of NCOs in rural communities.

Summary and conclusions

Rural viability is considered to be one of the major elements of agricultural multifunctionality. The OECD established a framework to classify multifunctional outputs. They are understood as joint outputs of commodity production. In this paper an attempt is made to apply the method developed by the OECD to evaluate the degree of jointness between agriculture and elements that contribute to rural viability.

Theory of regional development suggests that several key factors and indicators are important for the growth of regional GDP: infrastructure, population, labour market participation, hours worked, skill level, mobility of goods and factors, economies of scale and scope, and agglomeration forces. Factor mobility, openness to trade, a flexible and skilled labour force, the rapid adoption of new technologies, investments in human capital and high quality infrastructure contribute to regional growth. These factors are relevant for any type of region, rural regions are no exception. However, empirical results on theories of regional growth provide ambiguous results. Neoclassical growth theory would imply that regions converge, but observations show that this is not always the case. Other theories (endogenous growth theory and New Economic Geography) show that regional divergence may happen and urban centres may grow faster than other regions due to factors like localized knowledge spillovers and agglomeration effects. According to these theories not all lagging regions will necessarily catch up even if other conditions listed above are met.

Rural regions are characterized by remoteness and low population density. Owing to these characteristics, many rural regions face specific problems like out-migration and slow growth. The objective of rural development is to improve the well-being and standard of living of its residents. A multifunctional agriculture is supposed to contribute to this objective not only by providing food and fibre. Non-commodity outputs (NCOs) contribute to rural GDP via direct channels (*e.g.* services) and other factors (*e.g.* the provision of landscape amenities) foster rural growth via indirect ones. NCOs affecting the rural standard of living directly contribute to rural economic performance in a straight forward manner. NCOs affecting regional welfare indirectly are not evident and can be identified only by evaluating the outcomes. From an economic perspective, direct links are the consequence of pecuniary external effects, whereas most indirect links are the result of technological external effects.

The performance of regions can be measured by regional GDP. If agriculture provides NCOs related to rural viability, their effects should have a positive impact on rural GDP. In the case of direct effects, NCOs are components of observable indicators of regional growth (population, workforce, working hours, gross value added of goods and services). In the case of indirect effects of NCOs, their influence cannot be tracked directly. However, the effect should be measurable by revealed indicators (*e.g.* population growth or more productive local firms due to attractive cultural landscapes or higher productivity due to social capital).

Regional statistics published by the OECD provide an extensive overview of the performance of rural regions relative to urban and intermediate regions. In many OECD countries rural population is high and rural regions contribute a significant share of the overall GDP. The GDP per person is lower in rural regions than the national average in most OECD countries and many rural regions are growing slower than urban or intermediate regions. Agriculture is an important activity in most rural regions, however, even there its contribution to the regional labour force exceeds 20% only in few OECD countries.

At country and regional levels there is little evidence that the decline of agriculture (measured as gross value added) has diminished growth. Evidence from European countries suggests that there are very few regions in which both agricultural value added and regional GDP declined during the last years. Many European rural regions had a growing GDP despite negative growth rates of agricultural value added. These findings are not a proof that NCOs of agriculture are irrelevant for rural viability, but they do not prove that they are relevant either. If they exist, their effect on growth in rural regions does not seem to be very large.

Agriculture produces food and fibre. Thus downstream and upstream industries are linked to agricultural production. In a static framework these direct links can be analysed by input-output models. Using multipliers, it can be shown how changes in the level of agricultural activities change output and input levels in other sectors. Such results underline the importance of agriculture for the economy at a given point in time. In a dynamic framework it has to be considered, that many domestically produced outputs can be substituted by imports. If domestic supplies are not sufficient, down-stream industries will import the necessary supplies to keep their markets. Therefore strong direct linkages between agriculture and upstream and downstream industries in a static view may turn out to be weak from a dynamic perspective.

Economies of scope are an explanation why the agricultural sector produces not only commodities but also other marketable and non-marketable goods and services. The economic accounts of agriculture (EAA) measure these outputs in many countries. NCOs produced by agriculture are farm tourism, community services and food processed on the farm. These activities represent a value of ten per cent and more of total sector output in many countries. They contribute directly to rural GDP and are therefore important for the living standard of the rural societies. The supply of these goods and services may shift if prices for agricultural products decline. If there are no farms, farm tourism is no longer an option. But, even in such an extreme scenario, rural GDP does not need to be significantly negatively affected. Very similar services can be provided by specialised firms which are competitive without economies of scope. Direct NCOs of agriculture may be essential for the typical character of rural regions; however they are not indispensable when close substitutes exist. A policy aiming at a diverse business structure in rural areas contributes to lessening the regional consequences of shocks that affect only one sector adversely.

The literature suggests that there are further elements of multifunctional agriculture. Such NCOs contribute to rural development in an indirect manner: social capital, regional innovation, social coherence, rural culture, and other factors. There is plenty of anecdotal evidence that these NCOs exist and that they are important for rural development. However, there is only scant empirical evidence that would support such theoretical considerations and more research seems necessary in this field.

Every region develops in a special way and therefore NCOs of agriculture play specific roles. This is true not only for rural regions but for other regions as well. In some regions NCOs may foster rural development and the approach taken in this study could show a pathway to identify them. In many rural areas basic services are underprovided because of low population densities and low purchasing power. Specific programmes, fine tuned to the regional setting, are a precondition of targeted policy interventions. Such programs should focus more on providing the necessary services at risk and the people living in the region rather than addressing specific sectors. Since most farm households live in rural areas, they would be beneficiaries of such policies.

The analysis has shown that there is a large diversity among rural regions even within small countries. Any policy aimed at stimulating rural development should therefore be well targeted to addressing the specific growth drivers. The agricultural sector can be among them, depending on its contribution to rural viability. Focussing on those NCOs with a direct effect on regional growth seems to be a good option. The general rule is to address specific problems with the appropriate instruments. If, for example, rural employment is at risk, labour market policies should be adopted to enhance the competitiveness of the rural work force. Policies stimulating the output of a particular sector are not an adequate instrument in such a case. If, in another example, positive or negative technological external effects of agriculture are affecting the well being of rural communities, the set of instruments which addresses them in the best way, should be adopted.

Annex

OECD Regional Classification

The OECD has classified regions within each member country. The classifications are based on two territorial levels (TLs). The higher level (Territorial Level 2) consists of about 300 macro-regions while the lower level (Territorial Level 3) is composed of more than 2 300 micro-regions. This classification – which, for European countries, is largely consistent with the Eurostat classification – facilitates greater comparability of regions at the same territorial level. Indeed, these two levels, which are officially established and relatively stable in all member countries, are used by many as a framework for implementing regional policies [...]

The OECD has established a regional typology according to which regions have been classified as predominantly urban, predominantly rural and intermediate. This typology, based on the percentage of regional population living in rural or urban communities, enables meaningful comparisons between regions belonging to the same type and level [...]

The OECD regional typology is based on three criteria. The first criterion identifies rural communities according to population density. A community is defined as rural if its population density is below 150 inhabitants per square kilometre (500 inhabitants for Japan to account for the fact that its national population density exceeds 300 inhabitants per square kilometre).

The second criterion classifies regions according to the percentage of population living in rural communities. Thus, a region is classified as:

- Predominantly rural (PR), if more than 50% of its population lives in rural communities.
- Predominantly urban (PU), if less than 15% of the population lives in rural communities.
- Intermediate (IN), if the share of population living in rural communities is between 15% and 50%.

The third criterion is based on the size of the urban centres. Accordingly:

- A region that would be classified as rural on the basis of the general rule is classified as intermediate if it has a urban centre of more than 200 000 inhabitants (500 000 for Japan) representing no less than 25% of the regional population.
- A region that would be classified as intermediate on the basis of the general rule is classified as predominantly urban if it has a urban centre of more than 500 000 inhabitants (1 million for Japan) representing no less than 25% of the regional population.

Source: OECD (2005a), *Regions at a Glance*, Paris, pp. 177-178.

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Maintaining Farmland: a New Focus for Agricultural Policy

by
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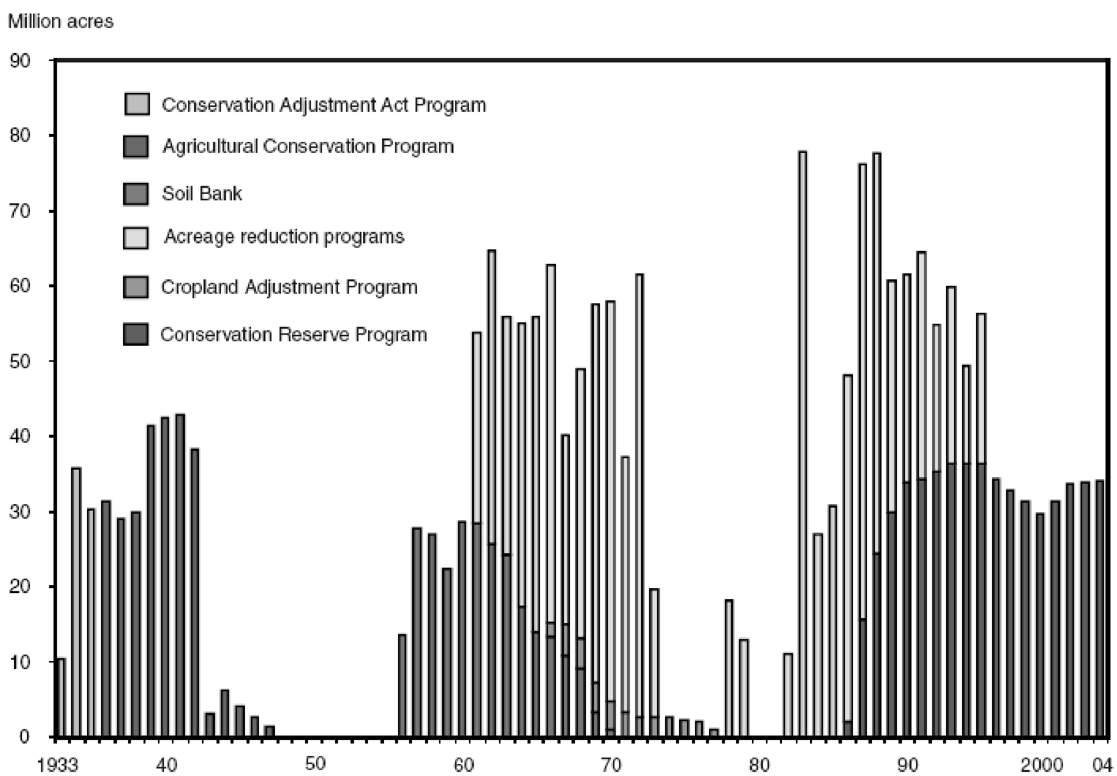
Agricultural policy reforms, including CAP reform in Europe, periodic changes in U.S. Farm Bills, and adjustments in Canadian agricultural policies, have a number of common threads. These can be grouped under the concept of multifunctionality, although in North America and some other countries the term is not popular (Garzon, 2005; Dobbs and Pretty, 2004). Even so, there is a general recognition by the majority of OECD countries that farm policy has to move beyond its historic focus on increasing commodity production and supporting farm incomes (Cochrane, Normile and Wojan, 2006). Largely, this involves recognizing the various non-commodity outputs of agriculture and finding ways to adjust farming practices to alter the balance between commodity and non-commodity outputs (OECD, 2003).

This shift involves two important changes in policy. The first is a focus on land use. Traditional agricultural policy considers land use as a secondary issue because it recognizes other factors of production are more important constraints on the level of commodity output and farm incomes. The second is a shift from a focus on aggregate production and aggregate farm income to a smaller spatial scale of the region and the individual farm. While commodities are by definition homogeneous products, non-commodity outputs have values that are typically specific to a particular location, and the potential mix of feasible commodity and non-commodity outputs varies considerably across farms. An important consequence of this adjustment is that agriculture becomes much more a domestic policy issue, because the majority of non-commodity outputs are not tradable.

These two changes are implicit in the moves to reform agricultural policy and they may appear to offer a way to harmonize policies as countries shift their focus from increasing outputs of food and fibre. However, in practice the term multifunctionality has become a divisive issue, even though there is considerable support for its underlying concepts (Dobbs and Pretty, 2004; USDA, 2001; Matheson, 2006). The main objective of this paper is to explore why this controversy exists, even though the adversaries share a common appreciation for the importance of rebalancing the mix of agricultural outputs. The conclusion is that while general concerns with land use, particularly the loss of farmland, are central in each country, the specific nature of the concerns vary greatly between the "old world" of Europe and the "new world "of North America." Differences in concerns are interpreted on each side of the Atlantic as a failure by the other side to truly embrace the underlying principles of multifunctionality, that thereby demonstrates a lack of commitment to true agricultural policy reform.

A key difference between the European Union and Canada and the United States is the historic policy response to maintaining the stock of farmland. In Canada and the Untied States, other than for brief periods of high market prices for commodities, there have been on-going efforts to take land out of production. The most obvious of these were in the 1930s when in both these countries a major portion of the vast amount of support for agriculture involved relocating farm families from marginal lands and eliminating production on these lands (Cochrane 1993; Fowke, 1946). Following World War II there were additional programs to further reduce production on marginal lands and to take them permanently out of production. Figure 1 shows the amount of potential cropland idled over time in the United States since the 1930s.

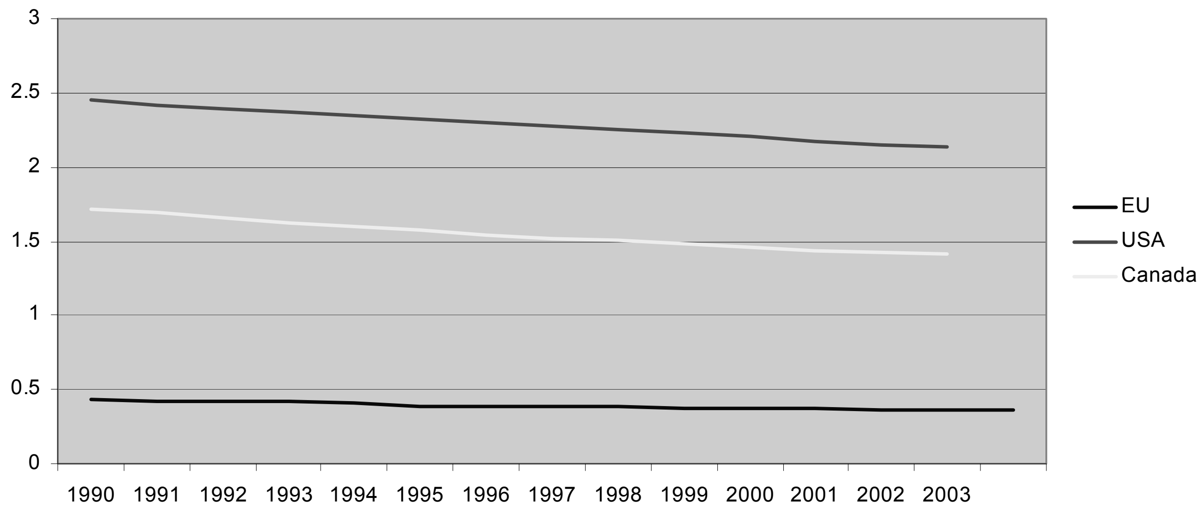
Figure 1. Cropland acreage reductions by program type 1933-2004



By contrast, a major concern in western Europe after World War II was to increase agricultural output. This reflected the effects of the war and the loss of food supplies from Eastern Europe combined with a large influx of refugees from the east. The result was policy that encouraged the utilization of virtually all arable land. It also encouraged land intensive production practices that maximized the output of food and fibre. Only recently has the European Union begun to try to reduce the degree of intensity of input use and to take land out of production.

In Canada and the United States issues of domestic food availability are largely irrelevant, but while they are almost as unimportant in Europe today there is still a recognition that not very long ago food was scarce. Moreover the stock of farmland per capita in Europe and North America is radically different (Figure 2). Even with rapid population growth in Canada and the United States there is still far more farmland available per person than in western Europe. This makes farmland relatively scarce in Europe.

Figure 2. Agricultural land per person



The farm policy context

In the majority of the industrialized nations farming is now a minor source of income and employment, even in their rural areas, and concerns with food shortages are now well past recent history. Moreover, the majority of the populations are now more urban and wealthier than at any time in history. In such an environment it is not surprising that there are growing questions about the role that agriculture plays in each society (Office of the President, 2006). In general; there is a growing sense that agriculture is becoming more valued for its contribution to the national landscape and less valued for its production of food and fibre (Platt, 1985). Larger and wealthier populations that seek an alternative to their normal urban environment now commonly travel to rural areas to experience nature. Because farmland is the dominant land use in those parts of all countries that are readily accessible from urban places, the nature that is experienced by urban residents is largely determined by farming practices.

In some cases farming practices provide a positive contribution to the urban visitors experience. This is generally the case for low intensity livestock operations that allow animals to graze in a pastoral setting, or where there is a variety of field crops (Glebe, 2003). In other cases farming provides a less desirable landscape, when an intensive animal feeding operation is encountered, or when monoculture crop systems dominate an area. To the extent that undesirable landscapes are the result of agricultural policies, while desirable landscapes are not encouraged by current policies, there is a disconnect between what the bulk of society wants from its farm policy and what is now provided.

Not surprisingly, in most countries agricultural policy is no longer determined just by farmers and the agricultural bureaucracy. It is now influenced by animal welfare advocates, environmental activists, and rural residents whose livelihoods and life styles are influenced by farming practices, even though they are not directly engaged in farming. The result is agricultural policy that is steadily moving toward a broader perspective than commodity production and policy which looks at the full set of market priced and unpriced outputs of agriculture.

The focus of this paper is the public concern with farmland preservation, particularly the implications of a decline in the quantity of farmland. However the reason for this focus is not the impacts on commodity production, where other inputs may be effective substitutes, but to ensure the production of non-commodity outputs. Farmland is the source of a large share of the non-commodity outputs of agriculture. It provides visual amenities. It provides habitat for desirable species of plants and wildlife. It provides the location for the cultural experience of observing farming that connects an urban population to roots, that while they may be mythical, are still valued. Striking in this concern with farmland preservation is the limited reference in both North America and Europe to a loss of commodity production in the short run. In those instances when the food security value of preserving farmland is raised, it is typically in the context of a future reserve that can be relied upon if production levels change in the future (Dobbs and Pretty, 2004; Garzon, 2005).

While agricultural subsidies appear large in aggregate, they are a relatively minor share of public outlays in virtually all OECD countries. Moreover they are a form of public expenditure that is not broadly controversial. Farmers and farm supports are generally viewed positively by the public. However, the broad public is increasingly interested in the mix of outputs produced by farmers and how those outputs are produced. In other words, the public is increasingly concerned with how farmland is used and is increasingly interested in ensuring that farm policy does not encourage socially undesirable behaviour by farmers. Society remains willing to support farmers, but there are growing expectations that something more than commodity output is to be provided in return.

One reason land use has become a divisive policy issue is the fundamental concepts underlying multifunctionality as a basis for farm policy imply that it is important to avoid conversion of farmland to other uses. It is farmland that produces the majority of non-commodity outputs. This means that policies to implement multifunctionality are necessarily largely based upon maintaining farmers on the land and the land in farming. Appealing to the non-commodity outputs of agriculture becomes the means for justifying the new policies, particularly those that try to maintain farms in Less Favoured Areas (LFAs) where the financial returns to production are low, even with direct income support for commodities (Brouwer *et al.,* 1997). By contrast, the countries that are suspicious of multifunctionality typically see no social value in preserving marginal farms and marginal farmland, and based upon their values assume that such strategies are merely a ruse to disguise new levels of direct income support to farmers.

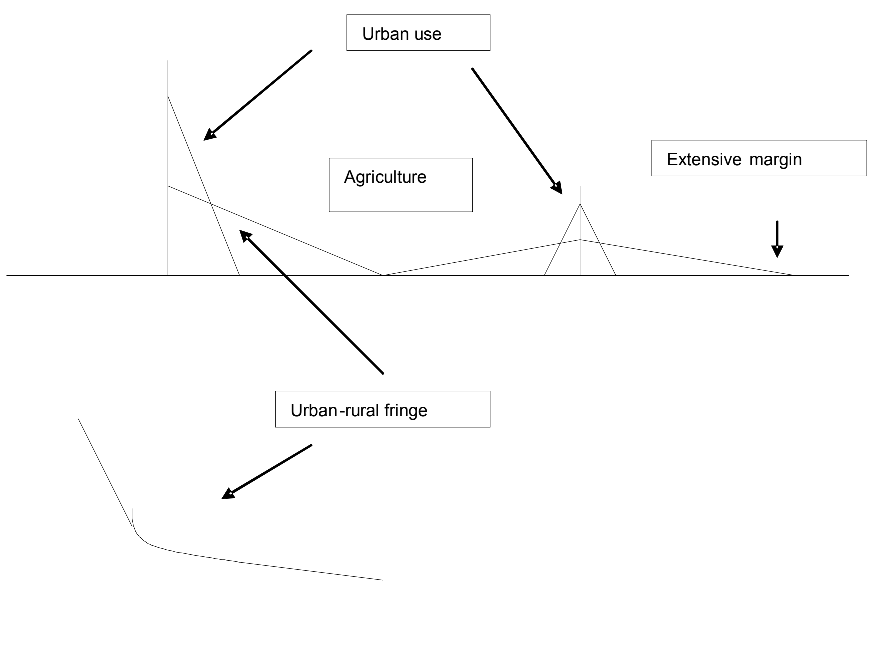
Farms in space

Typically, farmland has limited alternative uses. In most parts of most OECD countries individual farms may cease to operate but the land continues in agriculture under a new operator. This means that from a national, or aggregate, production perspective the stock of farmland can be considered fixed, at least in the short run. With a fixed stock the main land relayed issues are how much land is allocated to the production of specific commodities and the relative productivity of various parcels of land (Ricardian rents) (Tweeten, 1979).

However, while the assumption of a fixed stock of land is consistent with historical data on measures of the quantity of land in farms, it masks considerable change at two points. These are the urban fringe, where development pressure leads to land being converted from agricultural uses to urban uses, and the extensive margin, where farming ceases to a profitable activity and land is used for forestry, wildlife habitat or some other low value per hectare use. The nature of these changes is easiest understood by examining a simple von Thunen-type land use model.

Assume a uniform plain with a central market town. In the immediate vicinity of the market are homes for merchants and other urban dwellers. These urban dwellers have a strong preference for proximity to the market and are prepared to pay more for land near the market than can be justified by any agricultural use. Consequently in a ring surrounding the market we find urban land use. Land values decline with distance from the market because these locations are less desirable. Urban land use ends at the point where the highest value agricultural use just exceeds the urban use. In the classic von Thunen model every farmer producing a given commodity receives the same market price and all land is equally productive. However, each farm incurs transport costs to get to market, so locations closer to the market yield higher returns than more distant ones. This means that agricultural land values are higher closer to the market to reflect the higher profit potential (Figure 3). While the upper part of the figure suggests a clean break between urban and farm land uses, the urban fringe is generally less distinct. The lower part of the figure suggests that a mix of farm and urban uses are present, reflecting the reluctance of established farmers to sell, leap-frog development, variability in land quality and other factors.

Figure 3. Stylized Depiction of Intensive and Extensive Margins



Suppose there is only one crop. At some distance from the market transport costs will reach a high enough level to exhaust the return from producing and selling the crop. At this point agricultural activity ceases, and in the von Thunen model land beyond this frontier is wilderness. Now suppose crop prices fall. Logically the extensive margin should contract as farmers who were once able to earn an adequate return now find the market price no longer covers their production and transport costs. Similarly, suppose the urban population expands, increasing the need for housing. As house prices increase the value of farmland closest to the town becomes lower than its value in housing and land is converted. Note in this model the use of all other farmland remains unchanged. Only the land at the margins is affected by change.

Even with a model this simple it is easy to describe a situation where land use at the margins changes but the aggregate quantity of farmland remains constant. Consider the case of an increase in urban population. This leads to the loss of farmland in closest proximity to the town. However, if the larger population results in a greater demand for food, we might expect prices received by farmers at the market to increase. This will in turn allow expansion of the extensive margin because land that was unprofitable before now becomes viable farmland.

Space and farm policy

Standard analysis of farm policy ignores the spatial aspects of agriculture. But policy clearly has a spatial impact. In reality land is not uniform and parcels of land that are more productive command higher prices than do less productive land. In many cases highly productive land is in close proximity to urban centres because historically settlements near good farmland tended to grow faster and become wealthier than those in less favourable locations. Similarly, more remote land is often less productive because not only is it unsuitable for agriculture, but it is undesirable for most other human uses, which assures it remains remote. This adds a degree of complexity to the analysis, but does not alter the fundamental logic of the two margins.

The new agricultural policy framework necessarily involves recognizing spatial differences. The specific features of parcels of land and the local environment determine both the achievable level of non-commodity outputs, and, to a great extent, the value of land. For example, Vihinen notes that local communities in rural Finland are prepared to pay to keep fields open to preserve landscape amenities, but only in locations where there is the opportunity for people to actually view the specific open space (Vihinen, 2006). Classen *et al.* show that it is possible to achieve significant increases in environmental quality by spatially targeting programs to locations where environmental damages associated with production are high but remediation costs are relatively low (Classen *et al*., 2001). Not only is farmland important, where the parcel of farmland is situated is also important.

High levels of support for agriculture have three distinct effects. At the urban fringe they increase the returns to farming which will slow the rate of urban conversion. However, as Kuminoff, Sokolow and Sumner note the value of land in urban uses is typically an order of magnitude or more higher than its agricultural value. Thus in most cases agricultural support provides only a weak impediment to urban sprawl. A few counter examples to this are apparent. In Lexington, Kentucky, thoroughbred farms are effective barriers to urban sprawl because wealthy horse farm owners are prepared to pay more for farmland than most developers. Similarly, in the Cote d’Or of France the quality of the vines is high enough to control urban expansion. In these cases it is not public policy that supports farm uses but highly location specific agricultural activities.

Agricultural policy has a larger role at the extensive margin because it raises returns above market rates. Higher prices lead to agriculture being carried out in areas where it would otherwise not exist. Conversely significant reductions in price supports can have major impacts on farm viability in those remote areas with marginal productivity, as the combination of low yields and high transport costs overwhelm market returns. The third effect refers to those farms between the margins – the vast majority of farmland. For these farms price supports are pure rents,[1] in the sense that with or without the policy the land will have an identical use. This does not mean that policy has no effect. Removing price supports may lead to a reduction in the use of other inputs, so output declines, or it may lead to the farm operator becoming bankrupt and losing the farm. Nevertheless the land will not change use, so from an aggregate perspective the loss of policy support has no broad use effect on land that is not at either margin A shift in agricultural policy from traditional commodity support to multifunctionality has major implications for land use at the margins but less impact on other land.

Consequently in principle all three effects should be recognized, but in practice in both Europe and North America the focus is on just one. As noted earlier, in Europe the predominant concern is the loss of farms at the extensive margin if traditional supports to farmers are not replaced with an alternative mechanism. In North America the main concern is with urban sprawl encroaching upon prime farmland. The first question is why the difference in focus and, secondly, why there is limited concern in both regions with the impact on farmland between the two margins?

Land use at the margins

Two potentially important differences between land loss at the fringe and extensive margin are, the general irreversibility of losses at the fringe and the fact that land lost at the fringe is generally more productive. Land lost at the extensive margin can be readily shifted back into agriculture if its opportunity cost changes, so this land remains part of the agricultural reserve. But, land lost to urbanization is typically transformed in a way that eliminates the possibility of restoring it to farming uses in the future. Also, the loss of land to urbanization has a significantly higher cost than the number of hectares alone implies. Because cities were often first established in areas of high agricultural productivity, their expansion continues to consume high quality land. In most countries the quality of farmland is quite variable and there is more lower quality than high quality land. While modern farming methods have greatly reduced the agronomic benefits associated with high quality land they still remain, so urbanization typically leads to a reduction in average output per unit of land even if the extensive margin shifts out to leave the total amount of farmland constant.

Another way to consider the two types of farmland loss is to note that land lost at the fringe does not change function because of changes in agriculture that reduce its ability to generate output and income. Instead it leaves agriculture because the opportunity cost of remaining in agriculture exceeds the returns from farming. By contrast, land at the extensive margin typically has a very low opportunity cost. Land at the extensive margin

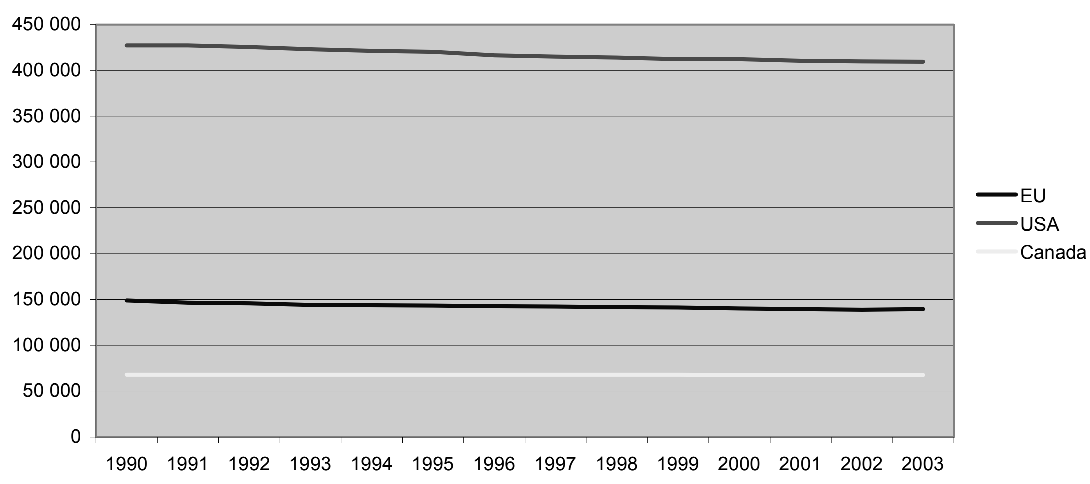
1. A rent is a factor payment that need not be made. With or without the payment the factor earns more than its opportunity cost and consequently does not change its use

leaves because the market value of the output produced is insufficient to cover the costs of the resources used in production.

From a larger perspective the model has some value in thinking about farm policy. In general most countries are mainly concerned with agriculture as a sector and less concerned with the well-being of individual farms. From this perspective the simplest way to think about agriculture is as if it were one large farm. Supposing that government is primarily concerned with sector wide results, then its main concern with farmland will be with changes in aggregate quantity. A change in the amount of land used for farming means that agriculture is either less able to compete for the resource at the urban fringe, or agriculture is not profitable enough to allow land to remain in agriculture at the extensive margin. Situations where the aggregate stock of land remains constant over time can be thought of as indicating that agriculture, in aggregate, is in equilibrium. Of course, within the agricultural sector there can be significant adjustments in the amount of land allocated to the production of specific commodities.

From this perspective significant reductions in the stock of farmland can be seen as an indicator of a weak farm sector, even if only commodity production is considered. In North America, the stock of farmland has remained remarkably constant over time in both Canada and the United States. despite large declines in farm numbers and large increases in farm output (Figure 4). In Europe the stock of farmland has declined somewhat over the last decades for the EU16, but with enlargement the relative decline has been reduced, since the new entrants have not lost as much farmland, Similar trends in farm numbers and farm output are equally evident. Thus, from a sector perspective, there is little evidence that agriculture is out of equilibrium in either the EU or North America. However, once we admit that government or society is concerned with more than just aggregate farm sector results, and we also include non-commodity outputs, then the problem of land conversion is more difficult.

Figure 4. Agricultural area: European Union, United States and Canada



Farmland conversion issues

In reality the loss of farmland is a more serious public policy issue than the aggregate changes in quantity would suggest in both North America and the European Union. It appears that public concern with the loss of farmland may actually be the main driving force behind multifunctionality. While farming has become a minor function in terms of most social and economic indicators, it remains the dominant land use in both regions. This means that small percentage changes at the aggregate level can be associated with large absolute changes in the stock of farmland at sub national levels. Recall most farmland is not subject to conversion, it is only land at the two margins that changes uses, so the effects are geographically concentrated. And if at those margins the land provides particular values that go beyond commodity outputs, the cost of conversion can be much higher than standard farm accounts would suggest. This is particularly the case if the farmland that lies between the two margins is unable to provide the same non-commodity outputs.

At the fringe farmland is typically of better than average quality and has a high productivity, but a major share of its total social value comes from the non-commodity outputs of "green space" and visual amenities that are readily available to urban residents. Farmland further away from the fringe is unable to provide these local public goods and externalities. Further, a normal by-product of urban conversion is higher cost public services for urban residents as public infrastructure (sewer, water, transit) is pushed out to more remote areas. Since local services are typically priced on the basis of average cost with a uniform charge for all residents, an implication of land conversion from farm to urban use is higher infrastructure costs for all.

At the extensive margin the value of commodity production is almost by definition low. However, once again, this land can have a social value that greatly exceeds its value in producing commodities. Because the land is marginal for farming, it is typically not intensively managed which often allows it to support a wide variety of wildlife. When the land has been involved in agricultural production for an extended period of time the local ecosystem adapts to the management process and may be unable to survive if land reverts to an unmanaged state. This means that ending farming may also mean accepting a significant change in the ecological balance of the region, not just on the farmland itself. Once again farmland that is interior to the extensive margin is unable to provide a similar function, because it lacks the same attributes and because of more intensive management practices.

Valuing farmland conversion: North America

The main public concern with the loss of farmland in North America is urban conversion. Since 1970 the population of Canada has increased by 50%, while the population of the United States has grown by 44%. Over the same period, the urban share of the population has grown and the majority of this growth has taken place in a relatively small number of the largest cities. Even if the average population density of cities had stayed at the level of the 1950s, considerable expansion of the urban footprint would have been required, but because the average population density of cities fell as suburbs became more desirable and accessible, the amount of farmland converted to urban uses was even larger (Hoffman,).

Urban conversion issues in North America reflect a relatively high rate of population growth that has been concentrated in a small number of urban centres. Much of the growth is from immigration, because natural population growth rates are low and falling. Immigrants overwhelmingly settle in urban areas. Internal rural to urban migration flows have slowed, and at times reversed in recent decades, so they have limited effect on the location of the population.

In recent decades high rates of population growth in urban centres imply urban expansion even where controls on land conversion are strong. However in most parts of North America land conversion has been a relatively easy process and farmers have typically been more than willing to sell property for development. Land use management is a provincial responsibility in Canada and a state responsibility in the United states. In both countries provinces and states have largely transferred this responsibility to local governments. Only recently have local governments been encouraged to adopt regional planning practices. Consequently even if one locality chose to limit urban expansion. it was relatively easy to simply bypass its territory and develop land in an adjacent county that had less restrictive practices. Ironically the consequence of local land use controls was often more rapid sprawl as developers jumped further out.

As noted earlier national averages mask huge variability in conditions across North America. Despite a large growth in the amount of land in urban use over the last fifty years the stock of farmland has remained relatively constant. Moreover, urban growth is only one way that farm land is lost. Large amounts of farmland have been converted to parks and recreation areas. Other farmland has been converted to forest. Finally large amounts of crop land have been idled for extended periods through agricultural policies that take land out of production. While some studies continue to consider idled crop land part of the farmland base, others do not (Greene and Stager). In the latter case declines in the stock of farmland appear much larger.

Moreover, the spatial distribution of land use has varied greatly. In Canada most of the land taken out of production at the extensive margin has been in the Maritime provinces where productivity was low (Parson, 1999). Additional land has been abandoned in the northern portions of Quebec, Ontario and the prairies. Concern with the loss of farmland to urban uses is concentrated in two regions – Toronto and Vancouver. Both cities have grown rapidly in the last three decades and it is inconceivable that their current population could have been contained within their historic footprint. But this expansion has had important consequences for some high value agricultural production that was concentrated in close proximity to the two cities (Farmland Preservation Research Project, 2005; Gordon and Richardson, 1998). As a result local capacity to supply specific commodities has been greatly reduced, but there has been no noticeable effect on the availability of these products for consumption.

Even in Ontario, where population pressures are most evident, there have been large losses of farmland to abandonment (Farmland Preservation Research Project, 2005). The area in farms in the vicinity of Toronto has declined largely due to urbanization. The area in cropland in south-western Ontario, which is relatively productive, has remained stable. The area in farmland in eastern Ontario, which is largely marginal land, has declined by a considerable amount, but not because of urban pressure. This land was largely abandoned due to its inability to produce an adequate return.

Similar patterns are true for the United States (USDA, 2006). Farmland declines in the Northeast reflect a mix of urban conversion, conversion to parks and recreation, and abandonment. Meanwhile cropland in the centre of the country has expanded as pasture was converted to crop production (Figures 5 through 8). Consequently the resulting appearance of stability at the national level reflects large gross increases and declines in various sub-national regions. While from a national perspective there is no obvious reason to worry about farmland, from a local perspective in many parts of the country farmland conversion is an important issue. And it is important largely because the loss of farmland has major consequences for the local supply of non-commodity outputs, especially visual amenities and recreation space. While farmland may not be experiencing any increase in scarcity from a national perspective it is becoming scarce in certain regions because large amounts have been lost to other uses.

In both countries there is a clear differentiation among the new uses. Farmland proximate to urban centres is valued largely because of its proximity which allows ready access. Even if similar land is available further away the cost of getting to it is higher making it less desirable. Further, even if per capita demand for access does not increase with urban expansion, the simple fact that there are many more people increases the demand considerably. By contrast, the conversion of farmland to wilderness typically improves access by reducing the distance that has to be travelled from urban areas to experience the site. In addition, because what was previously farmland is not considered to be “virgin wilderness” it may actually have greater value for more intensive recreational use. Similarly, farmland that is directly converted to park or recreation uses moves land that could previously only be used passively, because it was private property, into land that can be used actively.

Figure 5. Major land use share in the North-East

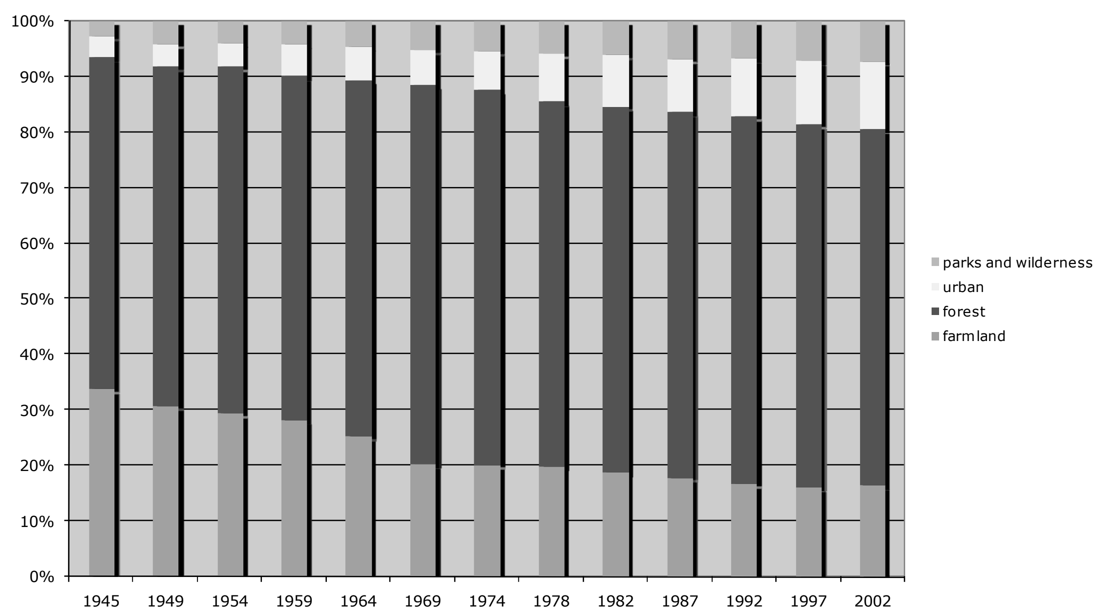


Figure 6. Land use share in New York

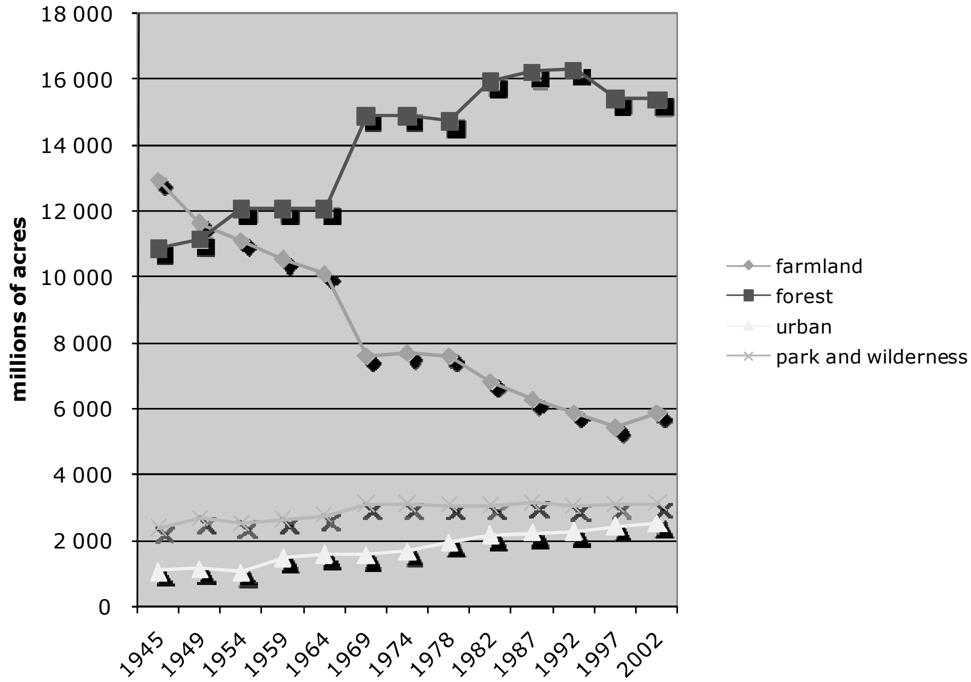


Figure 7. Land use share in the Northern Plains

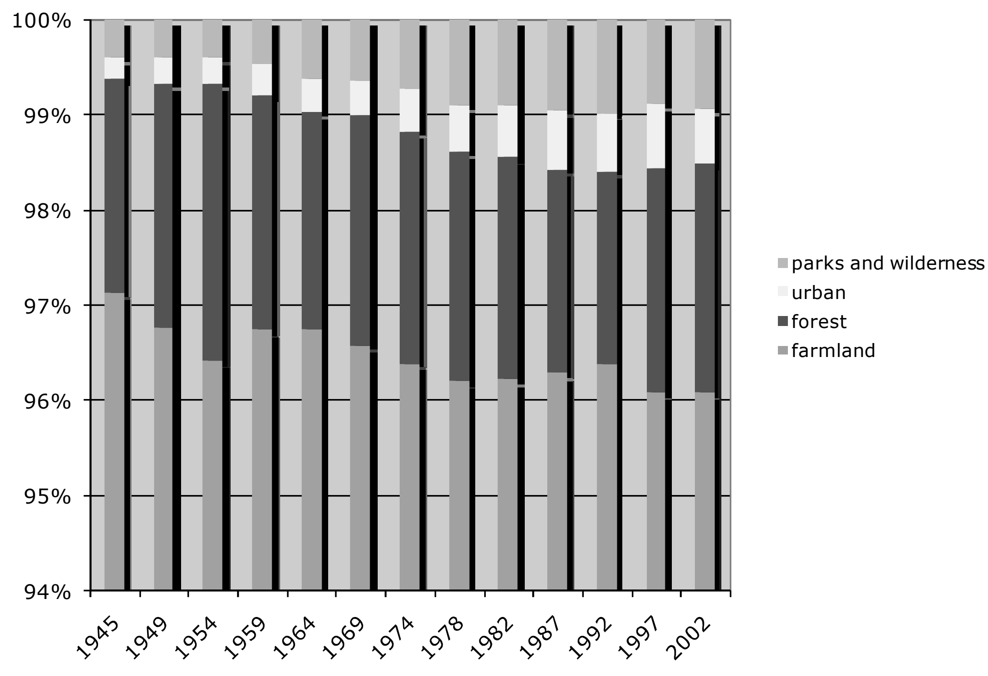
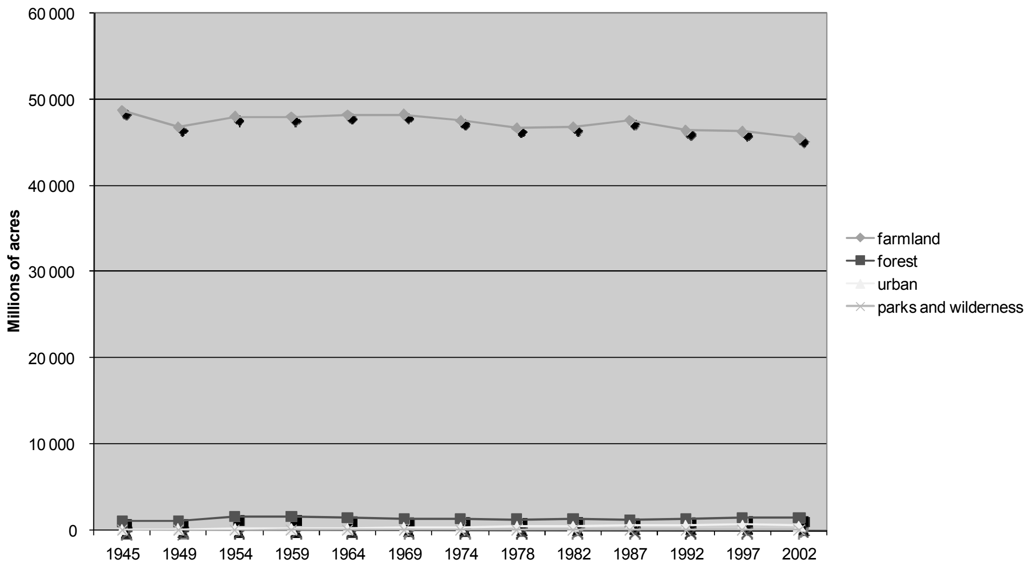


Figure 8. Land Use share in Kansas



Valuing farmland conversion: European Union

The concern with farmland loss is a much more recent phenomenon because of the pressures to increase food production in western Europe in the twentieth century. In Europe, urban sprawl is an emerging issue, but it is less visible as part of agricultural policy (EEA, 2006a). Urban areas account for a growing share of national populations, but in most countries the rate of growth in urban areas has been relatively slow by North American standards, except for those cities that have experienced large immigrant influxes (EEA, 2006b). In addition, European urban patterns are different than in North America. Central cities are still desirable residential locations, which reduces the demand by wealthy individuals for large low density ex-urban residences. This creates a much more compact urban form. Country houses are popular, but they are typically second homes in rural locations where farming is prevalent; unlike in North America where second homes are typically found in wilderness areas. Importantly, land use decisions in Europe are dominated by higher levels of government, and land conversion takes place only under strict supervision and in patterns that are consistent with long term plans.

The result is a much more regulated pattern of urban growth that typically considers the importance of maintaining green space in close proximity to urban centres as an important policy concern. When urban conversion takes place it is in a highly regulated process that has considered the broad public impacts. Further the settlement pattern in Europe tends to inherently mask growth effects. The existence of a dense set of villages throughout the countryside offers an opportunity to add housing with less noticeable effects than in North America where one year there is no housing, and the next year there is no farming.

At the extensive margin the driving forces for abandonment are more similar. However, the context is different. The relative scarcity of land in Europe argues for more attention being paid to opportunities for multiple uses. Because land is relatively scarce, abandonment is considered undesirable (Kovacshazy, 1992). The pattern of urban use of rural space reinforces multiple uses. Urbanites in Europe expect a managed environment that shows evidence of human activity when they visit the countryside. Second homes are typically in villages or near farms, so the abandonment of farmland reduces the opportunity for urban interaction.

Because most land in Europe has been farmed for centuries, it has developed an ecosystem that depends upon active management (Keenyside, Veen and Baldock, 2004). Without management there will be shifts in the mix of species and the possible loss of specific species. While this is not an argument that all marginal farmland in Europe should be protected, it is an argument that specific parcels should be maintained as farmland. As in North America, marginal land that is at risk of abandonment is regionally concentrated; mountain areas in France, Austria and Italy, most cropland in the Nordic countries, and a significant amount of the pasture land in the new Eastern members of the EU (EEA, 2004).

Land abandonment is also associated with an aging population and weak rural economies. Income from farming is too low to support a household and there are limited opportunities for off-farm earnings (EEA, 2004). But the current approach of supplemental payments to maintain full time farming is both expensive and the cause of trade frictions. However similar landscape effects could be achieved if farm households were able to earn more of their income from off-farm sources. This would entail a shift to part-time farming but it need not detract from the current level of production of NCOs. Moreover given the urban interest in Europe of a managed rural environment, it may be possible through rural development efforts to further enhance the level of amenities and maintain landscape value.

Conclusion

The loss of farmland is a sensitive issue in most OECD member countries. In almost every case the loss is characterized by farm interests as having significant implications for agricultural output, if not now, then in the future. However, a more dispassionate examination of broader social concerns reveals that the main issue is really a concern with the loss of non-commodity outputs of agriculture. These tend to be green space based, visual and recreation issues in North America, while in Europe they are more oriented to changes in ecosystems that endanger species of wildlife that are brought about by the end of intensive land management.

These differences in concerns lead to clear spatial differences in the focus of farmland preservation. In Europe the effort to maintain farming focuses on the extensive margin in Less Favoured Areas where small farms generate low incomes. Supplemental payments are used to subsidize production in areas that are incapable of generating adequate rates of return, even given the broad direct support provided under CAP. Payments are structured to preserve low rates of output per hectare in order to maximize NCOs.

In North America, even though large amounts of land have been taken out of production and converted to non-agricultural use in areas where urban pressures are nonexistent, the focus is on urban conversion. The loss of land to expanding suburbs provides a common cause for those trying to limit population losses in urban centres and for those who want to maintain the agricultural use of the land. Similar to Europe the loss of land is driven by an inability of farming to generate sufficient income to justify its continued access to the land. While high levels of government support for agriculture have raised farm income in both Canada and the United States, the value of land close to cities in alternative uses greatly exceeds its value in agriculture.

Interestingly, in North America the loss of land to abandonment has been a more significant factor in reducing the stock of farmland, in terms of the amount of land lost, than it is in Europe. Major regions of North America that are far from urban growth centres have experienced large declines in the amount of land in farms. Governments, especially in the United States, have removed a vast amount of cropland from production through long term conservation contracts. Unlike in Europe, this conversion of farmland to "unproductive" uses is viewed favourably by the population.

Also of interest is the relatively minor visibility of urban conversion in Europe. Despite the fact that Europe is much more densely populated than Canada or the United States, the conversion of farmland to urban uses is not a major agricultural policy concern. Possible reasons for this are: the much stronger controls on urbanization processes in the countries of Europe that strictly limit the expansion of urban development, a much slower rate of growth in the urban population relative to North America, and cultural preferences for urban centre housing instead of ex-urban homes.

A final difference between Europe and North America reflects the much greater relative scarcity of farmland. Because the amount of farmland per capita in Europe is far less than in North America, there is a much stronger interest in managing multiple uses on specific parcels of land. In Europe, even though NCOs may be the most important output of a specific parcel of land, there is still a desire to preserve some commodity production. By contrast, in North America, where farmland is still abundant, it is much easier to assign specific parcels to single uses. Withdrawing land from production to allow it to specialize in producing wildlife habitat is a much easier choice if there is a large supply of farmland relative to the size of the population. As farmland becomes relatively scarce, as in the Nordic countries, the North-eastern states, or in British Columbia, there is much more public concern about any form of single use conversion.

What seems evident from the last few decades of observing agricultural policies is that traditional agricultural policy is of very limited value in dealing with land conversion at either margin. In the case of urban sprawl it is impossible to imagine high enough levels of income support that would keep land in farming, instead of alternative uses. At the extensive margin even current high levels of payments cannot provide a large enough income to convince younger people to take over the family farm. Yet, there is a clear public interest in seeing that some of the land in both instances remain in agriculture. An important country-point to this public interest is a fairly small concern with the actual level of commodity production that takes place on the land. In Europe the existing LFA payment structure is already designed to minimize the incentive for farmers to reduce the ecosystem benefits by increasing commodity output levels.

Importantly it is specific parcels of land that are of interest, which means that any policy response has to be spatially targeted to be effective. This means that policy instruments have to shift from commodity outputs, which are homogeneous, to particular parcels of land, which are heterogeneous. Parcels may be relatively large in some cases – regions, or may be specific parts of a farm in other cases. This creates a very different policy problem that is much harder to manage at a national level, because local negotiations are the main means by which plans for land management are developed and monitored. While national governments can set broad standards and monitor performance most of the implementation has to be done at a sub national level.

At the extensive margin farm land abandonment in Europe and North America reflects both technological change that has increased the productivity of 'better land" that is more suitable for mechanization and more intensive production. In Canada and the

United States this is most easily seen by major declines in the amount of land used for farming in both the Maritime provinces and the states of New England. These lands were among the first settled by Europeans and were farmed from early colonial times until the 1950s and 1960s when their limitations became overwhelming. A combination of an aging farm population, fragmented farms, poor soils and short growing season led to large scale abandonment. Most of the land returned to native forest. In Europe a similar process appears to be taking place. Most land that faces abandonment has been farmed for centuries, but under modern production conditions now has too limited productivity to be viable only as a producer of commodities. The key distinctions between Europe and North America in these adjustments are the relative shortage of farmland and cultural differences that favour a managed environment in the "old world" and wilderness in the "new world".

In OECD countries agricultural policy has continued to focus on the aggregate value of commodity output long past the point where this is the main concern of the general public. While support for farmers remains politically popular there is a growing sense that farm policy should require farmers to produce more of what the public wants in return for continued support. The introduction of multifunctionality as a concept for thinking about what agriculture produces and how it produces it is part of this process. As the role of NCOs becomes more prominent, the inevitable effect for all OECD countries is a shift in the form of agricultural policy to emphasize the way farmland is used, instead of simply the food and fibre it produces. This will also require policy to shift to a spatially targeted approach where specific parcels of land receive support to produce a particular mix of commodity and non-commodity outputs.

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Agricultural Multifunctionality and Village Viability: a Case Study from Japan[1]

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The discussion on multifunctionality has evolved since the publication of *Multifunctionality: Its Policy Implications* (OECD, 2003), which developed a framework for developing appropriate agricultural policies without distorting trade liberalisation. Nevertheless, problems with multifunctionality in agriculture persist; one of the more significant problems revolves around the extent that there exists jointness between farming activities and multifunctionality.

This presentation seeks to evaluate various agricultural activities in terms of jointness. It is based on a survey taken in a single village and, although a more in-depth study is certainly necessary, this approach does serve a purpose in that a certain reality of village life in Japan is portrayed. This presentation will give a general overview of the village (called *Shuuraku* in Japanese), which is named Q[2], with an explanation of where jointness appears. It will then analyse certain features of village life more closely.

The village community

General description

Japan is a long, narrow archipelago with many volcanic mountains. In the central parts of the country are relatively high mountains from which a large number of small rivers flow into the sea. Flat plains are found only as small areas of alluvial land or as terraces along these rivers. The mountains and rivers fold into each other, giving Japan a microtopographical landscape.

In terms of agricultural activity, this geographical characteristic in the temperate zone provides the ideal conditions for the development of small units of rice fields that benefit from a form of "gravity" irrigation system. In view of the available transportation facilities, the production of rice has developed along a collaborative farming system that is conducive to raising productivity.

1. This is an introductory paper explaining the reality of a Japanese village. A vast amount of literature on the theme of Japanese villages is available.
2. There are more than 140 000 rural villages in Japan. The average size is 20-100 houses. It is difficult to say whether the selected village is typical or not if the word “typical” is used in the statistical sense.

Before describing village Q, it is useful to explain two general characteristics of Japanese rural villages that are commonly observed in the case study. The first is the small and self-dependent irrigation system that is typical of the microtopographical situation of the country; the second general characteristic is a communal lifestyle based on mutual aid. Village Q is representative of both the agricultural activities undertaken in Japan and daily behavior of rural life.

Isolated irrigation system in the microtopographical situation

Japan is perhaps geographically small, but it is composed of many microtopographical varieties of land. As such, the development of small rural villages will depend on its location. Despite the modernisation of Japanese agriculture after World War II and the development of irrigation systems, small farm units remain the basic structure of Japanese villages. Indeed, to date, it has been difficult to merge small farms into larger units.[3]

Communal life of rural community

Historically, rural village populations have worked in a collaborative way to repair roads and waterways, to collect wood, weeding, etc. This traditional way of living is marked by seasonal farming events, in particular those relating to water management and planting. In addition, the group is homogenous in so far as their religious beliefs are concerned and group together at village shrines and temples. Although the basis of rural life has been mutual aid, competition (even if muted and not always fair) does exist.

Village Q

Village Q is located in the south-western part of Japan. Generally speaking, Japanese villages can be grouped into south-western and north-western areas of the country, but we will deal only with the former. In Village Q, interviews were conducted with several villagers.

The following table shows the surveyed attributes of all village residents according to their sex, age, farming activity, family matters, and farm land.

Village Q is located in a hilly and mountainous area, along a 15 m wide river which flows west to east, and from which irrigation water is pumped over half the area of a paddy field. The village area is less than 100 ha and about 90% is covered by forest. Total farmland is about 6 ha. The population at the time of the survey was 46, although decreasing. There were 17 family houses in the village, two of which were vacant. The owners have moved to large cities, and although they do not intend to return to the village, their farmland continues to be cultivated by the village farm leaders. The age distribution of the population is shown in Figure 1.

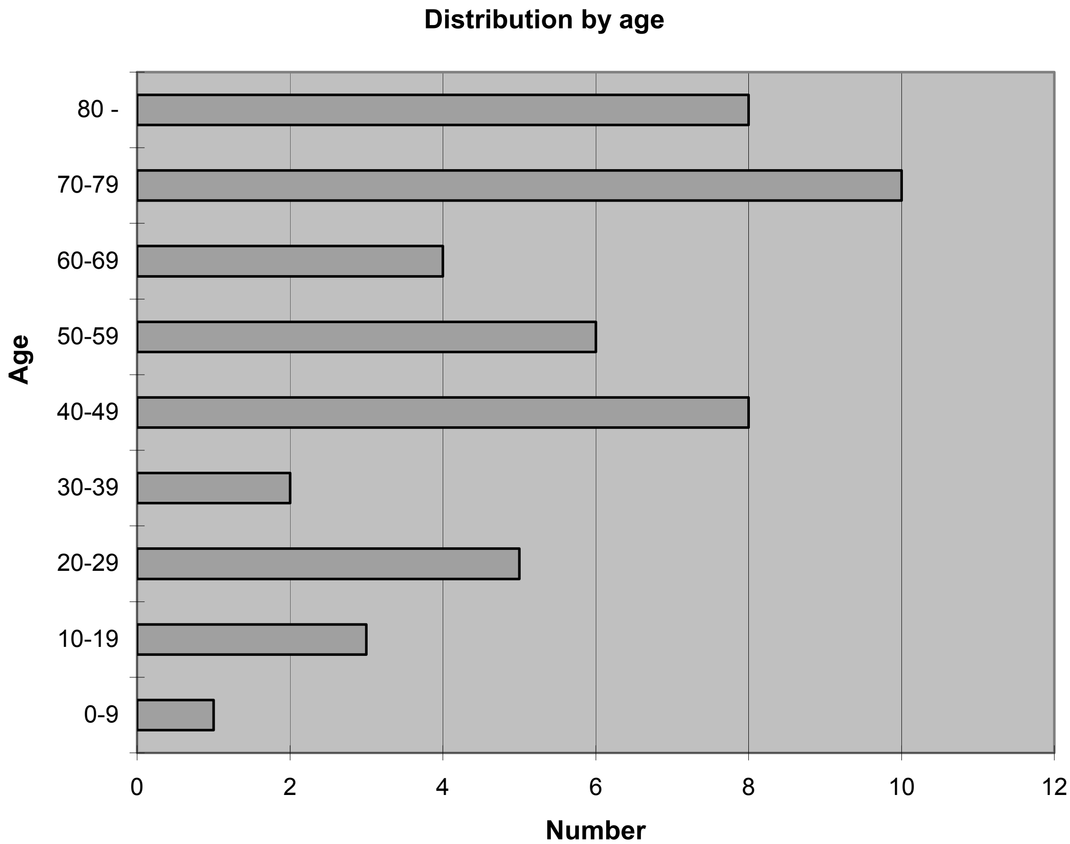
3. It is true that in many places in Japan, the modernization process has integrated small units of irrigation systems into a larger system, but the lower unit is often self-supporting. In case of Village Q, the integration process has not occurred.

Table 1. All households and members of Village Q (2006)

House-hold number	Name	Sex	Age	Occupation	Farming activity	Family situation	Farm land Paddy field
1	Na	F M F F	81 54 49 17	 Farmer Farmer Student	Tuna Contract farming 30ha (includes land located outside village)	23-year old daughter in Hiroshima and 22-year old son in Osaka	101 ares
2	Nb	M F M	80 81 46	Retired Construction	Land now belongs to Na		20 ares
3	Nc	M F M	65 65 29	Retired Retired Auto mechanic	Land now belongs to NA (last 30 years)	Daughter lives in Okayama	30 ares
4	Nd	F M F F	79 56 55 29	Wife of retired golf club employee	All land belongs to Na (last 4 years)		40 ares
5	Ne	M F	76 72		Sold their land five years ago (road construction)	Daughters live in Tokyo and Okayama	No farm land
6	Nf	M F M	54 50 25	 Hospital employee at golf club		Son at university	10 ares
7	Ng	F	86		All land to Na	59-year old son was due to return from Suita	35 ares
8	Ma	F M F M F	76 47 49 22 22	 Farmer Farmer Employee	Contract farming on 10 ha (for 6 neighbours) and part-contract farming on 20 ha employing 1 person (in next village)		50 ares

9	Mb	M F	78 75		Water management only; contract with Ma	Son (53 years) living in Yokohama; professional grass cutter (will return to village)	40 ares
10	Mc	M F M F	66 63 41 39	Farmer Employee Civil servant	Part-time farmer on own land		40 ares
11	Md	M F	94 93		All land now belongs to Na. Daughter's family do only planting	Two sons, neither of whom will return to village	45 ares
12	Me	M F M F M F	80 78 54 49 17 15	 Construction Employee Student Student	Part-time farming on own land		35 ares
13	Mf	M	76		Part-time farming on land located 100 km from his home	Son (55 years) lives with family in Kurashki. Returns to village on a regular basis, and will return definitively in 5 years.	30 ares
14	Mg	M F F	75 72 40	 Wife of the son	Sold 25 ares of paddy fields to neighbour of next village (only example of farming by an outsider of Village Q)	Son lives in Himeji City	No farm
15	A	F F	85 45	 Employee	All land to Ma (professionally active)		35 ares
Vacant 16	Va			Has lived in a retirement home last 10 years	All land to Na	Son (40 years) lives in Samama city	40 ares
Vacant 17					All land to Na	Uji city	40 ares

Figure 1. Age Distribution of Village Q



Farmland

The average farmland area is about 0.4 ha per household with one exception, a village farm leader who has 0.1 ha. Another leader owns only 0.5 ha, but he cultivates almost 30 ha by contract. Farmer n°10 is the only one farming by himself but he does reside in the village. Some families ask the farm leaders (No°1 and 8) to cultivate, plant and harvest their land. In general, although almost all units are farmhouses nominally, those who live there are not farmers in substance.

Irrigation system

There are two irrigation systems in village Q. The farmland on the north side of the river is irrigated by a pond, located in the nearby forest and owned by the village. Other farmland is located on the south side of the river, which is also the source of irrigation.

The irrigation system is maintained in a collaborative way by all the villagers. Waterways and roads in the village are also maintained in this way.

Daily life

The villagers have in common traditional religious belief. There are three small shrines located close to the residential areas and which are maintained by the local population. Today, as there are fewer farmers there are fewer opportunities for village people to meet. However, village events and annual rituals in the shrines have been maintained, and some people who work in the cities come back to the village in order to participate in these events.

The population, however, is ageing. Older villagers have difficulty moving about, whether it is to go to municipal offices or to do shopping. One of the leaders will collect on behalf of the older villagers their pensions and or buy miscellaneous items for their everyday use. Once again, we observe mutual aid amongst villagers.

Multifunctionality

Village Q is a typical rice-farming village and one finds various kinds of multifunctionality. Although the different facets of this multifunctionality have yet to be evaluated or fully identified, the above comments show that village viability is one of the key functions of agriculture.

The positive benefits from rice farming are not linked to the level of production, although negative multifunctions are linked. This is because the production system is linked to the community's social structure. Production facilities belong to all the farmers.

Evaluating jointness

Identifying the source of jointness

Only a few villagers are engaged in farming. Ownership of agricultural land, which can offer villagers the feeling of being a part of community life, is accompanied by the request or duty to participate in the collaborative work necessary to maintain the village. This includes the use and maintenance of the irrigation system and religious shrines, which is a source of jointness.

Exploring possibilities of de-linkage

Farming activities using irrigation systems are a source of multifunctionality. The system is independent and can easily be lost when farming ceases. "De-linkage" means changing the production system or the cultivation of new types of crops.

Possibility of other production system

Recently some programmes have been implemented to start the cultivation of forage rice. These programmes do not impose many changes in farming activities (at least physically). Rice is the best crop for the climate, temperature, and alluvial humid soil of the area. (Growing a crop best suited for an area is also a good way to maintain the environment.)

There is another option which involves the cultivation of crops requiring little or no management, *e.g.* forest or open land. In both cases, however, this would not produce any kind of multifunctionality in Village Q.

Identifying the spatial factors

The benefit can be site-specific, but many villages close to Village Q are in a similar situation. As a possible scenario, with a certain level of support, some villages could be sustained while others would disappear. Multifuntionality in Village Q would not be influenced by spatial factors.

Rural development aspect

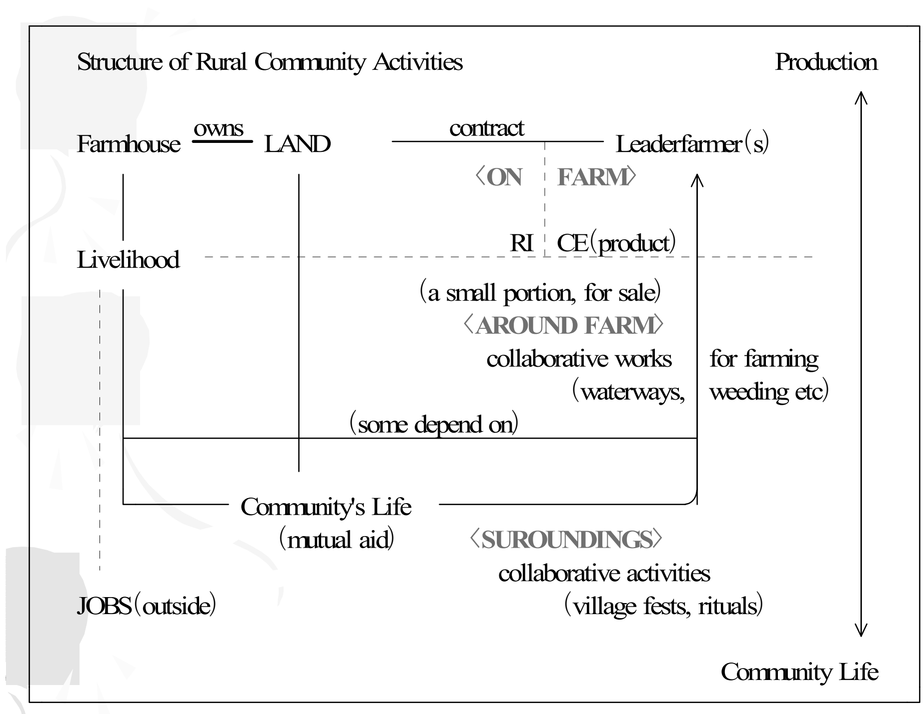
In Village Q, the farm leader enjoys inviting urban dwellers to his farm and exchanging views and opinions on their different lifestyles. However, to date this has not led to any kind of substantial profit.

Possibilities of policy-making for rural Japan

The policies related to multifunctionality in Japan are necessarily linked to the framework of maintaining agriculture, production and community life. In Village Q, maintaining multifunctionality necessarily entails maintaining rice farming, which in turn is essential to maintaining the community.

In terms of jointness, three activities in a community can be classified as shown in Figure 2. The essential point is that activities of the surrounding areas are very important in order to support the other two activities. However, the linkage is not so direct as compared to the other two.

Figure 2. Social Structure of Village Q



Landscape as an expression of ecological system

Jointness is a key concept that makes us think of how agricultural activities are related to multifunctionality. It teaches us the nature of multifuntionality and how it benefits us. Landscape in rural areas usually becomes an essential feature of the local area's nature. This is true especially in a region that uses water as an indispensable factor for production. In Japan, where there is much precipitation, steep mountains, and high density, the landscape must be shaped to fit the ecological system of the area it is located in.

There are many types of multifunctionality. Among them landscape is at the center of the issues of how important they are. Evaluating landscape is difficult, in general because it is closely linked to the culture of a region and of a nation.

Landscape is sometimes useful as a source to revitalize a local economy by attracting visitors from outside. In this case, the evaluation is based on the market price of a certain type of tourism. This is one of the successful attempts to evaluate the environment. A more realistic evaluation is based, however, on the sum of all individual demands. Some countries insist that landscape is important in the case of tourism, but this is usually based on individual demand rather than on collective demand. There could be other types of evaluation methods, around which there is a familiar and traditional controversy.

In addition, we must think about water-use type of agriculture. This is a special Asian feature. Productivity and efficiency are the universal standards today, but each region has a unique type of agriculture fostered by a long history, and which could be best suited to regional ecological conditions. There will be many changes in agricultural activities, but the basic relationship between ecological situations on site and agricultural activities will be the last thing to change.

Conclusion

Jointness is a key concept in the development of appropriate policy-making, especially in countries such as Japan which has many small-scale farmers working in geographically and ecologically complicated land situations. In Japan, a unit community （called *Shuuraku*） also represents a unit of everyday life. Therefore, the concept of agricultural activities in Japan cannot be disassociated from activities of everyday community life. Indeed, agricultural activities cannot be understood as pure units of production. Each unit of production, *Shuuralku*, requires a small irrigation system adjusted to the ecological conditions of its surrounding area and must be managed by the people living in that area.

Rural life in Japan is changing and many residents of rural communities live in difficult conditions. The population of rural communities continues to decrease and it is becoming more difficult to maintain agricultural activities. This has the result of also making it extremely difficult to maintain everyday life in the rural community.

Evaluation of Jointness Between Agriculture and Rural Development

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Since 1990, the term multifunctionality has served to define those public services provided by agriculture which arise as by-products of the production of marketable goods. According to Mann and Mack (2004), the term multifunctionality stands for the various tasks of agriculture which, in turn, can be derived from the targets set down in the Swiss Federal Constitution. The most important services of Swiss agriculture are (Federal Constitution, Article 104):

- to ensure food supply for the population;
- the conservation of natural habitats and maintenance of cultivated landscape; and
- decentralised population settlement of the country.

In association with these functions, agriculture provides other multifunctional services, such as the enhancement of the quality of life by means of natural and sustainable production, the maintenance of agriculture's socio-cultural contribution and the upkeep of traditions.

The concept of multifunctionality is internationally acknowledged in that it forms the basis for government support for agriculture. In 2001, the OECD published a study dealing with the concept of multifunctionality within the scope of a theoretical analysis (OECD, 2001) and derived conclusions for the development of policy measures (OECD, 2003). The purpose of the discussion concerning multifunctionality is to identify the most efficient measures to achieve policy targets. The degree of jointness between the production of goods (commodity output) and multifunctional services (non-commodity output) is one of the key values for the determination of suitable policy measures. The concept of economies of scope is used to translate the degree of jointness into an indicator. Economies of scope exist between the production of goods and multifunctional services if the by-production exhibits cost advantages when compared to an alternative form of provision de-linked from agricultural production. In this case, it is efficient to support agriculture to secure multifunctional services linked to agricultural production.

The evaluation of jointness between the production of goods and multifunctional services is based on the examination of three questions (OECD, 2005):

- Identification of the sources of jointness between the production of goods (commodity output) and multifunctional services (non-commodity output).

- Investigation of the possibilities to de-link the production of goods from the provision of multifunctional services and, on this basis, the estimated costs of de-linked provision of the commodity and non-commodity outputs.
- Identifying the spatial provision and distribution of the multifunctional services.

This paper evaluates the degree of jointness between agriculture and rural development in the Swiss mountain areas. The reason for this geographic limitation is that the role played by agriculture in rural development and decentralised settlement is far more important in mountainous regions (Rieder *et al*., 2004). This paper is divided into five sections. The first contains a description of agriculture's multifunctional services in mountain areas. This is followed by a theoretical analysis of agriculture's contribution to rural development. The methodological procedure for the evaluation of jointness and the case study regions are presented in the third section, while the fourth section contains the results of the evaluation. In the concluding section, these results are then used to analyse the significance of agriculture for rural development.

Multifunctional services of agriculture in mountainous areas

Among the multifunctional services of agriculture as defined in the Swiss Federal Constitution, the conservation of habitats, the maintenance of cultivated landscape, and the contribution to rural development and decentralised settlement are of primary importance in mountain regions. The necessity to assure food supply is of secondary importance given that the share of production is low in relation to the surface utilised.

There are two key aspects to the conservation and maintenance of cultivated landscape; namely, land is kept open and existing landscapes are conserved. Hereby, land-use and agricultural structures form a bond between agriculture and cultivated landscape. Land-use contributes to the conservation of cultivated landscape by means of the utilisation of the fixed factor land in agricultural production. The utilisation of the non-allocable fixed input factor land does not generate any rivalry between the two outputs: agricultural products and cultivated landscape. The use of an area for agricultural purposes inevitably generates a contribution to landscape conservation and maintenance since the area in question is kept open; the land factor cannot be clearly assigned to either landscape maintenance or agricultural production (non-allocable input). Furthermore, different variable, non-allocable input factors lead to landscape elements which determine structure and landscape diversity.

In contrast to the land-related aspects of land-use and landscape maintenance, the socio-economic aspects of employment and added value together with the (economic) viability of the rural zone are of greatest importance in the contribution to rural development (Hediger, 2004). In mountain areas, agriculture's contribution to rural development is more closely linked to agricultural structures, land-use and land-use intensity with regard to labour than it is to the production of goods. The use of the non-allocable factor labour is the source of jointness between agriculture and rural development.

In area-related production, the use of labour and land contributes simultaneously to the production of goods, overall cultivation and rural development. Labour is primarily an input in agricultural production. Therefore, agriculture's contribution to employment in rural areas cannot be characterised as a positive externality (OECD, 2001). This applies especially to regions in which settlement is ensured regardless of agriculture or where society does not view a possible depopulation unfavourably. The preservation of rural culture or agriculture's socio-cultural contribution in rural areas, however, has the nature of a multifunctional service which cannot be de-linked from agricultural production.

Agriculture's contribution to rural development in mountain areas

Taken together, the farms within a region can be interpreted as a branch of the regional economy. Several aspects must be given due consideration in order to assess the importance of agriculture as a branch of both the regional economy and of rural development. These are related not only to agriculture, but to the overall regional economy. There are four main characteristics which are interrelated (Buchli *et al.*, 2006):

- Branch structure with the size of the individual branches.
- Demand structure of the branches, whereby the share of exported products and services is of central importance.
- Consumer and input structure, which is determined by added value strength, wage shares of the branch, and the share of advance payments and capital goods which are obtained within the region.
- The size of the region.

The branch structure indicates how strongly which branches are represented within a region. The higher the share of employees working in a branch in relation to the total regional workforce, the greater the direct economic contribution generated by that branch. Consequently, the direct employment effect of agriculture varies considerably, both locally and regionally. For example, while the effect is very strong in small agricultural communities, it slacks off when other communities or whole regions are also taken into account.

Normally, the size of a branch depends on regional demand and export demand, and thus on the demand structure. However, agriculture is a branch which is subject to site limitations and therefore size is mainly the result of the area utilised, the natural yield potential, agricultural structures, and the labour intensity of production. The absolute size of agriculture as a branch within a region is the result of internal and external demand for products and public services provided by agriculture.

The economic relationship between agriculture and other branches depends on how the consumer and the input sides of agriculture as a branch are structured. On the consumer side, this is related to agricultural income and the wages paid within the region. The more diversified the economy and the wider the consumer supply in a region, the greater the effects generated by income and wages. In this case, a larger share of consumer expenditure can take place locally, which increases the induced economic effect. In addition to consumer expenditure generated by families, purchases of inputs from other economic sectors are also significant. These expenditures generate indirect economic effects in a region, in so far as they are (can be) carried out. In a small area, these effects are not significant as it is unlikely that advance payments can be obtained locally. On a regional level, with more widely diversified branch structures, the indirect employment effect increases because a lower share of the advance payments and capital goods must be imported. Consequently, size and branch structures within a region influence the magnitude of the indirect and induced effects and thus, in turn, the branch structure.

In addition to the direct, indirect and induced effects, agriculture also influences rural development via so-called catalytic effects. These are not directly related to agriculture, but to the influence of agricultural activities on other branches of the economy and society. For example, tourism generates added value through guests who spend their holidays in regions with well-maintained cultivated landscape.

Method for evaluating jointness

Three scenarios, for which the employment and added value effects of agriculture are estimated, serve as the basis for evaluating jointness between agriculture and rural development:

- S*cenario 1*: Agriculture 2002.
- *Scenario 2*: Agriculture at world market prices.
- *Scenario* 3: Agriculture at world market prices with area payments which ensure overall cultivation of productive land.

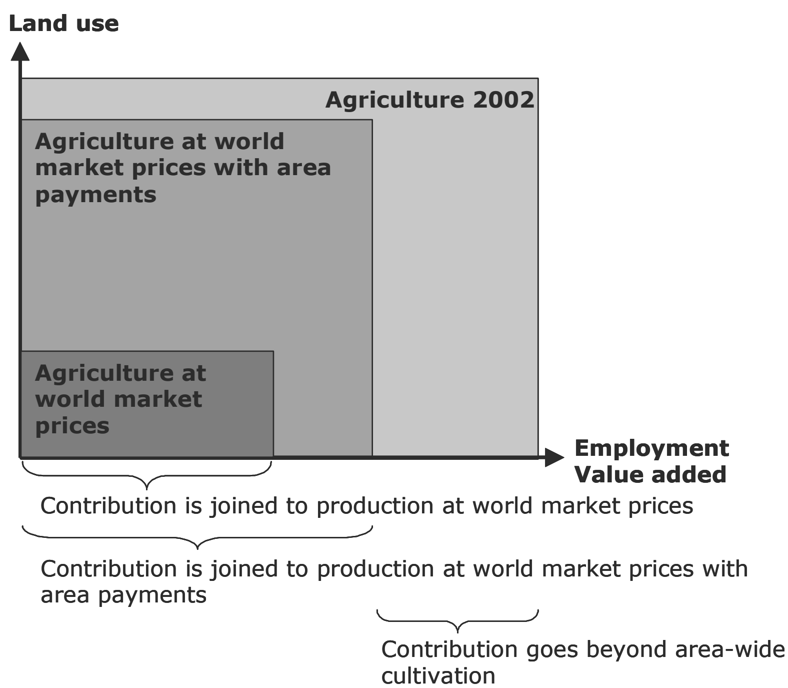
The assessment of the importance of agriculture for the regional economy under current conditions (Scenario 1) is carried out in three stages:

- Assessment of regional accounts concerning agricultural structure data and farms carried out by a central bookkeeping analysis. The direct employment and added value effects of agriculture can be quantified on the basis of the structure data and regional bookkeeping.
- Registering the origin of advance payments and capital goods as well as regional assignment of consumer expenditure of agriculture. The records of input and consumer structures form the basis on which the cost-side relationships between agriculture and the rest of the economy can be quantified. The indirect employment and added value effects of agriculture result from the branch-specific assignment of consumer expenditure, advance payments and capital goods.
- The economic importance of agriculture is determined by comparing its direct, indirect and induced employment and added value effects with the total employment and added value.

In the scenarios with world market conditions (Scenarios 2 and 3), the regional economic importance of agriculture is estimated on the basis of model calculations. The calculations are carried out using SULAPS, the agricultural structure and land-use model developed at *Agroscope Reckenholz-Tänikon ART* (Meier *et al*., 2006), which covers the Albula case study region. This is an agent-based land-use model which is composed of single-farm linear optimisation models. The farms are linked together in the model by means of an area mobility module. The farm models represent the farms in the region, whereby real resource availability, infrastructures, education and some non-economic targets of the farm managers are integrated directly into the calculations. The results concerning agricultural structures in the Albula model region are applied to the three other case study regions.

The comparison between agriculture today (Scenario 1) and agriculture in the scenario with world market prices and area payments (Scenario 3) permits the evaluation of jointness regarding employment and added value. The comparison is limited to the employment and added value effects which are not linked with the maintenance of a cultivated landscape. In this case, the factor labour is no longer linked to the multifunctional service of keeping land open. The procedure is explained in Figure 1.

Figure 1. Procedure for the evaluation of jointness between agriculture and rural development



- In Scenario 1, “Agriculture 2002,” the farms work a certain area and their economic activities represent a contribution to regional employment and added value. The costs of support are the sum of product support and direct payments.
- In Scenario 2, under world market conditions, the area utilised and employment are noticeably lower; the conservation and maintenance of the cultivated landscape utilised as well as the contribution to rural development are by-products of the production of commodities without support for agriculture.
- Based on the scenario with world market prices, additional area payments granted to ensure overall cultivation in Scenario 3 result in a relatively higher contribution to employment. The entire area is cultivated. In this scenario, the support required corresponds to the costs of the area payments; however, these cannot be divided between the two multifunctional targets.
- The direct comparison between the Scenario “Agriculture 2002” and Scenario 3 with world market prices and area payments reveals a difference in employment and added value and therefore in the contribution to rural development. On the other

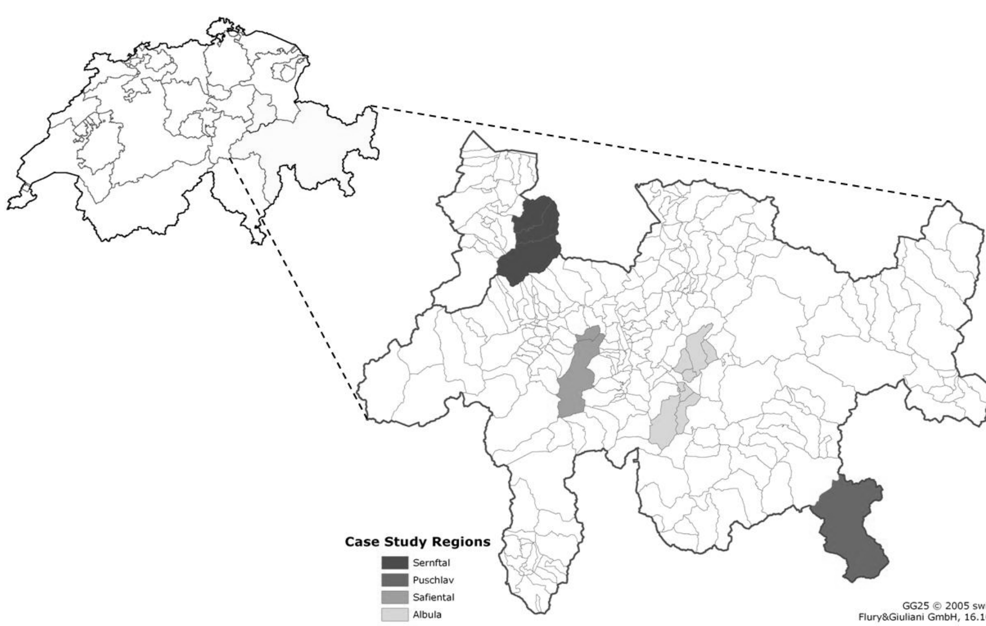
hand, land-use remains identical. This means that the difference in support corresponds to the difference in agriculture's contribution to rural development.

When interpreting the results, it must be borne in mind that the evaluation of jointness here is implicitly subject to a hierarchical target system for agriculture, whereby the target of overall cultivation has precedence over the target of rural development. At the same time, other services such as the conservation of natural, structured cultivated landscape are not taken into account, as only overall cultivation is specified for the comparison.

As already stated, the evaluation of jointness is carried out for four Swiss mountain regions. The case study regions Sernftal, Puschlav, Safiental and Albula are in eastern Switzerland in the Cantons Grisons and Glarus. The regions differ not only in size but, in particular, in their economic structures:

- The Sernftal region consists of the two rural communities Engi and Matt, with a strong manufacturing and industry sector as well as the tourist community Elm.
- The Puschlav region consists of the two communities Poschiavo and Brusio, whereby Poschiavo is regarded as a tourist community without taking its peripheral location into account. Brusio is regarded as an agrarian community due to the agricultural production of some farms just across the national border.
- The Safiental region consists of the agrarian communities Safien and Tenna.
- Die Albula region consists of two partial areas: the rural community Alvaneu with a strong manufacturing and industry sector, the agrarian residential community Brienz and the residential communities Schmitten and Surava with manufacturing and industry sector are located in the Belfort area. The Surses area consists of the tourist community Savognin together with the two residential communities with service sectors, Cunter and Riom-Parsonz.

Figure 2. Case study regions



Agriculture's contribution to rural development

The evaluation of jointness between agriculture and rural development focuses on employment and added value. In the four regions under investigation, the direct, indirect and induced employment and added value generated by agriculture are compared with that pertaining to the rest of the region's economy. The multiplier effect of agriculture in the fields of employment and added value is derived from the relationship between the direct effect with the indirect and induced effects.

As expected, agriculture contributes strongly to employment and added value most noticeably in regions with a marked agrarian nature. Due to the fact that the added value generated by agriculture is lower in comparison to other branches, the share of employees is higher than the share in added value. The direct employment and added value effect of agriculture depends primarily on the area utilised, yield potential, farm structures and labour intensity. Given comparable area utilisation, the direct employment effect of agriculture is higher in regions with small farm structures and/or labour-intensive agriculture than in regions where large and labour-extensive farms are predominant.

The regional multiplier effect results, on the one hand, from the size of agriculture as a branch and, on the other hand, from the regional grants for agriculture. Opportunities to obtain advance payments, capital goods and consumer goods locally are limited in regions with a high share of agricultural employees. Consequently, the indirect and induced multiplier effect is comparatively low in these regions. In larger regions, however, there is a much stronger economic relationship between agriculture and the more widely diversified economic structure in these regions and this leads to a higher multiplier effect. In the four case study regions, the regional multiplier effects for employment lie between 1.13 and 1.23 while the multipliers for added value are between 1.21 and 1.52. The difference between the employment and added value multipliers can be explained by the fact that agricultural advance payments and capital goods are obtained from branches with a higher added value per employee. The difference in added value per employee is also revealed by the share held by agriculture in the region's overall employment and total added value. On the whole, the share of employees dependent upon agriculture fluctuates between 14% and 72%. The shares in added value vary between 7% and 49%.

The scenarios with world market prices exhibit noticeable changes in agricultural structures. In the scenario for agriculture at world market prices without any agricultural support, land-use would decline by about 70% compared to today and livestock numbers would go down by 60%. The numbers of the workforce employed in agriculture is roughly 55% lower than under current conditions. The added value generated by agriculture also sinks significantly as a result of the clearly limited agricultural activities and the discontinuation of agricultural support.

Table 1. Structures and importance of agriculture for regional economy in the case study regions 2002

	Sernftal	Puschlav	Safiental	Albula
Structure of agriculture				
Number of farms	88	122	49	73
Agricultural land (in ha)	1279	1750	970	1355
Productive area per labour unit (ha)	8.1	7.6	11.6	12.2
Employment effect				
Employment effect of agriculture	157	231	84	111
Multiplier — regional	1.17	1.23	1.13	1.22
Total employment effect of agriculture	183	284	95	136
Share of total agricultural employment effect in overall employment	28%	14%	72%	16%
Added value effect				
Added value effect of agriculture (in CHF million)	5.0	8.5	3.9	5.2
Multiplier — regional	1.42	1.52	1.21	1.37
Total added value effect of agriculture (in CHF million)	7.0	12.9	4.7	7.2
Share of total agricultural added value effect in overall added value	14%	7%	49%	12%

In the scenario for agriculture at world market prices with area payments, general area payments serve to remunerate agriculture for keeping land open. This is due to the fact that when it comes to keeping landscape open, agricultural suppliers are regarded as the most favourably priced alternative. In particular, since alternative methods of biomass disposal are extremely costly (Huber, 2006), the only realistic way of utilising the biomass resulting from mowing or from meadows is in the livestock sector. The granting of general area payments which ensure the cultivation of 95% of the productive land leads to noticeably higher numbers of animals as well as higher added value for agriculture. In addition, the workforce is also higher than in the scenario in which agriculture receives no support. In accordance with the specified target, 95% of the productive land is utilised. Given the specific structural and topographic basic conditions in the Albula region, an area payment of CHF 2 200 per hectare is required to achieve this target. It is assumed that this sum is also sufficient to keep the landscape open in the other regions as well. Depending on the region, the overall direct payments granted sink by 30% to 40% compared with today's situation.

Table 2. Agricultural structures in the case study regions under world market conditions

	Sernftal	Puschlav	Safiental	Albula
Agriculture at world market prices				
Agricultural land (in ha)	357	508	262	431
Change compared to 2002	-71%	-70%	-73%	-68%
Numbers of animals (in LUs)	521	676	300	605
Change compared to 2002	-59%	-58%	-61%	-54%
Agricultural workforce (in full-time equivalent)	70	103	37	50
Change compared to 2002	-55%	-55%	-55%	-55%
Direct payments (in Mio. CHF)	-	-	-	-
Change compared to 2002	-100%	-100%	-100%	-100%
Added value from agriculture (in Mio. CHF)	0.4	0.9	0.2	0.4
Change compared to 2002	-92%	-89%	-95%	-92%
Agriculture at world market prices with area payments				
Agricultural land (in ha)	1219	1667	926	1292
Change compared to 2002	-5%	-5%	-5%	-5%
Numbers of animals (in LUs)	930	1189	562	978
Change compared to 2002	-26%	-26%	-27%	-25%
Agricultural workforce (in full-time equivalent)	113	166	61	80
Change compared to 2002	-28%	-28%	-28%	-28%
Direct payments (in Mio. CHF)	2.7	3.7	2.0	2.8
Change compared to 2002	-31%	-35%	-39%	-30%
Added value from agriculture (in Mio. CHF)	2.8	4.1	2.1	3.1
Change compared to 2002	-46%	-52%	-46%	-40%

Source: The figures are based on the model calculation of Meier *et al*. (2006).

Given a comparable area utilisation, the comparison of the scenarios agriculture 2002 and agriculture at world market prices with area payments results in a difference in the numbers of employees and added value for agriculture. This difference corresponds to the differing costs of agricultural support in the two scenarios. Consequently, the direct comparison allows a quantitative estimation of the costs of agricultural employment and added value effects which are not linked with the maintenance of a cultivated landscape.

Table 3. Importance of agriculture in regional economy and the costs of employment and added value effects

	Sernftal	Puschlav	Safiental	Albula
Agriculture 2002				
Total workforce in agriculture	183	284	95	136
Total added value from agriculture (in Mio. CHF)	7.0	12.9	4.7	7.2
Agriculture at world market prices with area payments				
Total workforce in agriculture	129	198	66	97
Total added value from agriculture (in Mio. CHF)	4.2	6.8	2.5	4.4
Comparison of agriculture today with agriculture at world market prices with area payment*s*				
Total difference in support [1] (in Mio. CHF)	1.9	3.2	1.6	1.8
Difference in employment (in Mio. CHF)	54	86	29	39
Difference in added value (in Mio. CHF)	2.8	6.1	2.2	2.8
Support per workforce (in CHF)	35 200	37 200	55 200	46 100
Support per CHF of added value (in CHF)	0.68	0.52	0.73	0.64

1. The difference in support is calculated from the general direct payments and today's product support minus the direct payments in the scenario agriculture at world market prices with area payments to ensure overall land-use.

The employment effect of agriculture which overshoots the target of overall land-use generates costs amounting to CHF 35 000 to CHF 55 000 per employee via product-related support and general direct payments. In the case of added value which is dependent on agriculture, the costs lie between CHF 0.52 and CHF 0.73 per franc of added value. The costs of the employment and added value effects are particularly high in the agrarian region Safiental. This is due to the lower added value of agriculture and, therefore, the low added value multiplier. The extensive production with relatively high direct payments influences the costs per employee. In comparison, the costs of support for agricultural employment and added value are roughly 30% lower in the Puschlav region. The decisive factor here is the stronger link-up between agriculture and the rest of the economy which generates higher employment and added value effects in other branches of the economy. This results in lower support per employee or per franc of added value.

For the evaluation of jointness, the costs of employment in agriculture must be compared with those arising from the creation of alternative employment opportunities. Based on the evaluation studies available, the costs of creating jobs outside agriculture are probably somewhere between approximately CHF 15 000 to CHF 30 000 per job (Flury *et al.*, 2006). When interpreting these cost estimates, it must be borne in mind that the studies used relate to projects which have actually been done and which were financed by public funding and by private means of the supported company. In addition, regardless of the effective costs, the question arises concerning the extent to which jobs outside of agriculture can in fact be created and maintained on a long-term basis in rural or mountain regions. This aspect is important since, in addition to financial factors such as government support or the level of taxation and other levies, further location factors are relevant for the establishment of companies and, it follows, for the creation of jobs (Jäger, 2004).

Regardless of the question of whether or not an effective possibility for the creation of jobs outside of agriculture does in fact exist, the direct comparison of the costs within agriculture with the estimated cost of creating alternative employment opportunities shows that agricultural support designed to ensure employment and added value is not efficient. However, based on the limitations discussed above, this statement only applies to those forms of employment which are not linked to overall cultivation.

Conclusions

The evaluation of jointness shows that it would be possible to de-link that part of agriculture's contribution to rural development which is not coupled to land-use. Compared to the costs of alternative employment opportunities, it can be seen that agricultural support — provided that it would be possible to create jobs outside of agriculture — is not efficient in many regions in the mountain area. The costs of creating alternative employment opportunities are likely to be lower. On the other hand, it must be stated that under the current basic conditions it is hardly possible to create jobs in the manufacturing and industry sector and in the services sectors in those regions which today still have an agrarian character. Therefore, an alternative source can only be achieved with high payments since the cost of creating and maintaining jobs outside of agriculture exceeds the added value which can be achieved. Employment and added value linked to agricultural production is an efficient way of ensuring rural development (strong degree of jointness) in regions where the creation of jobs outside of agriculture is impossible. In (larger) regions with a diversified economy or regions with a tourist industry, however, it should be possible to create alternative jobs outside of agriculture at a lower cost than within agriculture (weak degree of jointness). It follows that support for employment in agriculture over and above the target of overall cultivation is not efficient in regions of this kind.

The cost of ensuring rural development and settlement is not the only decisive factor when defining policy measures. The demands of society must also be taken into account. The inclusion of society's demands addresses the question of market malfunction related to multifunctional services. In regions with a tourist industry, the public does indeed demand that areas should be kept open and that cultivated landscape should be maintained. In regions of this kind, agriculture only plays a marginal role in rural development; the contribution to employment and added value which is not related to land-use can be obtained at a lower cost outside of agriculture. Nevertheless, agriculture's contribution to rural development is comparatively large in agrarian regions. Under the assumption that settlement and land-use are to be maintained, agriculture is an efficient way of ensuring rural development. On the other hand, a decline in agricultural employment and productive land allowed to lie fallow in mountain areas cannot be interpreted as a market malfunction *per se*. The latter is confirmed by the fact that in recent times the question has been frequently raised concerning an orderly discontinuation of utilisation and settlement in regions of this kind.

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To What Extent are Environmental Externalities a Joint Product of Agriculture? Overview and Policy Implications

by
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Jointness is a key attribute of multifunctionality. The first discussion of jointness in this context has been attributed by Nowicki (2004) to Harvey and Whitby (1988) who raise "the possibility of symbiosis between agriculture and the environment and the possibility of joint production of both environmental goods and services". However, as Nowicki comments "the relationship between the economic benefit and environmental good in the structure of joint production is not simple". It is defined more formally by the OECD (2001) in terms of situations where a firm produces two or more outputs that are interlinked so that an increase or decrease in the supply of one output affects the levels of the others. To be of policy relevance, one or more of the outputs must be a non-commodity output with some element of publicness. This report concentrates on situations where commodity outputs are potentially produced jointly with positive environmental or countryside goods.

There continues to be a substantial literature on multifunctionality. This often defines the subject from a wider perspective than that adopted by the OECD (Potter, 2004). Thus, for instance, a report on the European Framework 5 Multagri project commented that determining what exactly multifunctional agriculture was represented a major challenge; "there are almost as many definitions as groups interested in the subject". The project did not aim to find "a consensus on an ultimate, 'best' definition that would fit all countries and streams of thought, or to decide what is good or not". Rather they accepted a wide range of definitions. A similar variety is reflected by the range of papers presented at the 90th European Association of Agricultural Economists Seminar on Multifunctional Agriculture, polices and markets, which took place in Rennes, France (Mahé, 2004). These covered most aspects of externalities associated with agricultural land uses and the policy responses. The breadth of the approaches being proposed is suggested for example by Holmes (2006) who extends the concept of multifunctionality to encompass all modes of broadscale rural resource use, not limited as an attribute of agricultural use.

This paper keeps closer to the principles set out in the OECD approach. The objective is to explore the more practical implications of multifunctionality, exploring the specific characteristics of particular environmental non-commodity outputs associated with agricultural production and the particular ways in which they are generated through agricultural activities. This considers the types of policy mechanisms that may be used in order to promote the provision of non-commodity outputs in more specific contexts. In taking this approach we do not consider the wider institutional and social issues surrounding policy instruments relating to multifunctionality, such as Vandermeulen *et al*. (2006) on the influence of regional and local policies, or Wilson (2004) on *Landcare*. However, before this, it is helpful to set out a conceptual framework for the later discussion.

The characteristics of joint production

There are three reasons for jointness identified by OECD (2001). See also Blandford and Boisvert (2005):

- *Technical interdependencies in the production process*: Technical or biological linkages inherent in the production process – changes in the level of one output influences the supply of the other output without any change in the input allocation to these outputs. Marginal productivities of the inputs used in the production of one output depend on how much is produced of the other outputs.

- *Outputs are produced from a non-allocable input*: Non-allocable inputs occur where multiple outputs are obtained from one and the same input. Specific farming systems may be seen as combining production of a given commodity with a particular type of landscape. Technical interdependencies and non-allocable inputs are closely related. OECD (2001) comments that 'Some authors regard non-allocable inputs as a facet of technical interdependencies'.

- *Outputs compete for an allocable input that is fixed at the firm level*: Allocable fixed inputs – available to a firm in a fixed amount and which are allocated to various outputs in the production process. Thus a change in the production of one output changes the amount of the fixed factor available for the supply of the others and so the marginal productivities of the variable inputs used in the production of the other outputs also change, creating linkage among the outputs.

An alternative perspective concentrates on the costs, so that jointness can be a cause of economies in production, especially economies of scope where costs of production decline where more two or more outputs are produced together by the same firm. In this context, the implication is that one of the outputs represents a non-commodity output. But the context may be extended to include production within a single household or collective arrangement across several farms. Hagedorn (2004) refers to this as "institutional jointness."

It is recognised by the OECD that the classification may be seen as a useful pedagogical device that does not always correspond to the complexities of practical situations. In this paper we concentrate on two contexts:

- where production of the commodity and non-commodity are technically related, such that they cannot be produced independently, such as grazing and a grazing landscape, even though they may be produced in different proportions, or

- where there is potential separation but where there may be economies of scope. This will generally be because the firm, household or collective has access to particular inputs that tend to reduce the (opportunity) costs of producing the joint non-commodity output as compared to its being produced by a separate firm.

Characterising jointness in practice

Abler (2001) has provided a synthesis of country reports on jointness in OECD countries. There have been several pieces of work since 2001 that have involved empirical models of jointness and multifunctionality at the farm scale. Brunstad *et al*. (2005) model multifunctional agriculture in terms of its provision of public goods of food security and landscape. They focus on the amenity value of landscape that is derived from an open and varied landscape, sustained by agricultural production. Thus, while it is recognised that in practice it is not possible to model all the attributes that enhance the value of the agricultural landscape, such as openness, variation, biodiversity and type of agricultural technique, the non-commodity benefit is assumed to increase with an increased area under tillage, although marginal willingness to pay decreases as the area increases. They conclude that in the absence of policy towards non-commodity outputs, the level of agricultural production would be sub-optimal, although judge that in practice the level of subsidy offered in Norway exceeds the level required to optimise output levels.

In contrast, Lankoski and Ollikainen (2003) develop a model of land use at a more local level, with heterogeneous land qualities. They account for three agri-environmental externalities, biodiversity, landscape diversity and nutrient run-off. In the model, biodiversity is enhanced through the extension of field boundaries by means of buffer strips, the aesthetic value of landscape if provided through the diversity of land uses and nutrient run-off depends on both fertiliser use and buffer strips. Thus, non-commodity benefits are attained through a diversity of cropping pattern rather than simply an expansion and by means of buffer strips that reduce the area of land under production. Their preferred policy instruments are a fertiliser tax and a buffer strip subsidy and these have the effect of reducing total production. They note that in their model, price support would create no incentives for the establishment of buffer strips and so would fail to promote biodiversity, although they did not rule out the possibility of its use in combination with other instruments, perhaps where it made it possible to reduce transactions costs. The complexity of adjustments required is recognised by Miettinen and Huhtala (2004) who model the relationship between cereal production and the numbers of grey partridges. They show that farmers should increase the area under rye, reduce the use of herbicides and limit the partridge hunting bag in recognition of the social benefits associated with partridge conservation, but that this reduces the private returns to farming.

Work has also been undertaken on jointness in grassland systems. Peerlings and Polman (2004) investigate joint production of milk and wildlife and landscape services in Dutch dairy farming using a micro-econometric profit model. In the model, the output of wildlife and landscape service is measured in terms of the revenue received from government and nature organisations for participation on agri-environment schemes. They find that wildlife and landscape services are a substitute for milk and other outputs, that is to say that producing more milk makes the production of wildlife and landscape services less attractive. They also conclude that economies of scope exist on only a small proportion of farms. However, they do note that in practice farms do not specialise suggesting that there may be other factors that are not taken into account in the model.

Havlik *et al*. (2005) consider both complementarity and competition between agricultural production and environmental goods. They include two types of jointness. They note that with regard to grassland biodiversity, agricultural production and environmental goods can be complementary over a certain range but compete beyond this range. Evidence indicates that this is the case for pasture stocking intensity in the Pyrenees. In this case they argue that the non-allocable input is the cattle herd. They analyse the position in two different Environmentally Sensitive Areas, one in which there is a danger that over-intensification will damage fragile biotopes and the other where the threat to environmental values is associated with the risk of land abandonment. In the former case, agri-environmental policy consists mainly of restrictions on fertilisers use and stocking rates. In the latter case an agri-environment scheme sets out a minimum animal density and demands the rehabilitation of degraded grassland. There are no payments for biodiversity production and the provision of environmental goods is modelled by introducing constraints into a mathematical programming model that represent the requirements of particular agri-environmental contracts. They assume that keeping to the conditions set out in the contracts will generate the specified environmental goods. This is clearly an assumption that needs to be assessed. Kleijn and Sutherland (2003) have reviewed the available evidence on European schemes and conclude that, while just over half of the studies find an increase in species richness or abundance, research design was often inadequate to provide reliable results so that they could not reach a general judgement on the effectiveness on agri-environment schemes. They did not assess potential benefits other than biodiversity, such as reduced emissions or landscape gains. Based on their model, Havlik *et al.* conclude that there is little justification for commodity-linked instruments, noting that both types of jointness, complementary and competing, were observed even within a relatively small region, such that prices increases would generate a loss of biodiversity in some contexts.

These models generally produced the anticipated results. On the whole the models do not include direct measures of non-commodity production. It is generally assumed to arise from either general or particular land uses or from following agri-environmental agreement requirements. In one case, indices were included relating to land diversity or biodiversity. In some cases it is assumed that non-commodity production is promoted by increasing levels of agricultural output, while in others it is secured by reducing production intensity. Whether or not policies for multifunctionality lead to an increase in agricultural production depends on the assumptions made about the jointness relationship the way on which the relationship is modelled. In some cases, there is an assumed simple direct positive relationship between the level of agricultural production and the environmental good, but in others the relationship is more complex. Thus there is either an assumption of a general jointness, such as that agricultural production in some often not well defined way generates a non-commodity output, perhaps as a consequence of the presence of agricultural production maintaining an open or a diverse landscape. In the context a greater area occupied by agriculture is assumed to generate a greater benefit, albeit at a decreasing marginal value. In other contexts, the relationship is tied down to a narrower aspect of agricultural production, such as the grazing of livestock and the biodiversity value of the pasture, or the contribution of field margins and buffer strips for the provision of biodiversity. In the first case, the generality of the assumption may be questionable, not all agricultural landscapes may be seen as attractive and, even in this case, it is not certain whether the larger agricultural area necessarily leads to a greater increase in production as this will depend on its intensity. In the second, the implications of the analysis may not hold unless the particular non-commodity output is of high value relative to other non-commodity outputs. We should also note a further complication in that the marginal value placed on non-commodity outputs will tend to alter as the level of the non-commodity output production changes (Lee*, et al.* 2005).

There has been some discussion of the interactions amongst non-commodity outputs. Brunstad *et al.* (2005) consider both landscape preservation and food security and Lankoski and Ollikainen (2003) include both biodiversity and landscape. But there seems to have been little analysis that has modelled the complexities of the interactions between different environmental non-commodity outputs from an applied perspective. This suggests a need to clarify the circumstances under which non-commodity production takes place.

Assumptions about property rights

The implication that non-commodity outputs may be generated by either reducing or by increasing production raises the question as to the circumstances in which a reduction in production intensity can reasonably be regarded as the provision of an external benefit rather than the reduction of an external cost. As indicated above, this paper restricts the definition of multifunctionality to relate only to positive externalities. This is fundamentally a judgement about the property rights that are allocated to landholders.

The basic general assumption is that landowners have a right to undertake agricultural production activities subject to any laws that regulate land uses relating to limits on pollution or activities that might impose costs on third parties. This would define a reference level of property rights (Hodge, 1989; Legg, 2006) and a reference environmental standard that is associated with it. In some contexts, there are further restrictions placed over land uses in particular localities, especially in particularly sensitive locations where the biodiversity or landscape value is especially high and / or vulnerable. Beyond this, governments often define some sort of code of "good agricultural practice." If this is enforced by law, then this defines the reference level, but if it is a voluntary code, it may be seen as defining some sort of social norm, something that society may expect of landholders but that is not enforceable through legal action.

The implications of alternative types of jointness

The combination of reference level of property rights, social norms and the economic and financial environment will be the primary determinants of the type and intensities of farming systems that will be selected by landholders in the absence of specific agri-environmental policies. We refer to this as the counterfactual position. The implication of the conditions defined in multifunctionality is that landholders may then be given positive incentives to depart from this outcome in order to enhance the provision of a non-commodity output. This applies the 'provider gets principle' (OECD, 1999).

This indicates that payments might in principle be provided either to increase or to decrease the intensity of agricultural production from the counterfactual position. The position is illustrated in Figure 1.

Figure 1. Alternative arrangements for the support of non-commodity outputs

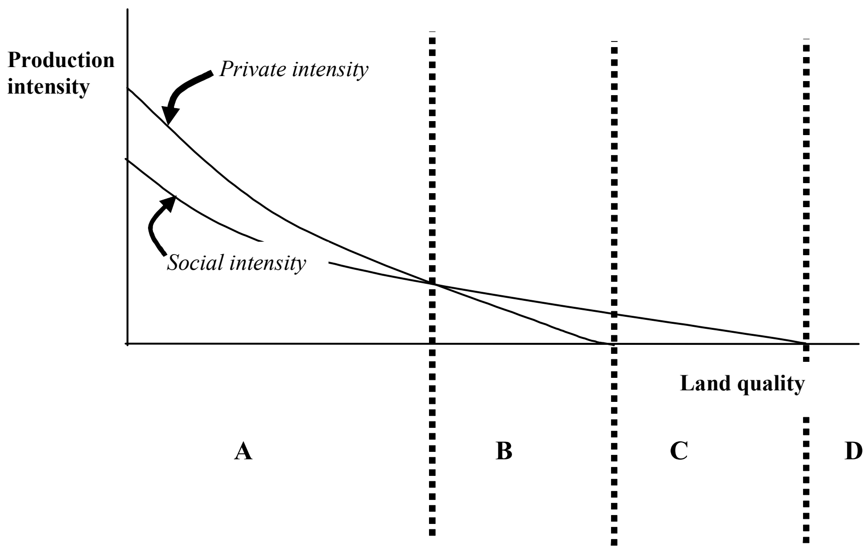


Figure 1 relates production intensity to levels of land quality, decreasing from the left-hand axis. It defines two types of 'optimal' uses, a 'private intensity', the counterfactual position, that maximises the returns to private landholders, and a 'social intensity' that maximises the net social benefit associated with the use of land of a particular quality. The figure indicates four possible relationships, as explained in Table 1.

Table 1. Alternative arrangements to attain a social optimum

	Requirements for a social optimum
Zone A	Private intensity exceeds social intensity. This assumes that the private intensity is consistent with the reference level of property rights. Policy would seek to reduce agricultural production intensity at the intensive margin. Example: payments for the provision of buffer strips in arable areas
Zone B	Social intensity exceeds private intensity. Policy would provide incentive payments to increase the level of production intensity at the intensive margin. Example: payments in upland areas to maintain sufficient grazing to prevent growth of scrub or to maintain heather.
Zone C	Social intensity would continue production in areas that are not profitable in the counterfactual position. This thus seeks to shift the extensive margin outwards. Example: payments to prevent land abandonment.
Zone D	No land uses are beneficial, from either a private or a social perspective

This suggests that policies may be designed to promote non-commodity outputs in quite different ways and, given that most areas will include a variety of different land qualities, some degree of targeting will generally be necessary.

The next section of the paper considers the range of environmental non-commodity outputs that may be valued from rural land areas in different contexts, the specific agricultural operations that are required in order to provide them and the ways in which policies might be introduced to generate the appropriate incentives. We here consider the position in the United Kingdom in some detail. Two alternatives, the North-Eastern United States and Australia are also considered in brief in Annex 2.

The environmental non-commodity outputs in a UK perspective

One approach towards the values of the rural environment is to take a total economic value perspective. Thus, we can argue that the rural environment has certain values, some of which are marketed and others for which there are no markets. There are illustrated in Figure 2.

Table 2. Total economic value associated with the use of rural land

Use values			Non-use values		
Direct use values		Ecosystem services	Option values	Existence values	Bequest values
Marketed outputs	Unpriced benefits	Benefits	Benefits	Benefits	Benefits
Crops Meat Timber Renewable energy Space for development	Recreation Amenity Landscape Heritage values	Flood control Carbon storage Water catchment Waste assimilation Nitrogen cycling	Future heritage values Potential gene pool Recreational options	Knowledge of existence without direct use	Benefits passed on to future generations

Amongst these values, the key non-commodity outputs in the UK are for landscape, biodiversity and habitat, resource conservation, and public access. Some might add the less tangible or cultural benefits, such as inspiration, spiritual refreshment or simply peace and quiet that can be associated with rural environments. We assume that these are included within the earlier categories. Each of these alternative non-commodity outputs can have different characteristics and different relationships with agricultural production, as emphasised by (Harvey, 2003).

Landscape

Preferences for particular landscapes are clearly a matter of taste. There are no single "best" landscapes and different people will find different types of landscape attractive. There are preferences for both wild, ‘natural’ landscapes as well as for man-made agricultural landscapes. These latter landscapes are often created by particular types of agricultural systems that have operated in a given environmental setting over long periods of time. They thus tend to be a characteristic of the ‘old world’ rather than of the ‘new’ or ‘resettled’ world (Hodge, 2000).

Lowenthal and Prince (1965), some time ago now, set out to describe landscape tastes in England as reflected in literature, speeches, at public hearings and in newspapers. Their comments still resonate today. They did not claim that these views necessarily reflect the views of the majority of the population, although they had no reason to doubt it. But they argue that "no landscape is intimately more man-made than the English countryside" (p186-7) and that such tastes have been influential in moulding it into its present form. The countryside that is appreciated is 'tamed and inhabited, warm comfortable, humanized'. The favoured landscape is pastoral, a calm and peaceful deer park, with slow moving streams and wide expanses of meadowland studded with fine trees. The landscape should be ordered and neat; grassland offers an open area easy to walk in and look at. Trees are neatly grouped. The scene should include free-ranging domestic animals, or when arable, hedgerows and small fields. In fact, such landscapes have often not happened by the chance optimality of particular agricultural systems, but are the deliberate creations of landowners who have often set out to manufacture scenes resembling idealisations such as portrayed by artists rather than allow 'real nature' to dominate. But there are also elements of this idealised view in the landscape generated by certain types of agricultural system.

Preferences differ in other countries, some favouring a greater degree of afforestation, or more open landscapes. There is clearly some element of feedback between the types of landscapes that are favoured by the local population and the types of farming system and land uses that have been commercially suited to particular environmental contexts and this is reflected in the ways in which landscape is appreciated in different international contexts. These in turn are also associated often with local cultures and traditions.

This approach will be seen by many as a rather too instrumental view of the countryside, suggesting that we only value the countryside for what we get out of it. Others will argue that we do not have rights to alter the countryside in certain ways, or that we have a duty to pass on certain fundamental values to future generations so that they may enjoy the same benefits that we have had. Others still may argue that the countryside has certain intrinsic values, independent of its values to humans. Bunce (1994) comments that the countryside is "a complex of myth and reality, encompassing at one end of the spectrum profound philosophical questions about modern civilisation and at the other, simple escapism". It is then difficult to separate the myth from reality. It is clearly difficult, perhaps impossible, to reconcile this type of attitude with the assumptions of a conventional economic analysis and we do not pursue this aspect of the debate. But it clearly exacerbates the complications associated with the measurement and assessment of landscape values and hence, in more formal terms, raises transactions costs.

The landscape also includes the built and cultural heritage so that landscape values may be defined to include the aesthetic and cultural values of traditional buildings, walls and archaeological sites. These are often redundant in terms of modern agricultural systems and land uses and so will often fall into disrepair in the absence of specific incentives for their conservation.

There are, then a number of common characteristics of preferences towards landscape:

- They tend to be towards the landscapes generated by longstanding and less intensive agricultural systems rather than by modern, more intensive ones.
- Preferences towards landscapes are subjective and vary between localities and communities. Thus there can be no direct quantitative measure of landscape quality other than through the values or preferences of a particular population.
- Landscape is generated by a combination of factors, both in terms of the topography and physical environment, as well as the history, culture and preferences of the local population. Landscape quality will often depend on the presence of particular elements of vegetation, water bodies, field boundaries or buildings and their juxtaposition.

The nature of jointness: In these circumstances, there is unlikely to ever be a simple relationship between the level of agricultural production and the quality or value of the landscape. The impact of policies to promote landscape quality will depend fundamentally on the counterfactual position.

Biodiversity and habitat

Biodiversity and habitat are a source of separate but related values; they are clearly in one sense inescapably a part of the 'landscape'. Wild birds, mammals or trees can be emblematic of particular local landscapes and so comprise a significant element of the landscape's value. But certain individual and groups of species can also have more "scientific" values. Nature conservation is particularly concerned with the protection of species and habitats that are at risk. Sometimes the risk is of complete global extinction, but more often the risk is that a particular species will be lost from a particular region or locality.

There is here too a distinction between a "new" and "old" world context. Often in the "new" world, it is a relatively recent process of resettlement bringing different, usually more modern and intensive agricultural technologies that threaten elements of biodiversity and habitat that were present, often predominant, in the landscape before the new technology was introduced. For instance, the introduction of cultivation for the production of corn / maize or soya beans in the mid western United States displaced the longer standing grasslands of the Great Plains. In this context, it is the species associated with this pre-existing grassland, whether or not we regard the grasslands as being the "natural" environment, that are typically most valued and they are clearly damaged by agricultural cultivation. So, this type of agriculture will simply be seen as damaging, a source only of external costs rather than of external benefits.

In other contexts, agriculture can offer the means whereby particular species and habitats and conserved. Green (2002) has described the way in which particular managed ecosystems have developed within European landscapes. He comments (pp.183-4):

> "It is the gradual development of farming over millennia that has permitted the largely spontaneous colonisation of cultural landscapes by indigenous species recruited from naturally open habitats such as dunes, cliffs, wetlands and woodland glades grazed by wild animals. …. The familiarity to the European of cultural landscapes composed of aggregations of these semi-natural managed eco-systems should not obscure the fact that such landscapes are virtually absent from those parts of the world where Western human intervention is more recent. Even in seemingly comparable and superficially similar parts of eastern North America, forest clearance and farming have resulted not in species-rich semi-natural ecosystems of native species but in species poor examples of meadow and pasture dominated by common European grasses and herbs. …. None of these [new world] countries has anything comparable to our [European] semi-natural heaths and downs."

In this context, the conservation of particular species and habitats may depend on the continuation of specific agricultural practices. But this will often be sensitive to the intensity of those practices, often in quite subtle ways. Intensification and changes in systems will generally put the conservation at risk, as will abandonment and neglect.

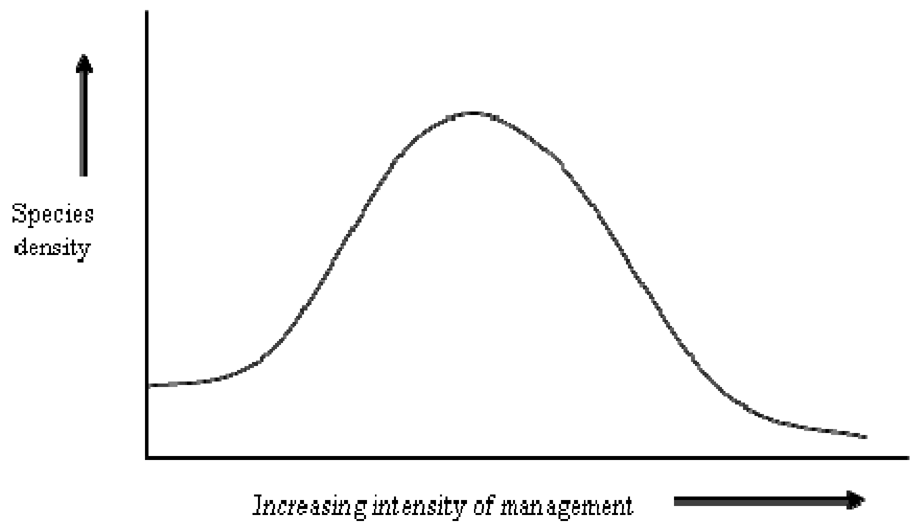
The example of grassland habitat

One particular example of jointness relates to the quality of grassland provided by alternative levels of grazing intensity. A detailed discussion of the influence of grazing is provided by Crofts and Jefferson (1999). A key focus of environmental management in England is on semi-natural grasslands, defined as "plant communities where a high proportion of vegetation consists of a mixture of native grasses and dicotyledonous herbs where woody shrubs are largely absent and where vegetation height is normally less than one metre." In most types of lowland grassland an absence of management by cutting, grazing or burning would lead to the development of scrub and woodland. The key threats to the grasslands are drainage, fertiliser application, fragmentation, over grazing, undergrazing and the production of silage rather than hay. In botanical terms, the species associated with scrub are considered to have low intrinsic value as they are relatively common, have low species richness, are often of recent origin and area easily recreated. Scrub is often regarded as a threat to the integrity of semi-natural grasslands which it can replace in the absence of management. A relationship between the intensity of stress or disturbance and the potential species density has been proposed by Grime (1973) as illustrated in Figure 2. Species richness is low in very highly stressed or harsh environments as well as in very fertile situations, such as in areas of deep, well-drained soils. Crofts and Jefferson (1999) comment that

> "Most species-rich communities, including many types of calcareous and neutral grassland occur in areas of intermediate fertility where competitive species are unable to thrive. Management (a type of stress) such as cutting and grazing, plays a part in maintaining species-richness by preventing build up of soil nutrients and in limiting the ability of competitive species to achieve dominance. Conversely, application of fertiliser to species rich grassland has the opposite effect decreasing species richness, enhancing the ability of competitive species to thrive and increasing the standing crop."

This has clear implications for conservation management. While the botanical interest will be lost through agricultural intensification, so a level of management is necessary in order to maintain the biodiversity value. The mix of species also influences the value of the grassland habitat for invertebrates and wild birds that feed on seeds of broadleaved weds or invertebrates. Thus birds are negatively affected by grassland intensification that reduces the number of grassland species (Atkinson *et al*. 2004). The value is thus threatened by both overgrazing and undergrazing. A recent report (Hewins *et al*., 2005) on the condition of lowland Biodiversity Action Plan priority grasslands has concluded that the sample of sites studied showed that under-grazing or management neglect may be a particular problem on calcareous and acidic grasslands. However, grasslands within agri-environment agreements were almost twice as likely to be in favourable condition as those outside agreements. They conclude that there is worrying evidence on the poor state of the lowland grassland resource outside of the statutory sites.

Figure 2. Species density at different levels of management intensity



Source: adapted from Grime (1973)

We should note a variety of characteristics of the provision of biodiversity and habitat:

- The values of biodiversity and habitat provided across particular areas of land will depend on the particular combinations of species and their global and local rarity. Thus values will depend on local context. The focus of conservation is often directed towards one particular keystone species, even though the aims of conservation relate to the habitat as a whole. But there will also be choices as to what sort of semi-natural habitat to aim at, with differing implications for agricultural activities.

- Agricultural production can be a source either of biodiversity conservation or of biodiversity loss, depending on the local context.

- Landscape and biodiversity values are generally closely interrelated; both will typically be higher for landscapes with mixed components that are less intensively farmed by longstanding agricultural systems. This suggests that there is likely to be a high degree of jointness amongst the non-commodity outputs.

The nature of jointness: Specific relationships between agriculture and environment will vary between localities. In some contexts there will be a complementary relationship where policy may seek to increase agricultural production from the counterfactual position in order to enhance environment. In others policy will seek to reduce agricultural production intensities. To some extent, this will depend on a policy choice as to what sort of rural landscape is desired, depending on agricultural production factors, climate and topography and demand factors, such as population densities and preferences.

Resource conservation and protection

At first sight it might seem that resource protection should be regarded as a reduction in external costs rather than a provision of a non-commodity output. It is difficult to conceive of any circumstances where there could be a complementary relationship between agricultural production and resource conservation. But, as has been argued above, whether or not the provision of resource conservation should be regarded as an external benefit depends on the assumptions made about property rights. Some standard of resource conservation and protection is generally required as a duty of landownership but where a higher standard is required, attainment of that higher standard may be regarded as a non-commodity output. This represents a social judgement and one that alters over time. What was regarded as acceptable land management in the past, perhaps as being 'good agricultural practice' may now be regarded as a form of pollution in particular contexts. There may be external benefits to be achieved through higher standards of resource conservation, particularly within catchments where higher standards of conservation management upstream can reduce costs of water treatment, water regulation or water use lower down the catchment. These will often be external benefits, although in some instances there can be particular beneficiaries, such as water companies which need to treat water to certain standards before it can be supplied to the public.

The nature of jointness: This depends fundamentally on the assumption about the reference level of property rights and the counterfactual position. We can generally assume that there is a competitive relationship between agricultural production and resource conservation. However, if the reference level allocates a right to an intensity of agricultural production that delivers a lower environmental quality than is demanded, the provision of this higher environmental standard through modification of agricultural activities can be regarded as a non-commodity output.

Public access

Access by the public into areas that have high landscape or biodiversity value or even an opportunity to escape from urban areas is clearly itself of value. Access rights vary considerably between countries and localities, ranging from the public having no right of access at all to a general freedom to roam anywhere at all, indicating that in some contexts actions by land occupiers that interfere with access will be regarded as external costs, while in others access will be treated as a public good or non-commodity output. In fact, these situations can apply within the same locations where a basic level of access is required by law, such that for instance land managers have a duty not to block public footpaths across private land in England and Wales, and payment may be provided to encourage landowners to provide extra access beyond this statutory level.

The values of public access will depend on both demand and supply factors. The size of the local population and the alternative access opportunities available will influence the demand for public access at any particular site. On the supply side, the quality and interest of the immediate environment, both in terms of landscape and historical or cultural factors will be significant determinants of demand.

The nature of jointness: Agricultural use of land can serve to keep it accessible for public access by avoiding the growth of scrub that could interfere with it. But beyond this, more intensive agricultural systems would seem likely to reduce the attractiveness of an area as a location for informal recreation. Thus the relationship would seem to be complementary at low intensities but competitive at higher intensities.

Ecosystem functions

An alternative approach towards the potential outputs from agriculture might be to start from a definition of ecosystem functions. Increasing attention is being given to the role of ecosystem functions in providing a range of goods and services both directly and indirectly that are of value. One definition defines ecosystem services as "the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfil human life. In addition to the production of goods, ecosystem services are the actual life-support functions such as cleansing, recycling and renewal, and they confer many intangible aesthetic and cultural benefits as well" (Daily, 1997, quoted in Heal and Barbier, 2006). They are often divided into various categories, such as (de Groot *et al*., 2002):

- Regulation functions (*e.g.* gas, climate, water, pollination)
- Habitat functions (refugium, nursery),
- Production functions (food, raw materials, ornamental)
- Information functions (aesthetic, recreation, cultural, spiritual, scientific)

On this basis, ecosystem functions represent both inputs to agriculture and outputs from it and so would include all of the commodity and non-commodity outputs from agriculture. By implication then, the non-commodity outputs represent those outputs for which there is no market. However, in this context, the specific question relates to the particular role that agriculture plays in the provision of non-commodity outputs, both goods and services. The contribution attributed to agricultural production depends on the assumption being taken about the counterfactual position. We could assume that the starting point for discussion is one where there is no agricultural production and ask whether the introduction of agriculture would also introduce other non-commodity ecosystem function outputs as joint products. Alternatively we might assume that we start from a system of agricultural land use that develops in response to market prices and the private preferences of the landowners and managers and then ask whether modifications to the agricultural land use would enhance the provision of ecosystem function outputs.

The interpretation of jointness with agricultural production would seem to be quite different as between these two different initial starting points. In the former case, adding agricultural production systems into unused 'natural' areas would enhance the provision of ecosystem functions where the systems created and supported habitats or stored water beyond that provided in the absence of agriculture. Alternatively, reducing agricultural intensity could enhance the provision of ecosystem services by reducing the stress on the ecosystem. This could still be regarded as a non-commodity output where the initial level of agricultural intensity is within the reference level of property rights. Adopting the counterfactual position, as argued earlier, indicates that reductions in agricultural intensity could in certain circumstances be regarded as ways in which the provision of ecosystem functions may be enhanced.

The nature of jointness: Jointness is found across many different ecosystem functions, some of which generate private commodities that can be sold in markets and others that have public good characteristics. They often have very indirect and uncertain linkages with human activities and there may be ignorance about how systems might respond to alternative external shocks.

Agricultural practices and changes that generate non-commodity outputs

Having considered the specific environmental non-commodity outputs that may be generated from certain sorts of agricultural systems, we next consider the specific attributes of those systems that may be instrumental to their provision. In practice there are many possible ways in which non-commodity outputs may be generated and it should be recognised that some specific changes in agricultural operations can contribute towards several non-commodity outputs at the same time. Thus for instance, provision of a diversity of habitats will commonly contribute simultaneously towards both landscape and biodiversity values.

The variety of changes that might be supported in order to enhance the environmental impact of agriculture in particular context is illustrated by the options provided under the Entry Level Scheme in England. The full range of options is shown in Appendix 1. We may summarise the types of actions that may be taken within agricultural systems in support of these outputs under various headings:

Within arable or pasture fields

- Intensity of and timing stocking with livestock
- Use of chemicals (pesticides and fertilisers)
- Timing and nature of grassland operations (*e.g.* hay or silage making)
- Timing of arable operations (*e.g.* winter stubbles)
- Management of water (irrigation and drainage)
- Trees within fields

Management of field boundaries

- Management of headlands
- Prevention of transmission of potentially damaging emissions around edges
- Hedges (creation and management)
- Stone walls (creation and management)

Management of land not directly used for agricultural production

- Taking land out of production
  - Set-aside and fallow (whole fields)
  - Headlands around fields
  - Uncultivated areas within fields
- Forest
- Water
  - Watercourses
  - Ponds and static water bodies

Management of built environment

- Buildings

Public access

- Allowing the public onto farmland where they have no existing legal right of access.

Resource management

- Production and implementation of plans for the management of soils, nutrients, manure and chemicals.

The majority of these activities have little direct relationship with agricultural production; many concern the management of field boundaries and land and structures that are anyway separate from agricultural production. In this respect, de-linking would be relatively straightforward. Indeed payments that are targeted on specific activities do allow farmers to choose for themselves whether or not to undertake the activity themselves or to contract it out to another operator. This offers a market test of the degree of economies of scope and the potential for de-linking. This clearly applies to the management of hedges or stone walls and this does happen to a considerable extent where the activity required is either performed at lower cost by specialist machinery or requires particular skills that the farmer may not have. Stone walling would be an example of the latter. On the other hand, there may be economies of scope for farmers who can undertake these other conservation activities at slack times during the agricultural year or using equipment that they already own. However, in order to assess the significance for the different activities for policy, it would obviously be necessary to assess the levels of government expenditure on each rather than simply the numbers of activities that are involved.

The relationships between agricultural practices and non-commodity outputs

We can thus in principle relate the activities that are typically supported under agri-environment schemes to the environmental non-commodity outputs that are expected to result. This produces a table such as Table 3. It is immediately apparent that there is no straightforward relationship between the activities that are promoted on farms and the provision of specific non-commodity outputs. Within field management, perhaps reducing grazing intensity could be seen as contributing to all of the non-commodity outputs that were identified: it can enhance the landscape, promote biodiversity, reduce nutrient emissions and enhance public access. Few non-commodity outputs are directly associated with single or particular changes in farm processes or actions. This is not surprising given the close interrelationships amongst the non-commodity outputs. Thus for instance, we might define biodiversity as being part of the landscape and public access in rural areas clearly benefits from a mix of landscape and biodiversity benefits. Non-commodity outputs are typically produced in bundles, *i.e.* there is significant jointness amongst non-commodity outputs. This parallels Heal and Small's (2002) discussion of ecosystem services. They comment that "ecosystems typically deliver multiple services in non-separable bundles. This "jointness" of the production output is a particularly salient feature of ecosystems. Whatever services an ecosystem delivers, their outputs are likely to exhibit a high positive correlation. As a consequence, policies designed to preserve or increase one type of service will often serve to enhance the flow of other ecosystem, increasing the flow of other services as a consequence. Ecologists refer to this phenomenon as the "conservation umbrella". This raises the issue of the extent to which process for producing the several types of ecosystem service exhibit economies of scope. This jointness amongst non-commodity outputs indicates that it will rarely be possible to develop single policy instruments to address single policy objectives.

Table 3. Relationship between activities and non-commodity outputs

Potential non-commodity output:Management practice	Landscape and cultural heritage	Biodiversity and habitat	Resource conservation and protection	Public access
Within field management	✓	✓	✓	✓
Management of field boundaries	✓	✓	✓	
Land not used directly for agriculture	✓	✓	✓	✓
Management of buildings	✓	✓		
Public access				✓
Resource management	✓	✓	✓	

It is also difficult to draw linkages between specific commodity and non-commodity outputs. Where the conservation management practices are associated with levels of agricultural production in one way or another, it is seldom linked to any specific agricultural commodity. Activities are generally differentiated between those relating to arable production and those relating to grazing management. Obviously, a field margin or buffer strip can surround or a reduction of fertiliser or chemical use can apply to any type of crop. Similarly a change in grazing intensity can apply to sheep or cattle. In some cases the required conservation activity will influence the relative attractiveness of alternative types of commodity production and so create a certain type of jointness. Overall, the effect would seem likely to be relatively modest.

However, we need to recognise that a focus on existing agri-environment schemes provides only a partial view of the weight and influence of agricultural policy as a whole. Care should thus be taken in generalising to circumstances in which there are no other elements of agricultural policy. We must anticipate that other forms of agricultural support influence non-commodity production in various ways, both in terms their impact through the Single Farm Payment and through support for commodity prices received by farmers. This remains critical to the determination of the counterfactual position. With significant levels of direct or market price support, agri-environmental policy will inevitably do more to emphasise restraint of agricultural production activities relative to their promotion. Reduction or removal of agricultural support mechanisms will cause a downward shift of the private intensity curve in Figure 1 and so reduce the area of Zone A, where policy aims to reduce intensity and increase the areas of Zones B and C, where policy aims to increase intensity. It will presumably also increase area of Zone D, where no agricultural use represents the social as well as the private optimum. We must therefore be cautious in extrapolating policy implications from the present situation to one in which agricultural policy has been liberalised.

Implications for agri-environmental management

Grassland in England

Grassland production takes place under a variety of different circumstances with a range of environmental impacts, both positive and negative. There are four broad types of grassland habitat (Tucker, 2006):

- Artificial temporary grass, *e.g.* rye grass leys.
- Agriculturally improved permanent grasslands.
- Unimproved / semi-natural permanent grasslands.
- Semi-natural habitats other than grasslands (*e.g.* heathlands, fens and woodlands).

Areas of grasslands in England representing different land use intensities are shown in Table 4, where it is clear that the majority of grassland is permanent. Much of this grassland is relatively intensively grazed.

Table 4. Agricultural land use in England, 2004 (1000ha)

Total area	9 168
Crops and fallow	3 932
Temporary grass	674
Permanent grass	3 011
Rough grazing	643
Woodland	274
Set-aside	476

Source: Defra website (accessed 29-10-06).

A significant proportion of the grassland is included within various agri-environment and similar schemes. Agriculture in the Less Favoured Areas, covering some 1.6 million ha in the Severely Disadvantaged Area and 587 000 ha in the Disadvantaged Area, is supported by special payments under the England Rural Development Programme. We return to the experience with the LFAs later. Grassland management is also a major focus of agri-environment schemes and the areas entered into these schemes are illustrated in Table 5.

Table 5. Agri-environment schemes in England - Area under agreements, 2005

		Thousand hectares
Organic Farming Scheme	Payments for conversion	141
Countryside Stewardship Scheme	Individual farm contracts	511
Environmentally Sensitive Areas Scheme	Standard ESA contracts	597
Environmental Stewardship Scheme: Entry Level Scheme (a)	Broad-based scheme	1 354
Organic Entry Level Scheme	Broad-based organic scheme	21

Source: Department for Environment, Food and Rural Affairs, Agriculture in the United Kingdom, London.

Most grassland has been improved for agricultural uses and so is regarded as being of less value than grassland that remains under extensive grazing. The areas that have not been 'improved' for agriculture of particularly high environmental value tend to be relatively small. For instance, the UK Biodiversity Action Plan identifies species rich priority grassland habitats. Lowland grassland areas are defined as being enclosed by fences, hedges walls or ditches to distinguish them from the unenclosed uplands. Most lie below 350 m altitude. These probably total some 360 000 ha, dominated in this list by upland heathland.

Table 6. Areas of species-rich habitat in England

Species-rich priority grassland habitat	Estimated area in England
Lowland calcareous grassland	38 345 ha
Lowland acid grassland	20 500 ha
Lowland meadow	8 500 ha
Purple moor-grass and rush pastures	11 000 ha
Upland calcareous grassland	10 000 ha
Upland heathland	270 000 ha
Upland hay meadows	< 1 000 ha

Source: Townshend *et al.* (2004); English Nature (2001).

The level of stocking intensity varies considerably between these different categories of grassland. For instance, in very general terms the typical stocking density on improved lowland grassland would be around 2.0 Livestock Units[1] (LUs) per ha. In contrast, there is a general requirement to maintain a minimum stocking density in order to be eligible for the Hill Farming Allowances in the Less Favoured Areas set at 0.15 LU/ha. There is no maximum in the LFA, although production is required to be consistent with good farming practice. Lowland Grassland Management Handbook provides a general guide to per ha per year stocking levels for lowland grassland in terms of livestock units as illustrated in Table 7.

Table 7. General stocking levels for lowland semi-natural grasslands

	LU/ha
Calcareous grassland	0.25
Neutral grassland	0.5
Acidic grassland	0.2
Wet/ marshy grassland	0.2

Source: Crofts and Jefferson (1999)

1. Livestock Units are approximate measures of stocking intensity based on feed requirements. In England and Wales, a dairy cow = 1, beef cow = 0.75 and lowland ewe=0.11

Thus, grazing takes place under a very wide variety of conditions at different stocking densities and with different environmental impacts. In some circumstances, policy aims to reduce stocking intensities, while under others, especially in the Less Favoured Areas, policy is concerned to maintain agricultural production activities. In this context we consider the ways in which alternative policy instruments might be applied in order to promote the production of environmental non-commodity outputs.

Implications for non-commodity policy instruments

Policy mechanisms are justified in terms of shifting private production intensities and management practices towards social intensities and practices. In some contexts they may be directed specifically at the non-commodity output separately from agricultural production, such as hedgerow management. In others, such as in promoting landscape or some aspects of biodiversity, they will seek to influence the manner in which agricultural production takes place. We consider here a policy objective of maintaining and enhancing a bundle of non-commodity outputs, including landscape and biodiversity benefits. These will be delivered primarily by means of extensively grazed pastures and well managed hedges and stone walls. We can thus consider in general terms the potential for alternative policy mechanisms to achieve these objectives. Clearly it would be desirable to be able to pay according to the non-commodity outputs generated, but in practice this is generally precluded by lack of information and transactions costs.

Cross-compliance

One approach is to creating incentives for the provision of non-commodity outputs is to remove support payments where land managers fail to achieve a required standard of management. With the introduction of the Single Farm Payment (SFP), landholders are required to maintain the land in Good Agricultural and Environmental Condition. This establishes a baseline standard of environmental management. However, there are at least two limits to cross-compliance. While it might in principle be possible to set differential cross-compliance standards in particular locations to reflect the desired environmental standards, the level of leverage available over agricultural activities relates to the level of support payment. Thus, it either relates to some historic level of production activity or it is a flat rate across all land irrespective of the value of potential non-commodity outputs or the costs of delivering them. This depends on the way in which the SFP has been implemented. The second problem is that the incentive relies on the continuation of the payment of the SFP. If the level of the SFP were to be reduced or the entitlement to SFP transferred away from an area of land, then the incentive for environmental management is either reduced or lost entirely. Cross-compliance can then make some contribution in promoting environmental standards but is unlikely to be able to deliver the provision of specific non-commodity outputs in particular circumstances.

Commodity price support

Commodity price support increases the returns to agricultural production and hence stimulates higher volumes of production. This might be represented by an upward shift of the private intensity curve in Figure 1 and so we could conclude that it would tend to move some production systems, generally on poorer quality land, towards the social intensity (in Zones B and C), but others (Zone A), generally on better quality land, away from it. In practice, the supply responses may be different in different contexts, but it is impossible to imagine that any single level of commodity prices could deliver the environmental outcomes that are demanded across the different environmental contexts.

The main priority habitats represent a little less than 8% of the total area of permanent and rough grassland in England. These areas are likely to represent lower quality grazing and they may be in relatively isolated and remote locations. It is thus likely that any increases in production stimulated by generally higher price levels would take place on areas of land other than those on which higher production levels are desired for environmental reasons. This is a particular problem for example in the East of England, where the decline of livestock numbers has made undergrazing a significant concern.[2]

It is also unlikely that higher commodity prices would systematically promote other actions that would enhance the provision of non-commodity outputs. They would, for instance, reduce incentives to take land out of agricultural production around field margins. It might be argued that increased farm incomes would allow farmers to hire labour to undertake environmental management actions, such as hedgerow and wall maintenance, where they gain personal satisfaction from well-kept landscape, but this influence would seem minor, especially in the context of the generally declining farm labour force and the predominance of family worked farms. It might similarly be argued that higher farm incomes would encourage farmers to spend their own time on environmental management activities that generate no financial return, but this would have to rely on sacrificing behaviour by farmers.

Livestock headage payments

The implications of support for grazing activities by headage payments would seem to have the same characteristics. They create a direct incentive to increase production and so standard livestock headage payments do not offer an adequate alternative policy instrument to output price support. We may note that prior to 2000, farming in Less Favoured Areas was supported by means of Hill Livestock Compensatory Allowances (HLCAs) paid per unit of livestock. This acted as an incentive for overstocking in a number of areas in the uplands and was a cause of environmental damage.

Area payments

An alternative would be to provide a standard payment per unit area, but again, this would not provide differentiated incentives in different contexts. The problem is illustrated by experience in the LFAs. HLCAs were replaced in the LFAs by a general area-based payment, the Hill Farm Allowance,[3] paid per hectare of land. There are three rates of payment, relating to land above the moorland line, other land in the Severely Disadvantaged Areas and other land in the Disadvantaged Areas. This system is currently under review. In a consultation paper on the review, Defra (2006) comments that, even though the HFA does offer some payment enhancements for having some arable land, woodland or mixed livestock on the holding, "evaluations of the HFA found the scheme was a blunt instrument providing limited environmental benefit" and that "the scheme

2. An Undergrazing Project Partnership has been established in the east of England to demonstrate the problem and to support farmers and land managers who are seeking to maintain grazing in particular areas: http://www.defra.gov.uk/rds/ee/undergrazing.htm

3. Details of the Hill Farm Allowance can be found at: www.defra.gov.uk/erdp/schemes/hfa/default.htm

was not targeted as well as it could be. Simply keeping hill farmers in business is not in itself sufficient to ensure that key environmental goods and services are provided. Defra's strategic outcomes of protection for the countryside and natural resources will only be fulfilled when land managers are rewarded for the provision and maintenance of environmental goods and services." In place of the HFA, Defra proposes that upland farmers should be given more encouragement to enter their land into a specific agri-environment scheme. The application of general area payments in the lowland areas would face similar limitations.

The clear implication is that some element of targeting is necessary in order to set the appropriate incentives in particular contexts. It would also seem to be necessary in most if not all contexts to set some constraints on the activities that are permitted, such as on stocking densities, in order to be eligible to receive the payments.

Targeted payments: by activities and context

If it is not possible to specify the non-commodity outputs that are demanded and to base payments on the levels provided, then the closest is to make payments against undertaking (or not undertaking) specific activities in particular circumstances. The Countryside Stewardship Scheme in England made payments based on individual farms plans drawn up within national guidelines. Farms were accepted on a competitive basis judged on the basis of the level of non-commodity outputs that were expected to be delivered. The Higher Level Scheme within Environmental Stewardship develops from the Countryside Stewardship Scheme in tailoring contracts more specifically to individual farm circumstances. Clearly it would be possible to extend this approach to a fully competitive tendering or auction process.

The introduction of the Environmental Stewardship Scheme in England represents a shift away from generalised spatial targeting as represented by the Environmentally Sensitive Areas scheme in which farmers were offered standard contracts towards targeting that is related to agricultural activities or that is more specific to individual farm circumstances. It illustrates the point that a 'broad' scheme may at the same time still be 'targeted'. Targeting in early agri-environment schemes has tended to be at the extensive agricultural margin often concentrating on preventing agricultural intensification at the expense of landscape and biodiversity. The introduction of schemes, such as the Entry Level Scheme, that seek to influence production practices across the whole range of land qualities and intensities may be viewed as targeting at the intensive margin. It thus does not focus on particular places by means of spatial designation so much as on particular agricultural practices, wherever they take place. This is clearly an approach that could be developed further to differentiate the options and incentives at a more local level, reintroducing an element of spatial targeting.

These changes in policy approach increase the opportunities for separating incentives for provision of non-commodity outputs from incentives for agricultural production. For example, under the ELS farmers receive payments for hedgerow, ditch and stone wall management. They can then choose whether to undertake the work themselves or whether to contract it out to someone else.

Selecting instruments: Balancing precision and transaction costs

Two key criteria may be applied in evaluating alternative policy instruments. Vatn (2002) analyses policies in terms of their precision and their transactions costs. He defines a precise solution as being reached when the standard conditions for optimality are met in the production of the good (*i.e.* marginal cost equals marginal gain) and thus precision represents the closeness to optimality. Transactions costs (OECD, 2007) are the costs involved in establishing and running a policy: collecting information, formulating contracts and monitoring and enforcing them. These are incurred both by government and by the private actors who are affected by the policy.

There is generally a trade-off between precision and transactions costs. With more information and more detailed contracts, governments can implement policies for land uses that deliver a more valuable package of non-commodity outputs prescribing the least cost method of provision. This will take account of both supply considerations, in terms of the capacity for local areas to supply such goods using alternative means of provision, and demand considerations, taking account of the demand within that local situation, given the size, location and preferences of the affected population. But the acquisition of such information is expensive and in practice the information available to government is always imperfect, particularly affected both by the degree of spatial heterogeneity in supply and demand conditions and by the incentives that decision-makers face to hide information and actions.

Generally, a higher degree of targeting, progressing from commodity support through to detailed environmental contracts with individual farmers will be associated with a higher level of transactions costs. However, this is conditional on the assumption that the increased level of support does indeed generate an enhanced flow of non-commodity outputs. As has been indicated here, this will not always be the case. It is possible that in a significant number of contexts non-commodity output provision will be decreased rather than enhanced. In this context the loss of non-commodity output would need to be balanced against any enhancement achieved. This indicates that information is required not simply that jointness can occur but also on the range of production levels and contexts within which that jointness occurs.

Conclusions

Multifunctionality and jointness have been extensively discussed in the literature, but from an apparently increasing variety of perspectives. Multifunctionality seems often to be interpreted as meaning that agriculture, or even rural land uses generally, can be a cause of externalities. This would seem to render the term somewhat meaningless. A restriction of the term to refer to jointness between agricultural production and positive non-commodity outputs does provide a framework to discuss rural land use issues that are distinct from the more usual issues of environmental damage and pollution in environmental policy debates.

There is good evidence that some agricultural commodities are technically related as joint products with non-commodity outputs, as well as grounds for believing that there are also economies of scope between agricultural commodity and non-commodity production. However the relationships between technically related products are not simple. It is often the case that a complementary relationship over one range of production intensity changes to a competitive relationship at higher levels of intensity.

Environmental quality on grassland might be relatively low at both very low levels and high levels of stocking intensity. As a consequence, the types of changes that need to be made to agricultural practices in order to enhance the provision of non-commodity outputs are rather varied. This is reflected in the modelling of multifunctionality, where the relationships are assumed to take on different forms, implying policies sometimes to reduce intensity of production and at other times to increase it. In fact, there are probably stronger and more consistent joint product relationships amongst non-commodity outputs. In this respect, policy will have to relate to bundles rather than individual non-commodity outputs and it may be difficult to be specific about the particular non-commodity outputs that are sought from particular policy interventions.

In the British context at least, there is a wide variety of ways in which agricultural systems may be modified in order to increase the production of non-commodity outputs, these relate to the management of land within fields, of boundaries around fields and of land that is not in use for agricultural production. And most of these modifications can give rise to bundles of different types of non-commodity outputs, relating simultaneously to landscape, biodiversity and resource protection. The particular modifications required to attain the highest environmental standards are typically spatially heterogeneous and involve detailed changes to farming systems. A further complication recognises that the marginal value placed on non-commodity outputs will tend to alter as the level of the non-commodity output production changes.

In this context, it is most unlikely that any particular level of commodity price or a flat rate livestock headage or area payment will deliver the desired levels of non-commodity outputs. This is reflected in the shift in agri-environment policy approaches in the UK, where incentives have come to be much more specifically tailored to particular farming systems and contexts and have been extended to influence farming practices across the whole country. But ‘targeting’ does not relate only to spatial targeting; schemes may be targeted at specific land management activities, although some element of spatial discrimination may still be appropriate.

It is not clear to what extent the British experience is equivalent to conditions in other countries but it seems likely that the complexity and non-linearity revealed here will apply elsewhere too. Similar issues do apply in the cases of the USA and Australia. There is of course generally a trade-off between the precision of policy instruments and transactions costs and some appropriate balance has to be struck. But this needs to take account of both gains and losses in non-commodity production that is associated with any policy intervention. Policies linked to agricultural production will be more likely to be appropriate where there is a close linkage between the agricultural and non-commodity production across a wide range of production intensities, where there is a very general and widespread desire to raise the intensity of agricultural production above the intensity of the counterfactual position that does not cause a loss of non-commodity outputs to any significant extent elsewhere, and where production conditions and the demand for non-commodity outputs are spatially homogeneous. These conditions would seem likely to be quite restrictive.

Annex 1.

Entry Level Scheme: summary table options and points available

	Code	Option	Units	Points
Options for Boundary Features	EB1	Hedgerow management (on both sides of hedge)	100m	22
	EB2	Hedgerow management (on one side of hedge)	100m	11
	EB3	Enhanced hedgerow management	100m	42
	EB4	Stone-faced hedgebank management on both sides	100m	16
	EB5	Stone-faced hedgebank management on one side	100m	8
	EB6	Ditch management	100m	24
	EB7	Half ditch management	100m	8
	EB8	Combined hedge and ditch management (incorporating EB1 hedge management)	100m	38
	EB9	Combined hedge and ditch management (incorporating EB2 hedge management)	100m	26
	EB10	Combined hedge and ditch management (incorporating EB3 hedge management)	100m	56
	EB11	Stone wall protection and maintenance	100m	15
Options for Trees and Woodland	EC1	Protection of in-field trees – arable	Tree	12
	EC2	Protection of in-field trees – grassland	Tree	8
	EC3	Maintenance of woodland fences	100m	4
	EC4	Management of woodland edges	ha	380

Options for Historic and Landscape Features	ED1	Traditional Farm Buildings	m^2	2
	ED2	Take archaeological features currently on cultivated land out of cultivation	ha	460
	ED3	Reduce cultivation depth on land where there are archaeological features	ha	60
	ED4	Management of scrub on archaeological sites	ha	120
	ED5	Archaeological features on grassland	ha	16
Options for Buffer Strips and Field Margins	EE1	2 m buffer strips on cultivated land	ha	300
	EE2	4 m buffer strips on cultivated land	ha	400
	EE3	6 m buffer strips on cultivated land	ha	400
	EE4	2 m buffer strips on intensive grassland	ha	300
	EE5	4 m buffer strips on intensive grassland	ha	400
	EE6	6 m buffer strips on intensive grassland	ha	400
	EE7	Buffering in-field ponds in improved grassland	ha	400
	EE8	Buffering in-field ponds in arable land	ha	400
Options for Arable Land	EF1	Field corner management	ha	400
	EF2	Wild bird seed mixture	ha	450
	EF3	Wild bird seed mixture on set-aside land	ha	85
	EF4	Pollen and nectar flower mixture	ha	450
	EF5	Pollen and nectar flower mixture on set-aside land	ha	85
	EF6	Over-wintered stubbles	ha	120
	EF7	Beetle banks	ha	580
	EF8	Skylark plots	plot	5
	EF9	Conservation headlands in cereal fields	ha	100

	EF10	Conservation headlands in cereal fields with no fertilisers or manure	ha	330
	EF11	6m uncropped, cultivated margins on arable land	ha	400
Options to Encourage a Range of Crop Types	EG1	Under sown spring cereals	ha	200
	EG2	Wild bird seed mixture in grassland areas	ha	450
	EG3	Pollen and nectar seed mixtures in grassland areas	ha	450
	EG4	Cereals for whole crop silage followed by over-wintered stubbles	ha	230
	EG5	Brassica fodder crops followed by over-wintered stubbles	ha	90
Options to Protect Soils	EJ1	Management of high erosion risk cultivated land	ha	18
	EJ2	Management of maize crops to reduce soil erosion	ha	18
Options for Lowland Grassland Outside the LFA	EK1	Take field corners out of management	ha	400
	EK2	Permanent grassland with low inputs	ha	85
	EK3	Permanent grassland with very low inputs	ha	150
	EK4	Management of rush pastures (outside the LFA)	ha	150
	EK5	Mixed stocking	ha	8
Options for the Uplands (LFA land)	EL1	Field corner management (LFA land)	ha	100
	EL2	Manage permanent in-bye grassland with low inputs	ha	35
	EL3	Manage in-bye pasture and meadows with very low inputs	ha	60
	EL4	Management of rush pastures (LFA land)	ha	60
	EL5	Enclosed rough grazing	ha	35
	EL6	Moorland and rough grazing	ha	5

Management Plans	EM1	Soil management plan	ha	3
	EM2	Nutrient management plan	ha	2
	EM3	Manure management plan	ha	2
	EM4	Crop protection management plan	ha	2

Source: Department for Environment, Food and Rural Affairs, http://www.defra.gov.uk/erdp/schemes/els/handbook/chapter3-index.htm

Annex 2.

Jointness and multifunctionality in the United States and Australia

The UK has a particular approach towards the non-commodity outputs reflecting the particular historical, cultural and environmental contexts. We may then expect to find some differences in the contexts and approaches in other countries. This is explored briefly through a review of some aspects of the situations in the United States and Australia. Given the limits on time and space, the discussion here should be regarded as exploratory rather than definitive.

Jointness and multifunctionality in New England, United States (especially Vermont)

Non-commodity production

Vermont is characterised by a combination of open grazing land often used for dairy production within a generally afforested landscape. Small dairy farms are set in valleys that often limit the scale that is possible on an individual holding. Herds are relatively small and forage is provided from hay.

The land was settled early after the European settlement of North America and was substantially cleared before being allowed to re-afforest during the 19th and 20th centuries. The combination of dairy farming and forestry creates a characteristic landscape of open grazed hay pastures, traditional wooden barns and livestock in fields that is generally valued by the local population. It is also argued, such as by the Vermont Land Trust, that the activity of dairy farming itself is an important element within the mix of non-commodity outputs.

The Northeast Dairy Compact Commission argued that "States in the Compact region have found that dairy farming is essential to the region's rural communities and character. The farms preserve open spaces, sculpt the landscape and provide a base for a diversity of recreational pursuits. In defining the rural character of our communities and landscape, dairy farms also provide a major draw for the regional tourist industry."

Further, the perpetuation of active farming tends to reduce the chances of the land being converted for urban development, although this can only be prevented with a degree of certainty through the sale of conservation easements.

The history of land use since European settlement in the late 17th and 18th centuries suggests a shift from a new to an old world example. Over time, the landscape that has been created by particular agricultural systems and practices has come to be valued in its own right over the landscape that would emerge if the land was to be abandoned.

Type of jointness

The non-commodity output is then a joint product with the marketed dairy products. There is a technical relationship between the particular milk and dairy products produced by 'traditional' dairy production systems and the landscape and cultural non-commodity outputs.

Potential to generate non-commodity outputs

Changes in relative prices and technology have increased the degree of economies of scale in milk production and decreased transport costs challenging the continued viability of the traditional dairy production approaches in Vermont. On the assumption that there is no duty on landholders to continue with 'traditional' dairy production systems, then the provision of this landscape must be regarded as an external benefit, i.e. a non-commodity output. The implementation of the *provider-gets principle* would thus indicate that if society determines that the benefits exceed the costs, payments would be made to landholders to encourage them to continue with traditional production methods.

It is the practice of this particular type of dairy farming generally that provides the source of the non-commodity output. However at the same time, there can also be problems of damage to water quality from dairy farms located in valleys close to rivers. There is thus a clear requirement to balance out the respective external benefits and costs in determining policy approaches.

Another perceived benefit of maintaining agricultural production is that it reduces the probability that the land will be converted into urban uses. Again, if it is assumed that the landholder does have the right to convert his land for development, then society may choose to offer payment, or relief from taxation, in order to discourage urbanisation where the social costs of development exceed the social benefits.

Policy issues

It is not clear that this type of traditional dairy farming system can survive at world market prices. There are substantial economies of size in dairy production and such farms must be subject to competitive pressures from larger production units in other parts of the United States. There may be scope for some types of niche production, such as sales to a local population that values the non-commodity outputs as embodied in products from the system and is prepared to pay a premium price to sustain it. The area may also be protected to some extent by its relative isolation.

In the absence of dairy production it would seem likely that the land would go out of production and the forest cover would become much denser. This alternative environment may be favoured by some people, perhaps as being better for biodiversity, and so it would be necessary to consider the relative preferences for the alternative environmental outcomes.

The system of dairy farming might in principle be supported by means of a price premium and such a scheme for the North-East United States has been mooted (was in existence). However it would seem unlikely that a general increase in milk prices would have the desired effects. Clearly it would also be available to larger lower cost producers who may then increase their production.

Some degree of protection for selected farms is provided by means of the acquisition of conservation easements by land trusts. For farmers who wish to continue with this type of farming, the sale of an easement can provide a cash injection to the farm that can then be invested in the farm business, perhaps to pay off debt, to modernise the production system or to introduce some added value to the product. This may or may not be sufficient to achieve a sustainable business in the longer term.

Some payments are available to farmers through USDA schemes, but while they schemes are tailored to the conditions in Vermont, they are not significantly different from schemes available to farmers generally across the United States.

There would thus seem to be a *prima facie* case for some sort of government support mechanism should it be determined that the value of the non-commodity outputs justified the cost. Such a scheme would need to be targeted on particular localities and would need to regulate the types of farming system that are permitted and take precautions that the support provided did not generate significant damaging environmental impacts

Multifunctionality in Australia

A new / resettled world example

Australian land has the capacity to produce non-commodity outputs. The most obvious type of output would be the production of value from indigenous bush habitat. This has become increasingly scarce with the land clearance that has been undertaken since European settlement. The variations in climate and topographical conditions across the Australian continent means that there is substantial local variation in indigenous species, such as in birds or tree species, so that bushland conservation becomes very locally specific and remnant areas may contain species that are threatened with extinction. Non-commodity production may thus involve either protection of remnant areas of bush or bushland regeneration.

Payment for protecting existing habitat v payment for habitat creation

Treatment of this as a positive externality depends on the social judgement that landholders have a right to clear land. Some element of protection for native bush may be included as part of a "duty of care", of reference level of property rights. A failure to attain this standard of environmental management would be defined as an external cost but actions beyond this could be regarded as an external benefit, or non-commodity output, to which the provider-gets principle may apply.

It might potentially be argued that investment in protection of soil and water resources also could constitute a non-commodity output. This could be argued on the grounds, perhaps, that farmers have historically been encouraged by government to clear land for agricultural production and that only more recently has this been recognised as environmentally damaging. There is thus some element of public complicity in the environmental damage that has been wrought and hence some duty on the public to provide support for the investment that is now required in resource conservation.

Potential to generate non-commodity outputs

Production of bush habitat involves a reduction in the intensity or scale of agricultural production, by de-stocking or taking land out of production entirely, planting native species and providing breeding programmes for threatened species. This often requires fencing and various forms of creek and river management.

Thus, investments in non-commodity production are either competitive with or independent of agricultural production activities. It is not a joint product in a technical sense.

The situation might however be potentially regarded as multifunctionality to the extent to which there are economies of scope between the commodity and the non-commodity production activities. This would seem a plausible argument, to the extent that landholders would seem likely to be the only people capable of undertaking the work. The low level of population settlement outside of the major urban areas and the vast distances between holdings that are common would make it most unlikely that non-commodity production could feasibly be undertaken by contractors.

Policy issues

A decision whether or not to implement a policy for the provision of non-commodity outputs depends on judgements about the social costs and benefits of their provision. If the benefits were deemed to exceed the costs, there would be a case for some sort of policy implementation. However, this would need to be targeted on the specific non-commodity outputs and could not be by means of support tied to agriculture. Assuming that payments were offered to landholders for specific activities, such as tree planting, clearing weeds or fencing, landholders could then decide whether to undertake the work themselves or to contract it out to someone else. There would thus be a market test for de-linking.

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Different Types of Jointness in Production of Environmental Goods and Agricultural Policy Change

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This paper analyses the effects on environmental good production by farmers of the transition from coupled direct payments to fully decoupled payments as proposed in the June 2003 CAP reform. Two types of environmental goods differing in their production relationships to agricultural commodities are considered: complementary goods and competing goods. Uncertainty, together with the farmers' risk aversion, is likely to change the production neutral character of fully decoupled payments therefore we account explicitly for it. First, some general results are derived analytically. Then several case studies are carried out by means of mathematical programming farm-level models applied to the case of joint beef and biodiversity production in France and in the Czech Republic. Both the analytical and numerical results confirm that decoupling of direct payments is likely to have a positive effect on competing grassland biodiversity production but its effect will be negative if biodiversity production is complementary to beef production. The observed effects of uncertainty and risk aversion are negligible. The simulation results draw our attention to the fact that on the one hand, the type of jointness between agricultural commodities and environmental goods determines the effects of applied policy instruments on environmental good production, and that on the other hand, the type of jointness itself is to a certain extent determined by these policy instruments and their parameters, like the output price level or the degree of decoupling of direct payments.

The process of decoupling the farm income support from agricultural production started in the European Union (EU) in 1992 with the MacSharry reform of the Common Agricultural Policy (CAP) when a part of the support was transferred from guaranteed prices to direct payments attributed per hectare or per animal. The process continued with the Agenda 2000 reform but the possibility to effectively decouple direct payments from agricultural production was established only by the June 2003 CAP reform. This reform proposed the full decoupling of former crop and livestock direct payments as one of the options individual member states may adopt. The aim of this paper is to show the effects of transition from coupled direct payments to decoupled payments on environmental good production. For this purpose, we summarise, complement and expose in a unified way results obtained in some of our previous studies especially those presented in Havlík *et al.* (2005, 2006) so that their comparison leading to a more general understanding of the problem becomes possible.

Even completely decoupled direct payments attributed in the form of a lump sum per farm are not without impact on farmers' production decisions as could be supposed under some simplistic assumptions. Antón (2001) summarises the potential effects of decoupled subsidies into three groups: (i) static effects (*e.g.* income effects relaxing the liquidity constraint and facilitating investment), (ii) dynamic effects (*e.g.* through farmers' expectations about future policies), and (iii) effects under uncertainty (*e.g.* increasing income decreases risk aversion). Hennessy (1998) investigates the uncertainty effects of different income support instruments on input use and demonstrates that only under specific assumptions about the farmers' preference structure, namely constant absolute risk aversion, payments decoupled under certainty do not influence farmers' production decisions under uncertainty. In order to estimate the uncertainty effects and thus the error one can generate by neglecting farmers' risk aversion in the models, we analyse the difference in effects of decoupling on the environment between a risk-neutral farmer and a risk-averse one when output prices are uncertain.

Environmental goods produced by agriculture can be divided into two groups according to their interdependences with commodity production: complementary goods and competing goods. These interdependencies can often be assimilated with two different sources of jointness considered by OECD (2001): non-allocable inputs and allocable fixed inputs, respectively. Complementarity holds usually only within a certain range of agricultural commodity production and changes to competition beyond (Vatn, 2002).

An example of environmental goods, which enable us to illustrate both the complementary and the competing production relationship, is grassland biodiversity. This is due to the ecological context of the European agriculture, where according to Pienkowski (1998), the long process of agricultural development resulted in a significant diversification of landscape patterns. New habitats created by extensive farming practices, such as semi-natural grasslands, were invaded by species formerly not native to the region and became the source of high biodiversity (Pott, 1992; cited in Abensperg-Traun *et al*., 2004). Therefore shifts away from the extensive practices, in both directions – intensification and land abandonment, jeopardise grassland biodiversity (*e.g.* Balent *et al*., 1998; Carrère *et al*., 2002; Schmitzberger *et al*., 2005). Thus depending on the current farming intensity and the biotope, biodiversity and agricultural commodities production will exhibit complementarity, if the current farming intensity is below the optimum, or competition, if the current farming intensity is above the optimum.

Some general results are first obtained analytically, then, these results are illustrated numerically in case studies applied to the joint production of grassland biodiversity and an agricultural commodity specifically concerned by the June 2003 CAP reform –beef. These cases represent two different EU countries: an old member state, France, and a new member state, the Czech Republic. In both countries, we chose mountainous regions where beef cattle production plays an important role and the environmental value of their semi-natural meadows is formally acknowledged. In France, the analysis was carried out for two different zones in *Monts du Cantal*, with two clearly different biotopes. The first zone is a river valley threatened by land abandonment and progressive afforestation, thus beef and biodiversity are complementary there. The second zone is constituted around peatlands threatened by high farming intensity, where beef and biodiversity are competing. In the Czech Republic, the White Carpathians Protected Landscape Area (PLA) was studied. There the farming intensity is to be held within a quite narrow range in order to protect biodiversity; hence depending on the current farming intensity on a particular farm, beef and biodiversity production can be complementary or competing.

The analysis applied is implemented by means of mathematical programming farm-level models. These models enable the management requirements supposed to lead to environmental good production on the area where they are respected to be represented in detail. The requirements are overtaken from current agri-environmental agreements and they are displayed in the programming model in the form of voluntary technical constraints. The model can either (i) be allowed to decide about the area to be enrolled in the agreement, the area managed in compliance with this agreement is then used as a primal proxy for environmental good supply, or alternatively, (ii) be forced by a supplementary constraint to enrol a fixed area, the environmental good supply can then be approximated by the marginal cost of compliance with the agreement on the fixed area, a dual proxy, obtained on the basis of the dual value of the supplementary constraint. The second approach helps to overcome the problem mentioned by Röhm and Dabbert (2003) who argue that linear programming models do not allow for a gradual reaction and thus the agri-environment variant typically either stays in the solution or it drops out totally. Therefore the "dual" approach is applied for the majority of simulations presented here.

The rest of this paper is organised as follows. In Section 2, the effects of decoupling on farmers' production decisions are analytically derived both for a risk-neutral and a risk-averse farmer. In Section 3, the general structure of the applied models as well as the case studies are briefly presented. Section 4 comments on the numerical results and Section 5 concludes.

Analytical approach

The following presentation is based on a stochastic profit function $\tilde{\pi}$, which can be written as follows

$$\tilde{\pi} = (\tilde{p} + s) y_M + t y_B + L - c(y_M, y_B) \qquad (1)$$

The farm is assumed to produce two outputs y_i: the agricultural commodity – beef – indicated by M, and the environmental good – grassland biodiversity – indicated by B. The sole source of uncertainty is the stochastic beef price $\tilde{p}$. Besides sales, the farm income is made up of a coupled subsidy s, the transfer payment for biodiversity production t, and a decoupled subsidy L awarded to the farmer without linkage to his agricultural activity (or inactivity) as a lump sum payment per farm. The production cost is represented by a joint cost function $c(y_M, y_B)$. We assume that the marginal cost of production is positive for both outputs, $c_{y_i} > 0$, and that in the case of complementarity, the marginal cost of biodiversity production decreases if beef production increases, $c_{y_B y_M} < 0$, while in the case of competition, the marginal cost of biodiversity production increases if beef production increases, $c_{y_B y_M} > 0$.[1]

A *risk-neutral farmer* is supposed to maximise the expected profit $E(\tilde{\pi})$, which if we replace $E(\tilde{p}) = \mu$ can be written as follows

$$E(\tilde{\pi}) = (\mu + s) y_M + t y_B + L - c(y_M, y_B) \qquad (2)$$

1. The last two assumptions correspond to the definition of technically complementary and technically competing products given by Carlson (1965).

The optimal quantities for a risk-neutral farmer have to solve the following first order conditions

$$\mu + s - c_{y_M} = 0 \text{ and} \quad (3)$$

$$t - c_{y_B} = 0 \quad (4)$$

Comparative static results concerning the direct payments can be derived from these two equations considering the cost function characteristics. First, for equation (3) to hold, an increase in the coupled subsidy *s* will lead to an increase in beef production. This is what Hennessy calls a coupling effect. *Ceteris paribus*, the coupling effect will produce an increase (decrease) of complementary (competing) biodiversity production in order for equation (4) to continue to hold after the increase in beef production. Second, a change in the lump sum payment *L* will have no impact on either beef or biodiversity production. Thus decoupling, the transition from coupled subsidies to a lump sum payment, will have a positive effect on competing biodiversity production and a negative effect on complementary biodiversity production by a risk-neutral farmer.

The comparative static results for a *risk-averse farmer* presented here rely basically on those derived by Sandmo (1971) in the single output framework. Therefore we only summarise them without repeating the demonstration and focus on their implications for the jointly produced environmental good. A risk-averse farmer is supposed to maximise the expected utility of profit $E[U(\tilde{\pi})]$. Here, it is specifically assumed that farmers exhibit decreasing absolute risk aversion (DARA), which means that the value of the Arrow-Pratt measure of their absolute risk aversion ($R_A = -U_{\tilde{\pi}\tilde{\pi}} / U_{\tilde{\pi}}$) decreases as the profit increases. This assumption is widely accepted and supported by empirical evidence, *e.g.* Saha *et al*. (1994) or Chavas and Holt (1996). The first order conditions for a risk-averse farmer are

$$E[U_{\tilde{\pi}}(\tilde{p} + s - c_{y_M})] = 0 \text{ and} \quad (5)$$

$$E[U_{\tilde{\pi}}(t - c_{y_B})] = 0 \quad (6)$$

Equation (6) can be rewritten as

$$E[U_{\tilde{\pi}}](t - c_{y_B}) = 0 \quad (6')$$

The marginal utility of profit is always positive for a risk-averse farmer. Hence, for equation (6') to hold, a risk-averse farmer, in the same way as a risk-neutral one, has to produce a quantity of biodiversity such that the marginal cost of biodiversity production equals the unit transfer payment. This marginal cost rule is not valid for beef production.

Sandmo demonstrated that a risk-averse farmer will produce a quantity of the risky output for which the marginal cost of production is lower than its expected price plus the coupled subsidy, $c_{y_M} \leq \mu + s$. Thus, *ceteris paribus*, a risk-averse farmer will produce less beef than a risk-neutral one. For equation (6') to hold, a risk-averse farmer will produce more (less) biodiversity than a risk-neutral farmer, if biodiversity production is competing with (complementary to) beef production.

Concerning the policy parameters, the DARA preference structure is a necessary and sufficient condition for the lump sum payment *L* to encourage the risk-averse farmer to increase his beef production. This effect arises because the lump sum payment increases the farmer's wealth and thus decreases his risk aversion and brings his optimal beef production closer to that of a risk-neutral farmer. Hennessy calls this phenomenon the wealth effect. Because of the wealth effect, introduction of a lump sum payment will lead to an increase (decrease) in biodiversity production by a risk-averse farmer if it is complementary to (competing with) beef production. The coupling effect of the coupled subsidy *s* remains active also for a risk-averse farmer and is even enhanced by the wealth effect. Thus, the same as with a risk-neutral farmer, an increase in the coupled subsidy will lead to an increase in beef production and to an increase (decrease) of complementary (competing) biodiversity production. If the profit remains stable, decoupling of direct payments should have similar effects on a risk-averse farmer as on a risk-neutral one because only the coupling effect changes, the wealth effect remaining the same under both policy options.

Applied approach

The analytical results would be useless if we had no information about the magnitude of effects they describe. Therefore we decided to carry out a numerical analysis by means of mathematical programming models. These models were applied to case studies in *Monts du Cantal* and in White Carpathians. We first describe the general structure of the applied models, then the case studies and corresponding environmental goods are presented.[2]

Mathematical programming models

A mathematical programming farm-level model of always one representative farm is implemented for each studied zone. Opt'INRA Salers model developed at the *Laboratoire d'Economie de l'Elevage*, INRA-Theix, represents a suckler cow farm breeding the Salers race in *Monts du Cantal*. It was applied in two variants to represent separately a zone where beef and biodiversity are complementary and another where joint production is competing. BEGRAB_PRO.1 – a mathematical programming model for BEef and GRAssland Biodiversity PRoduction Optimisation – elaborated for analysis of organic suckler cow farms in the White Carpathians PLA is applied to the Czech case study. Here we present only the general structure of these models. We focus on the objective function and the way environmental good production is depicted in the models. Other aspects are presented in a simplified way.

2. Only the information indispensable for good understanding of the simulations and their results is given here. A detailed description of the applied models and of the case studies is provided in: Havlík *et al*. (2005) for *Monts du Cantal* and Havlík *et al*. (2006) for White Carpathians.

The general model structure can be algebraically written as follows:

$$\max \mathrm{E}\left(GM_l\right) = \sum_l w_l GM_l \tag{7}$$

or

$$\max \mathrm{E}U\left(\pi_l\right) = \sum_l w_l U(\pi_l) \tag{8}$$

s.t.

$$GM_l = \sum_{j,e,c} p_{jl} x_{jec} + \sum_{j,e,c} s_j x_{jec} + L + T - \sum_{j,e,c} r_{jec} x_{jec} \ , \ \forall l \tag{9}$$

$$\pi_l = GM_l - FC \ , \ \forall l \tag{10}$$

$$\sum_{j,e,c} a_{ijec} x_{jec} \leq b_i \ , \ \forall i \tag{11}$$

$$\sum_j d_{jk} x_{j11} \leq q_k \ , \ \forall k \tag{12}$$

$$T = t \sum_j x_{j11} \tag{13}$$

$$\sum_j x_{j11} \geq Z \tag{14}$$

$$x_{jec} \geq 0 \ , \ \forall j, e, c \tag{15}$$

Equation (7) represents the *objective function of a risk-neutral farmer*. Such a farmer maximizes, in the short-term, the time perspective adopted in this paper, the expected gross margin *GM* over the possible states of nature *l*, occurring with probabilities w_l. Simulations under the assumption of risk-neutrality are used to provide a benchmark for the simulations of a risk-averse farmer in the French case, and because of technical difficulties, the assumption of risk-neutrality is adopted for all the simulations concerning the Czech case.

The *objective function of a risk-averse farmer*, which corresponds to maximisation of the expected utility of the net income π, is represented by equation (8). This approach to accounting for risk-aversion in mathematical programming models is known as the direct expected utility maximisation nonlinear programming (DEMP), and it was presented by Lambert and McCarl (1985). The utility function $U(\pi_l)$ must correctly account for a farmer's preference structure concerning the absolute risk aversion as well as the relative one. As stated above, DARA preference structure is the assumption adopted here with regard to absolute risk aversion. Concerning the type of relative risk aversion, no strong empirical evidence exists in favour of any particular type. Thus, the constant relative risk aversion (CRRA) preference structure seems to be an acceptable compromise. The power function, equation (16), is acknowledged as a suitable functional form representing the DARA-CRRA preference structure by *e.g.* Hardaker *et al*. (1997), and it is also the form adopted here. One of the advantages of this functional form is that it contains only one parameter – the relative risk aversion coefficient, *RRA*,

$$U\left(\pi_l\right) = \left(\frac{1}{1 - RRA}\right) \pi_l^{(1-RRA)} \tag{16}$$

The gross margin for a state of nature l is schematically expressed in equation (9). An activity x, has three indexes: the common index j differentiating an activity from the others, *e.g.* a fertilised pasture from a twice mowed hay meadow, or a cow from a heifer; an index e, which indicates whether a specific activity is eligible for production of an environmental good within an agri-environmental agreement (In this paper only one agri-environmental agreement is considered for each model, thus $e = 1$ or $e = 0$ if an activity is or is not eligible.); and finally, an index c is used to differentiate the area on which the farmer complies with management requirements contained in the agri-environmental agreement ($c = 1$ if the farmer complies, $c = 0$ if he does not comply). On the income side of the gross margin, there are: the sum of market revenues $\sum_{j,e,c} p_{jl} x_{jec}$, coupled subsidies $\sum_{j,e,c} s_j x_{jec}$, a decoupled subsidy L, and the total agri-environmental payment T. On the cost side, there are just the direct (assignable) costs $\sum_{j,e,c} r_{jec} x_{jec}$. Output prices p are differentiated according to different activities j and different states of nature l, coupled subsidies are differentiated along the activities j only, the decoupled subsidy L is by definition attributed without any relationship to the activities, direct cost coefficients r are differentiated along the indexes j, e and c in order to reflect any increased management cost of land subscribed under an agri-environmental agreement. The calculation of the total agri-environmental payment is explained below. In order to obtain the net income, which enters the risk-averse farmer's utility function, the fixed cost FC is to be subtracted from the gross margin, equation (10).

The block of equations (11) represents the common technical constraints with b_i representing the available quantity of resource i, and a_{ijec} representing the requirements of this resource by the activity x_{jec}. This single equation describes in reality the core of the farming system modelled including: *land management*, with basically the land availability and rotation constraints, *herd management* describing the herd demography and animal sales decisions, *feeding system* ensuring that feed availability meets animal requirements, and *fertilisation system* controlling fertiliser production and consumption.

Equations (12) and (13) describe the environmental good production and remuneration respectively. q represents the management requirement k contained in an agri-environmental agreement. d is the environmental coefficient of activity j with respect to the requirement k. The total environmental payment T is calculated as the sum of activities eligible for and complying with an agri-environmental agreement, multiplied by the agri-environmental payment t. In the cases modelled, activities eligible for agri-environmental agreements are specific grassland types. The environmental requirements q_k are usually expressed in terms of stocking densities or nitrogen application limits. Thus an example of the environmental coefficient d_{jk} is the annual nitrogen application on a certain grassland type. The agri-environmental payment t is then awarded per hectare of eligible grassland which complies with all the environmental requirements, x_{j11}. As stated in the introduction, the total area of land subscribed under an agri-environmental agreement, $\sum_j x_{j11}$, is considered as the primal proxy for environmental good production.

We mentioned above that it may be advantageous to use as a dual proxy for environmental good production the marginal cost of compliance with the agri-environmental agreement. This marginal cost of compliance for the environmental objective Z, expressed in hectares, can be obtained as the dual value of equation (14). More precisely, it can be obtained in this direct way only for a risk-neutral farmer. For a risk-averse farmer, whose objective function is not in monetary units, we have to re-calculate it following the procedure suggested by Preckel *et al*. (1987).

Direct payments and other income support instruments, like the Less Favoured Area (LFA) payments, are often accompanied by eligibility conditions, which have considerable influence on a farmer's management decisions. The eligibility conditions were omitted in the general model presentation but not in the applied models. These conditions could be theoretically modelled in a similar way as the environmental requirements but as they usually concern the whole farm, it is easier not to differentiate the activities by indexes but rather to introduce binary variables which enable eligibility constraints to be relaxed and in this way they indicate whether a farmer is or is not eligible. This approach was adopted for models used here.

Case studies

For the French case studies, we chose the region of *Monts du Cantal* located in the centre of France. Its landscape is of volcanic origin formed mainly by plateaux and river valleys. The altitude goes from 218 to 1 858 meters, and the studied zone is situated between 900 and 1 300 meters. Agriculture in *Monts du Cantal* is extensive, permanent and temporary grasslands representing some 95% of the utilised agricultural area (UAA). Sixty% of farms breed suckler cows in specialised or mixed herds. Sixty-five per cent of the total suckler cow herd is made up of the Salers race.[3] Several zones were designated as Environmentally Sensitive Areas, ESAs, (Opérations Locales Agri-Environnementales, OLAE) in order to enhance both the complementary and the competing beef and grassland biodiversity production.

An example of complementary beef and biodiversity production is the *Haute Vallée du Mars* (Upper Valley of the Mars River) ESA. In this ESA, grassland biodiversity is jeopardised by abandonment and by very low intensity of agricultural activity. The agri-environmental agreements impose on farmers minimum stocking density requirements and require renovation of already degraded grasslands. As mentioned above, we approximate biodiversity production by farmer's compliance with requirements contained in selected agri-environmental agreements. Biodiversity production in the Mars ESA is analysed on the basis of the agri-environmental agreement aiming at restoring seriously degraded pastures (pastures with more than 35% coverage by bushes). The land subscribed under this agreement (hereafter called the Mars Agreement) is to be mechanically cleared in the first year of the contract and maintained by grazing in the following years; a minimum stocking density of 1.5 livestock units (LU) per ha at least once a year must be respected on the cleared pasture.

The *Tourbières du Nord Cantal* (Northern Cantal Peatlands) ESA is constituted around valuable peatlands, where the danger of over-intensification is predominant. Because of the fragility of these biotopes, beef and biodiversity production are competing there. Several agri-environmental agreements were proposed to farmers containing basically restrictions on fertilisation and on the stocking density. Biodiversity production in the Tourbières ESA is for the purpose of this analysis defined by compliance with the agri-environmental agreement designed for pastures in the neighbourhood of peatlands.

3. Source: Chambre d'Agriculture dans le Cantal. (2002), *L'agriculture dans le Cantal*.

On plots enrolled under this agreement, in what follows called the Tourbières Agreement, mineral fertilisation is limited to 20 units of nitrogen per hectare and per year, and the maximum average stocking density per year is set at 0.55 LU per ha.

The region chosen for the Czech case study, the White Carpathians PLA, is situated in the East of the Czech Republic along the border with Slovakia. Its altitude varies from 175 to 970 metres. The main natural feature is the large area of calcareous grasslands with an exceptionally rich flora (orchids) and entomofauna, the existence of which is completely dependent on man's activities. The UAA covers some 44% of the PLA and 44% is grassland. Suckler cows represent 80% of the cow herd.[4] In 1996, the White Carpathians PLA was included into the world network of Biosphere Reserves under the UNESCO programme Man and the Biosphere (MaB) for its natural, scenic and cultural qualities.[5]

The White Carpathians PLA was one of the five zones selected for application of pilot projects in the framework of SAPARD (Special Accession Programme for Agriculture and Rural Development) and special agri-environmental schemes were designed for it. But this local approach to agri-environmental programmes was abandoned after the EU accession in 2004. Thus, nowadays the major instrument for biodiversity protection in White Carpathians is the national Sound Grassland Management (SGM) programme. The SGM programme is composed of *general agreements*, which can be subscribed by any farm in the Czech Republic, and of *supplementary agreements*, which can be subscribed only by farms in formally designated protected areas like the White Carpathians PLA. This programme distinguishes agreements for hay meadows, exclusively cut never grazed grassland, and for pastures. Only one supplementary agreement concerning pastures was proposed to farmers, we retained it for the present analysis in order to obtain some comparability with the French cases, where also only pastures are concerned by the modelled agreements. Biodiversity production in White Carpathians is thus approximated by compliance with requirements contained in the supplementary pasture agreement, called here the Carpathians Agreement.[6] The management requirements contained in this Agreement are: zero nitrogen application and stocking density of 0.4 to 0.8 LU per ha. From the latter requirement concerning stocking density it is obvious that beef and biodiversity production in the White Carpathians PLA is neither clearly complementary with beef production, there is an upper limit on the stocking density, nor clearly competing, there is a relatively important lower limit on the stocking density.[7]

Simulations and results

The simulations focus on the impact on environmental good production of decoupling of farming subsidies from agricultural production. This is modelled by summing up the coupled direct payments obtained by the modelled farm under a base scenario and by

4. Source: Partial report from the VaV/620/11/03 project (2003).
5. Source: *Bílé Karpaty Biosphere Reserve* at http://mab.kav.cas.cz/bile.karpaty/ (4 May 2006).
6. Havlík *et al*. (2006) call this agreement the 'pasture agreement'. Here the name was changed to maintain some coherence in names with the French cases.
7. The lower stocking density limit was for the below presented simulations increased to 0.5 LU per ha in order to better illustrate the potential complementarity relationship.

attributing this sum in the form of a lump sum payment under an alternative scenario. In order to obtain more insight into the problem, a coefficient of the degree of decoupling is introduced into the model and its value is progressively being varied from 0, zero decoupling, to 1, full decoupling.

First, results for the French case studies are presented. As mentioned above, results for a risk-neutral farmer are compared with those obtained for a strongly risk-averse one, defined in line with Anderson and Dillon (1992) by a coefficient of relative risk aversion with respect to wealth equal to 4. (The coefficient of relative risk aversion used in equation (16) must be expressed with respect to net income. Lien and Hardaker (2001) propose a method for the conversion.) The output price variability considered during the simulations is twice as high as the variability obtained from the price statistics. This is justified first, by the desire to make the effects of risk aversion visible if the uncertainty represents a real problem for the farmers, and second, by the fact that the variability in annual average prices as reported in aggregated price statistics is usually lower than the variability faced by an individual farmer. The base scenario for the French case studies corresponds to year 2002. Thus the amount of the fully decoupled payment is calculated as a sum of the beef market premiums existing at that time (suckler cow premium, special premium for male bovine animals, extensification premium and slaughter premiums). Thre is no arable land on sample farms; therefore arable crop premiums are not relevant.

The Czech case study results are then presented. This case study considers only a risk-neutral farmer. The reason is that the detailed representation of biodiversity production in the Czech model, especially the actual stocking density control, uses a lot of computational resources. Therefore additional complexity of the model by a non-linear objective function is not desirable.[8] The base scenario is represented by the year 2004. In that year, the CAP already applies to the new EU member states but its implementation differs from the old member states. Direct payments are attributed to Czech farmers in two different forms at the same time: a completely decoupled payment, the Single Area Payment Scheme (SAPS), and several coupled payments, the so called Top-Ups. SAPS is paid per hectare and does not differ according to land type. The funds available for direct payments from the EU budget are distributed in this form. Top-Ups represent the part of direct payments the Czech Republic is allowed to add to the EU funds to bring the total amount of direct payments received by Czech farmers closer to the level of direct payments attributed to farmers in the old member states. In year 2004, Top-Ups pertinent for our study were: the Arable Land Top-Up, paid per hectare of arable land, the Suckler Cow Top-Up paid per suckler cow, and the Cattle Top-Up, paid per livestock unit of cattle. In order to obtain totally coupled direct payments comparable to the French case, we set to zero the SAPS payment and we proportionately increased the Top-Up payments. Then the simulation of decoupling concerned the Top-Up payments only.

Both in France and in the Czech Republic, suckler cow premiums on an individual farm are limited by the number of individual premium rights. This makes the suckler cow payment in fact decoupled if the actual number of cows is higher than the number of premium rights. In order to avoid this confusion, we do not consider the individual premium limits during the simulations presented below.

8. It is possible to represent the risk aversion in a mathematical programming model also using linear objective functions in different forms *e.g.* MOTAD (Hazell, 1971) or Target MOTAD (Tauer, 1983) but then the comparability with French results would not be ensured either. As results presented in Havlík *et al*. (2005) show, the risk aversion is not likely to be the decisive parameter. Therefore we prefer to neglect it completely for the Czech case.

The simulation results are presented in terms of the technical stocking density (TSD) calculated as the number of livestock units per hectare of UAA, and the marginal cost of compliance (MCC) with particular agreements, expressed in euros per hectare. The technical stocking density serves as a proxy for the quantity of beef production, since we assume that land is a fixed factor, and for the farming intensity. The marginal cost of compliance is applied here as a dual proxy for the quantity of biodiversity production, varying in the opposite direction; an increase in the marginal cost of compliance leads, *ceteris paribus*, to a decrease in biodiversity production. The marginal cost of compliance was measured for the agreements to be subscribed on 10% and 20% of the UAA in the Mars ESA and Tourbières ESA, respectively. These values were determined using estimates of the Agreement eligible area based on interviews with local administration and with concerned farmers. In the White Carpathians case, theoretically all grassland is eligible for the Carpathians Agreement, but this is probably not the goal of the administration as other agreements are also proposed to the farmers. However, preliminary simulations showed that a large share of land has to be enrolled in order for the Carpathians Agreement to have an observable impact on the farming system. Therefore we decided to measure the marginal cost of compliance for 250 ha of land to be enrolled under the Agreement (the UAA of the modelled farm is 300 ha).

Monts du Cantal: complementary AND competing beef and biodiversity production

Results of simulations over the degree of decoupling carried out for the Mars ESA are summarised in Table 1. In the first row, we can observe that progressive decoupling of direct payments leads, as expected, to some extensification of the beef production; the average stocking density decreases by 8% between the zero decoupling and the full decoupling scenarios. This produces an increase in the marginal cost of compliance with the Mars Agreement. In fact, if all direct payments are coupled with beef production, and up to a 20% decoupling, the clearing and use of degraded pastures according to requirements contained in the Mars Agreement are the optimal production decision even if there is no remuneration for the compliance; the marginal cost of compliance is nil. But if direct payments become fully decoupled, the marginal cost of compliance increases to more than € 100per hectare. Thus as the analytical results suggest, decoupling direct payments is harmful to biodiversity production if it is complementary to beef production as is the case in the Mars ESA.

Results obtained for the strongly risk-averse farmer do not differ by much from those for the risk-neutral one. Thus we can observe also a decrease in the farming intensity accompanied by an increase in the marginal compliance cost. Differences between outcomes obtained for these two types of farmers, which can be considered as the uncertainty effect, are given in percents in the last two rows. If there is any uncertainty effect on beef production, it goes generally in the expected direction, making the farming intensity slightly lower for a risk-averse farmer compared to the risk-neutral one. The only exception is if the level of decoupling attains 80%. This insignificant deviation appears because the number of livestock units is only a proxy for beef production which hides differences in the herd structure between the two farmer types. The risk-neutral farmer prefers at this level of decoupling to have slightly less cows than the risk-averse farmer and to fatten animals up to 13 rather than 10 months of age, which is a riskier option. He produces probably more beef meat but the livestock unit coefficients do not reflect it correctly.

Table 1. Results of simulations over the degree of decoupling in the Mars ESA — complementarity

Degree of decoupling in %		0.00	20.00	40.00	60.00	80.00	100.00
RRA=0							
TSD	LU / ha	0.94	0.91	0.88	0.88	0.87	0.86
MCC	€ / ha	0.00	0.00	6.68	35.96	69.66	108.41
RRA=4							
TSD	LU / ha	0.94	0.91	0.88	0.88	0.87	0.85
MCC	€ / ha	0.00	0.00	10.26	39.38	72.53	111.77
Δ							
TSD	%	0.00	0.00	-0.43	-0.26	0.28	-1.31
MCC	%	x	x	53.64	9.51	4.12	3.09

RRA – coefficient of relative risk aversion with respect to wealth, TSD – technical stocking density, MCC – marginal cost of compliance, Δ – difference between the outcomes of risk-neutral and risk-averse farmers, $\Delta = 100 \times (X_{RRA4} - X_{RRA0}) / X_{RRA0}$

When comparing the marginal compliance cost of both farmers, we see that the risk-neutral farmer is more likely to produce biodiversity in the Mars ESA than the risk-averse farmer. The difference seems considerable for the medium degree of decoupling when expressed in percents, but in absolute terms it is less significant and rather stable across all the higher degrees of decoupling, amounting to some € 3 per hectare.

Simulation results for the Tourbières ESA are summarised in Table 2. Decoupling of direct payments leads to a decrease in beef production by the risk-neutral farmer also in this ESA, by 7%. But contrary to the Mars ESA, this produces a decrease in the marginal cost of compliance with the Agreement, by some 60%. Thus decoupling of direct subsidies is beneficial for biodiversity production if it is competing with beef production as is the case in the Tourbières ESA.

Table 2. Results of simulations over the degree of decoupling in the Tourbières ESA — competition

Degree of decoupling in %		0.00	20.00	40.00	60.00	80.00	100.00
RRA=0							
TSD	LU / ha	0.92	0.89	0.88	0.88	0.87	0.86
MCC	€ / ha	258.14	209.32	214.31	175.00	136.09	102.96
RRA=4							
TSD	LU / ha	0.92	0.89	0.88	0.88	0.87	0.86
MCC	€ / ha	256.44	208.50	212.54	171.85	127.28	100.05
Δ							
TSD	%	-0.36	0.00	-0.63	0.00	-0.50	0.00
MCC	%	-0.66	-0.39	-0.83	-1.80	-6.47	-2.82

Similarly as in the Mars ESA, there is not a significant difference between the results obtained for a risk-neutral farmer and those obtained for a risk-averse one. We can observe also for the risk-averse farmer a decrease in the farming intensity accompanied by a fall in the marginal compliance cost. The uncertainty effect on beef production goes in the expected direction; if beef production is not the same, the risk-averse farmer produces less than the risk-neutral one. The expectations concerning environmental good production are also confirmed; the risk-averse farmer is more willing to produce biodiversity if it is in competition with beef production than is the risk-neutral farmer.

In summary, the French example showed that decoupling of direct payments from beef production can have significant effects on grassland biodiversity production. These effects depend essentially on the type of jointness between beef and biodiversity but they seem to be similar for both risk-neutral and risk-averse farmers.

White Carpathians: complementary or competing beef and biodiversity production

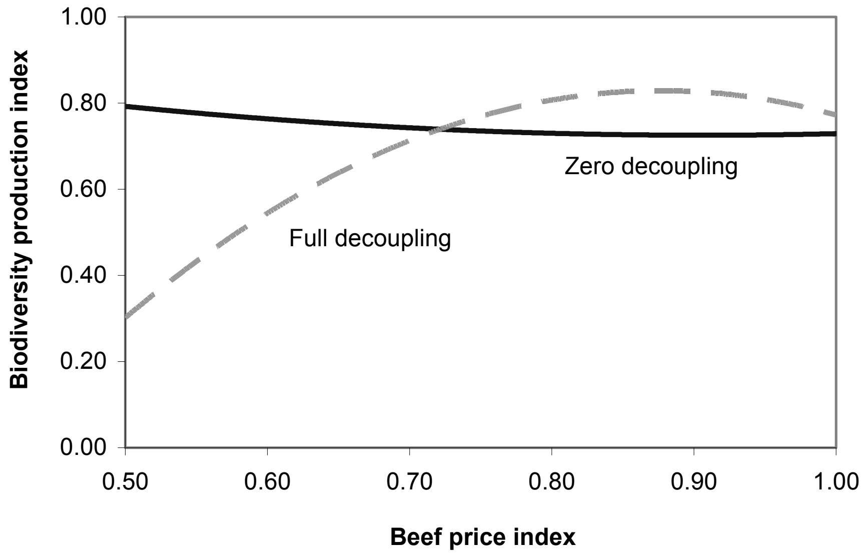
Simulations for grassland biodiversity production in the White Carpathians PLA were carried out only for a risk-neutral farmer. As we have seen above, the uncertainty effect is rather small, thus little information should be lost if we neglect the risk-aversion. The results are summarised in Table 3. As in the French case studies, decoupling of direct subsidies leads to a decrease in beef production, by 17% in this case. Concerning environmental good production, the marginal cost of compliance with the Carpathians Agreement decreases systematically as the degree of decoupling increases; it is 59% lower for the full decoupling scenario compared to the zero decoupling scenario. This result is similar both in direction and value to the result obtained for the Tourbières ESA. However, the definition of the grassland biodiversity production within the Carpathians Agreement, where the required stocking density is not defined only by an upper limit but also by a lower limit, suggests that we should be careful before concluding that beef and biodiversity production competes one with the other, and that thus full decoupling is the best policy option.

Table 3. Results of simulations over the degree of decoupling in the White Carpathians PLA: base scenario price level (output price index = 1)

Degree of decoupling in %		0.00	20.00	40.00	60.00	80.00	100.00
TSD	LU / ha	0.82	0.80	0.80	0.78	0.75	0.68
MCC	€ / ha	235.25	203.49	170.44	139.53	124.28	95.28

We should analyse the beef and biodiversity production relationship on the basis of the firm market behaviour characteristics in the presence of different sources of jointness, as it was summarised by Moschini (1989). According to Moschini, if beef and biodiversity are joint through a non-allocable input, in other words if they are complementary, biodiversity production will increase when beef prices increase. If beef and biodiversity production compete for a fixed allocable input, biodiversity production will decrease when beef prices increase. We carried out simulations over different beef price levels, and their results in terms of biodiversity production are summarised in Figure 1.

Figure 1. Joint beef and biodiversity production



Biodiversity production is expressed here by an index indicating the share of land managed in compliance with the Carpathians Agreement on the modelled farm. An agri-environmental payment is to be introduced into the model for the environmental good production to enter the optimal solution without forcing the farmer to do so. A payment of 20 euros per hectare is proposed for the Agreement. Under the zero decoupling scenario, beef and biodiversity are competing over the whole range of simulated price levels. Under the full decoupling scenario, it can be observed that for low levels of the beef price index, beef and biodiversity production are complementary but when beef prices approach the base scenario level, beef and biodiversity production becomes competitive.

This shows the complexity of the production system interlinked through several production factors. For low price levels and high degrees of decoupling, the production process is determined by the presence of non-allocable inputs. We suggest here to consider the cattle herd as the major one; when farming intensity is low, an increase in the herd size leads to an increase in biodiversity production. For high price levels and low degrees of decoupling, the production process is determined by fixed allocable inputs, here namely the land, which, above certain farming intensity, cannot be used for higher levels of both beef and biodiversity production at the same time.

Simulations over the degree of decoupling were also carried out for beef prices decreased by 50% compared to the base scenario in order to check the effects of various degrees of decoupling on environmental good production at a price level where beef and biodiversity production might be complementary. Results of these simulations are summarised in Table 4. As expected, the farming intensity is lower for any degree of decoupling than with the base scenario price level, and it decreases as the degree of decoupling increases, at least to a certain value, then it stagnates. More interesting is the evolution of the marginal cost of compliance with the Carpathians Agreement. It decreases as the degree of decoupling increases up to some 40% decoupling, where it approaches zero, than it starts to increase. Thus, while marginal cost of compliance falls to not more than 6% of the value with zero decoupling, for 40% decoupling, it represents

56% of the zero decoupling value if direct payments are fully decoupled. This is because while without decoupling, it is the upper stocking density requirement which is binding for the modelled farm, beef and biodiversity are competing, at 60% and higher degrees of decoupling, the lower stocking density requirement is binding, beef and biodiversity are complementary.

Table 4. Results of simulations over the degree of decoupling in the White Carpathians PLA: decreased price level (output price index = 0.50)

Degree of decoupling in %		0.00	20.00	40.00	60.00	80.00	100.00
TSD	LU / ha	0.74	0.71	0.50	0.39	0.39	0.39
MCC	€ / ha	92.30	40.56	5.15	17.74	34.60	51.47

In summary, the White Carpathians case study demonstrates on the one hand the general validity of the analytical results and the numerical results for the French case, which suggests that decoupling is, from the environmental point of view, beneficial for competing beef and biodiversity production but harmful to complementary beef and biodiversity production. On the other hand, this case study reminds us that the type of jointness is relative. It depends not only on physical parameters like the biotope or the current farming intensity, but also on market parameters such as the output prices and on policy parameters such as the degree of decoupling of farm income support.

Conclusion

We investigated potential effects on the environment of decoupling farm income support from agricultural commodity production, more specifically on grassland biodiversity production by suckler cow farms. Application of mathematical programming farm-level models allowed us to explicitly account for the production relationships between beef and biodiversity. Different biotopes representing complementarity and competition in beef and biodiversity production in different zones or in a single zone were analysed in France and in the Czech Republic. The numerical results confirm those obtained analytically: decoupling is likely to be beneficial for grassland biodiversity when the latter competes for inputs with beef production but it will be harmful when beef and biodiversity production are complementary. We checked also for the effects of uncertainty and farmers' risk aversion on these outcomes. The approach applied confirmed that the risk-averse farmers are more (less) willing to produce grassland biodiversity when it is competing with (complementary to) beef production than the risk-neutral farmers. Nevertheless, the uncertainty effects appear negligible.

To decouple or not to decouple in order to enhance environmental quality? If we considered the region of *Monts du Cantal*, to which the French case study was applied, as a whole, the answer is: "It doesn't matter!" Actually what we gain by decoupling on grassland biodiversity production in the Tourbières ESA, we lose in the Mars ESA. If we consider only the region of White Carpathians, the answer is: "It depends!" We have observed that under the current price level, full decoupling of direct payments is the best choice. But if prices decreased, partial decoupling could become preferable. If we consider also other environmental effects of agriculture like water and air pollution or land erosion, it can be assumed that at the beginning of the 21st century, agriculture is generally in competition with the environment therefore decoupling could, in total, be beneficial but it is not a remedy to all environmental problems. For this reason, the June 2003 CAP reform accompanied direct decoupled support by, among others, environmental cross-compliance conditions. The results presented above recall that these conditions should pay at least the same attention, if not higher, to complementary environmental goods, directly threatened by decoupling, than to competing environmental goods, whose production is facilitated by decoupling.

The argument to pay special attention to complementary environmental goods during the process of decoupling of direct payments is further strengthened by the fact that as we have observed in the case from White Carpathians, decoupling may even change the type of jointness, from competition to complementarity. This last point illustrates that the type of jointness is not only policy relevant, in the sense that information about it is important to design appropriate agricultural policies because their effect will differ depending on the underlying type of jointness, but also policy relative, in the sense that the type of jointness may differ depending on the type of policy implemented.

These conclusions are to be considered with caution because of some limits of our analysis. First, a short term perspective was adopted, considering certain production factors and some costs as fixed. In the long-term, decoupling of direct payments can lead to structural changes and to land abandonment. These effects are likely to further support our claim for concrete cross-compliance conditions aiming at environmental goods complementary to agricultural commodities. Second, we investigated a specific sector – beef cattle farms in mountainous areas. It is not sure that decoupling will have the same effects in terms of farming intensity, neither that the observed uncertainty effects will remain insignificant, also in other sectors. Thus further empirical studies are needed in different sectors by means, if possible, of models able to account for the structural change in order to better inform policy decisions.

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De-linked Cost of Rural Landscape Maintenance: A Case Study from the Swiss Lowlands

by
Robert Huber

Land-use in Switzerland continues to be dominated by agriculture. Approximately 40% of the total area (11 000 km^2) is managed by farmers. The rest of the surface is either forest (30%), unproductive mountain area, lakes and rivers (26%) or built up areas (BLW, 2004). A change in agricultural structures or the amount of land in production would therefore also change landscape and open space amenities. This leads to the fundamental source of jointness between agriculture and landscapes. Since both have the same input factor, land, no separate production functions exist for agricultural products and landscape maintenance. For that reason, the latter can also be seen as an externality of agricultural production (Hediger and Lehmann, 2003). However, the intrinsic relationship is shifted under current agricultural support schemes. In Switzerland, market price support and direct payments result in a producer support estimate (PSE) of 68% (OECD, 2004). The extent of agriculture's contribution to landscape amenities in an unsupported situation is unknown. From an economic perspective, however, the assessment of jointness needs a reference to this basic situation in order to evaluate efficient provision schemes. Moreover, agricultural support not only entails positive effects on landscapes, such as open space amenities or the provision of certain landscape elements, but also negative effects, *e.g.* the deterioration of wild life habitats or nutrient runoff. These relationships are based on complex ecological interactions which are often poorly understood (Heal and Small, 2002).

Complexity and distortion make a well-founded analysis of jointness between agriculture and landscape difficult. Therefore, the OECD framework suggests that economies of scope should be evaluated in order to translate jointness into a policy-orientated indicator (OECD, 2003). In the case of landscape amenities, economies of scope exist if the joint provision of commodity production and landscape amenities by agriculture result in lower costs than if the commodity was imported and landscape amenities were to be provided by alternative non-agricultural actors. Determining economies of scope involves three steps (OECD, 2003)

- *Assessment*: can landscape maintenance be de-linked from agricultural production? Is it possible to de-link landscape maintenance without costs?
- *Estimation*: if de-linkage generates costs, estimate these costs.
- *Comparison*: do economies of scope exist in agricultural joint provision compared with the costs of the de-linked provision of landscape and the import costs of the commodities.

With regard to landscape maintenance, the first two questions in step 1 must be answered with yes. It would be easy to de-link provision, because landscapes in Switzerland could be managed and maintained by other parties, such as governmental institutions, farm contractors or machinery pools, instead of farmers. However, this de-linkage would generate costs. This implies that the provision costs of alternative actors (step 2) must be estimated in order to assess economies of scope (step 3).

The purpose of this article is a) to analyse the consideration of alternative actors in the context of landscape maintenance from a theoretical point of view and b) to estimate provision costs for a case study in the Swiss lowlands. In a next step, the latter can be used as a basis for the identification of economies of scope in agricultural landscape provision.

From a welfare economic point of view, the basis for this analysis is a given societal demand for the emerging benefits of landscape maintenance. Consequently, the existence of a demand for these benefits is a "first order condition" (Wolcott, 2006). Furthermore, an existing study of the demand for multifunctional benefits in Switzerland shows clear spatial patterns (Haller *et al*., 2006). Therefore, demand for landscape maintenance in urban areas differs from that in rural or mountain areas.

This paper is organised as follows: Section 2 describes the general relationship between agriculture and landscape. In Section 3, the effects of alternative actors on the optimal provision of open space amenities are analysed using a standard theoretical model. The case study is presented in Section3. It consists of four parts: a) Description of the case study region, b) Reference scenario, c) Basic calculation set-up, d) Results. A concluding section ends the paper.

Agriculture and landscape

Landscape is an amalgam of natural, economic and cultural aspects and can be defined in different ways. Hence it is important to delimit the term landscape for the following investigation (Umbricht, 2003). Basically, landscape can be defined as an object which consists of ecological functions and processes (Leser, 1997). In addition, such an ecosystem interacts with humanity in two ways: on the one hand, people use ecosystem goods and services for the production of commodities and services, while on the other hand, landscape is a cultural and recreational resource (Gerber, 2006; BUWAL, 2003; Coe, 2000). The latter is beyond the scope of this study, but is nevertheless an important aspect in identifying the demand for a certain landscape (Hunziker, 2000).

Ecosystem services provide a holistic concept for the assessment of the interactions between agriculture and environment (Daily, 1997; Costanza *et al*., 1997; Heal and Small, 2002). This concept defines regulation, production, habitat and information functions which emerge from the underlying structures and processes of the ecosystem (De Groot *et al,* 2002). In this study, only the aesthetic function of landscapes is considered, *i.e.* a specific part of the information functions in the ecosystem services concept. The other functions are excluded in order to avoid duplicating provision costs and thus allow the assessment of economies of scope in non-agricultural provision (OECD, 2003). Landscape aesthetics are represented by agricultural land-use and landscape elements such as trees or hedgerows. In addition, other aspects of landscape aesthetics, such as residential area enlargement, buildings, forests or the importance of panorama are excluded, because they are not regulated by agricultural policy.

The sources of jointness between agriculture and landscape aesthetics cannot be reduced to a single cause. Rather, all causes listed in OECD (2001), technical and economic interdependencies, contribute to the provision of landscapes. For this study, the emphasis is placed on two main aspects:

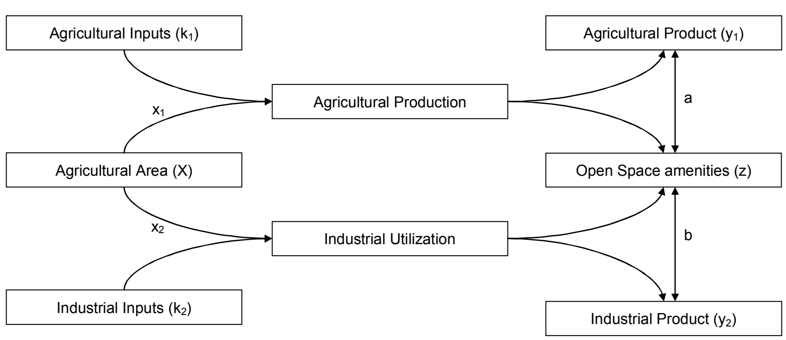
- in the case of land-use, the non-allocable input land is the source of jointness Regardless of the form, intensity and character of the use, the important aspect is to have land in any kind of production. This source is related to all open space amenities;
- the source of jointness between agriculture and landscape elements is based on more complex interrelationships. Here, allocable fixed factors are an important source of jointness. Landscape elements such as trees, hedgerows or colourful fields are often complementary to a certain degree of agricultural intensity and compete thereafter (Havlik *et al*, 2005; Harvey, 2003).

Consideration of alternative actors in landscape maintenance: theoretical aspects

From an agricultural point of view, the main function is the production of food and fibre whereby landscape maintenance is a by-product. On the other hand, alternative actors deal with the problem arising from landscape maintenance with biomass as a by-product. In a sustainable system with closed production cycles, the accumulated biomass ends up as industrialised products such as energy, chemical products, fuel, protein forage or insulation material.

The following theoretical model analyses the consequences of integrating alternative actors in an optimal provision of cultivated landscapes. The analysis is reduced to open space aspects of landscape maintenance. The model consists of two inputs and outputs respectively. Private products (y_1, y_2) are conjoint with open space amenities (z) due to the use of the common input land (x_1, x_2). This relationship is represented by the two arrows a, b in Figure 1. It is assumed that society demands the use of the whole area (X); otherwise the analysis of an optimal provision would not be justified.

Figure 1. Inputs and outputs in the provision of open space amenities



The problem can be formulated as follows:

(1a) $$MaxU = U(y_1, y_2, z)$$

(1b) $$y_1 = y_1(x_1, k_1) \qquad y_2 = y_2(x_2, k_2)$$

(1c) $$z = z[y_1(x_1, k_1), y_2(x_2, k_2)]$$

(1d) $$X = x_1 + x_2$$

Further assumptions are: small country case, open economy and world market prices.

The following first order condition can be derived on the basis of the economic axiom that in a social optimum the value of the marginal product of an additional input must be equal in both uses:

(2) $$\frac{\partial U}{\partial y_1}\frac{\partial y_1}{\partial x_1} + \frac{\partial U}{\partial z}\frac{\partial z}{\partial y_1}\frac{\partial y_1}{\partial x_1} = \frac{\partial U}{\partial y_2}\frac{\partial y_2}{\partial x_2} + \frac{\partial U}{\partial z}\frac{\partial z}{\partial y_2}\frac{\partial y_2}{\partial x_2}$$

The sum of marginal utilities from the private good (term 1) and the open space amenities (term 2) are equal in both uses. Moreover, the net marginal utility of land must correspond to the shadow price — the price at which another unit of land would be cultivated. How can the conditions in (2) be achieved? This causes the following optimisation problem for both farmers and the alternative actors:

(3) $$Max\pi_i = p_{y_i} y_i(x_i, k_i) + p_z z\{x_i[y_i(x_i, k_i)]\} - rx_i - C_{y_i}(x_i, k_i)$$

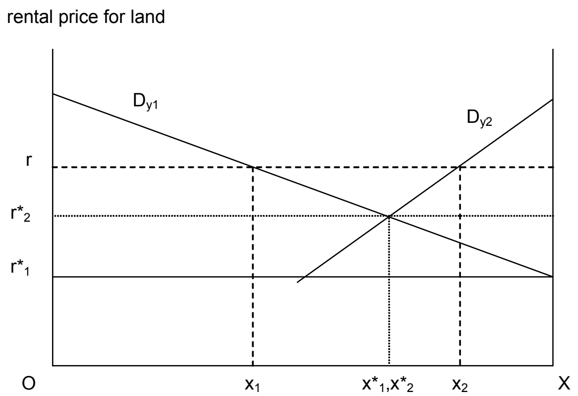
P_{yi} and p_z are the prices for the private and the public good respectively (p_z can be interpreted as societal marginal willingness to pay for open space areas); r is the rental price for land, which is assumed to be exogenously determined, and C_{yi} is defined as other production costs of the corresponding good. In this case, the first order condition for an optimal allocation of the input factor x_i has the following form:

(4) $$\left(p_{y_i} + p_z \frac{\partial z}{\partial y_i}\right)\frac{\partial y_i}{\partial x_i} = r + \frac{\partial C_{y_i}}{\partial x_i}$$

As long as p_z is zero, farmers and alternative actors would use land to the point at which marginal profits equal private marginal costs. The latter contains two components: the rental price per unit of land and other marginal production costs. Under unfavourable conditions for agriculture (low agricultural surface suitability, steepness etc.), it is unlikely that the whole area would be cultivated in the case of a private optimum. In order to satisfy the assumed societal preferences, either the price for the private goods must be elevated by p_z ($\partial z/\partial y_i$) or society must make an equivalent area payment, which would lower the rental price for land r. This would represent a direct reward for the delivery of open space benefits.

Since open space areas are easy to monitor, low transaction costs can be expected and a direct payment would, in this case, be more efficient than a price subsidy (Vatn, 2002). Moreover, because of the small country case, effects on international prices and trade regimes would be negligible (Le Cotty and Voituriez, 2003; OECD, 2003). Therefore, in the following comparative static analysis, the internalisation of open space amenities is implemented via an area payment. Figure 2 illustrates an optimal allocation of the input factor land. D_{y1} and D_{y2} represent the demand for area of farmers and non agricultural actors respectively.

Figure 2. Optimal allocation of agricultural area between farmers and alternative actors



D_{y1}: agricultural demand for land
D_{y2}: demand of alternative actors for land
X: total area (societal demand for Open Space)
x_1: area used by farmers (no support)
x_2: area used by alternative actors (no support)
$x^*_1 x^*_2$: optimal allocation of land
r: exogenous land rent without payments
r^*_i: land rent with area payment

Under a given land rent r, agriculture and alternative actors would – in their private optimum – use the area x_1 and x_2 respectively and the area in between would not be cultivated (fallow land). The introduction of an area payment lowers the rental price for land and allows a societal optimal allocation of land.

If agriculture alone is considered in the provision of open space, the condition at which a social optimum is achieved would be an area payment amounting to $r\text{-}r^*_1$. At this point, farmers cultivate the whole area.

If both actors are taken into account, equations (2) and (4) imply the following efficiency conditions:

$$(6)\ \left(p_{y_1} + p_z \frac{\partial z}{\partial y_1}\right)\frac{\partial y_1}{\partial x_1} - \frac{\partial C_{y_1}}{\partial x_1} = \left(p_{y_2} + p_z \frac{\partial z}{\partial y_2}\right)\frac{\partial y_2}{\partial x_2} - \frac{\partial C_{y_2}}{\partial x_2} = r$$

In the social optimum, the net marginal social benefit of land is the same in both activities and is equal to the rental price for land. This is represented by the intersection point of the demand functions in Figure 2. An area payment of $r\text{-}r^*_2$ is required to reach this point. Here, the social demand for open space is attained with a lower area payment than if only farmers are considered because both demands for land are taken into account. This leads to the conclusion that economies of scope in agricultural landscape maintenance exist as long as the value of the marginal product of an additional unit of fallow land is higher in the agricultural production cycle than in an industrial one.

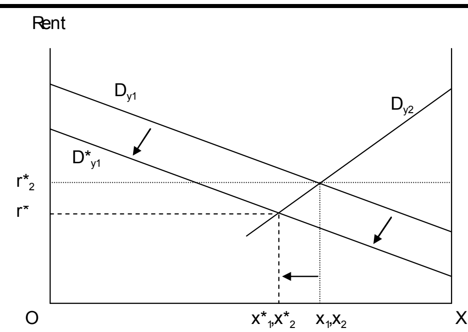
This aspect is explored in more detail with a comparative static analysis in Tables 1 and 2. The figures show changes in the general conditions which

- weaken the relative jointness of agriculture and landscape in comparison to the reference scenario without any support;
- strengthen the relative jointness.

Table 1. Relative weakening of jointness between agriculture and open space amenities

Decrease in demand from agriculture

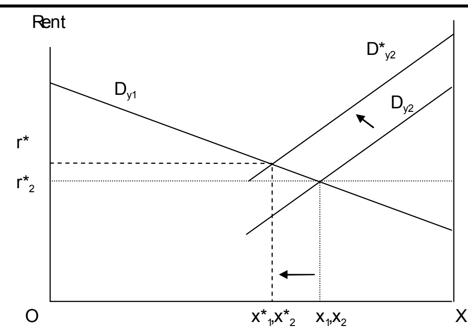
- Decreasing prices for agricultural products
- Higher production costs in agriculture



A decrease in agricultural demand implies a shift of D_{y1} to D^*_{y1} and the area still in agricultural production moves to the left (x^*_1). Under the assumption that only an area payment would allow an optimal allocation in the first place (x_1x_2), this payment would have to increase by the amount of r^*_2-r^*.

Increase in demand from alternative actors

- New (improved) technologies in biomass utilisation
- Increasing energy prices

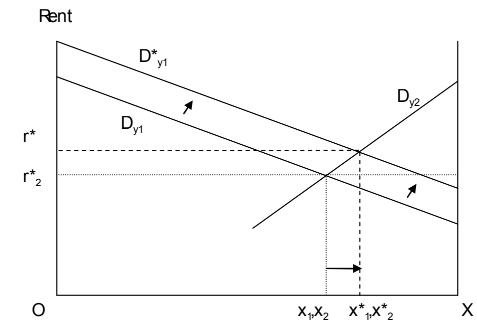


An increase in demand from alternative actors from D_{y2} to D^*_{y2} also causes a decrease of the area in agricultural production. However, the amount of the area payment needed to reach an optimal solution falls by (r^*_2-r^*).

Table 2. Relative strengthening of the jointness between agriculture and open space amenities

Increase in demand from agriculture

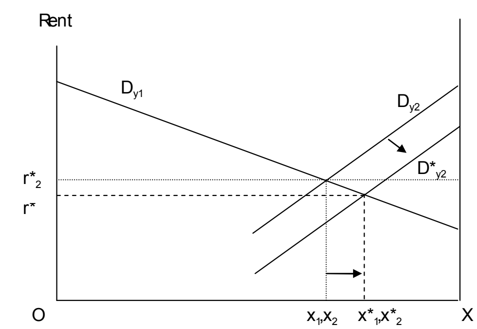
- Increasing prices for agricultural products
- Productivity gains in agriculture (technical development, structural change)



An increase in demand from the agricultural side shifts the demand function from D_{y1} to D^*_{y1}, and a bigger part of the total area would be cultivated by farmers. The area payment would decrease by the amount of r^*_2-r^*.

Decrease in demand from alternative actors

- No technological development and stagnating or decreasing energy prices



The emerging demand function in this case would be D^*_{y2}. Again, the area in agricultural production increases, but in comparison to the initial situation, the area payment required would increase by (r^*_2-r^*).

Two conclusions arise from this comparative analysis:

a) From a theoretical point of view, economies of scope in agricultural provision of open space amenities exist as long as the value of the marginal product of an additional unit of fallow land coming into an agricultural production cycle is higher than in an alternative, industrial utilisation. A main challenge is to identify spatial aspects. In the optimal solution, demand varies strongly due to:

- varying social demand for open space amenities in different regions;
- different spatial provision costs as a result of surface suitability, steepness, etc., and the distance to markets for private goods;
- existing property rights.

b) Economies of scope, as a means of identifying jointness, adds a dynamic component to the analysis: the degree of jointness changes with different general conditions (OECD, 2003). The following factors are important with regard to landscape maintenance:

- structural changes in agriculture;

- new technologies and technical development in the industrial utilisation of biomass and biomass conversion facilities;
- increasing demand for food and energy;
- institutional change in domestic policies (property rights, environmental and agricultural policies).

However, open space amenities are only one part of landscape maintenance. This static analysis does not take into account any changes in agricultural production intensity, which can affect landscape elements negatively. Nevertheless, in reality, area payments also have insurance and welfare effects and can therefore change agricultural production intensity (OECD, 2006). Another important restriction is the "small country case" assumption. Since the amount of food produced on the additional surface does not influence world market prices, feedback effects need not be taken in account (Le Cotty and Voituriez, 2003).

In the Swiss lowlands (in contrast to the mountain area), current market price support and area payments for farmers generate such a demand for agricultural area that an emergence of fallow land cannot be observed at the moment. The merging of agricultural policy measures makes it difficult to adapt the theoretical model to the actual situation in Switzerland. Therefore, it is all the more important to investigate the structural effects of a large price reduction for agricultural commodities in order to assess the underlying jointness between agriculture and landscape (Abler, 2004).

Case study

Region

The watershed of Lake Greifensee in the Canton of Zurich, with a total area of 15 579 ha, provides a basis for the case study region. The calculations of de-linked landscape maintenance costs are restricted to the surface currently in agricultural production, which covers 8357 ha (54% of the total area). Climate and surface conditions, which limit crop production to one fifth of the agricultural area, lead to a grassland dominated landscape (Zgraggen, 2005). This area is suitable as a case study region for two reasons:

- a previous research project in this region (Flury *et al*, 2004) provides well developed (GIS-) data on existing land use, surface suitability and landscape aesthetics;
- Lake Greifensee is a local recreation area for more than one million residents in the agglomeration of Zurich. Current demand concerning recreational and ecological amenities implies a certain willingness to maintain existing landscape in the future.

The latter is confirmed by two research studies regarding landscape aesthetics in the Greifensee region: a) a study based on expert knowledge, which describes landscape by means of characteristics, diversity and nature proximity (Schüpbacke *et al*, 2004); and b) a willingness to pay analysis for land-use change using “choice experiments” (Schmidtt *et al.*, 2005).

Reference scenario

In order to estimate the de-linked costs of landscape maintenance, it is necessary to know what amount of area and landscape elements respectively must be provided in the case study region. This in turn raises the question of how much of the area would, under world market prices, still be used for agricultural production thereby revealing the underlying jointness between agriculture and landscape. As mentioned above, the contribution to rural landscape maintenance which could be expected under world market prices is as yet unknown, because so far, the effects of large price reductions on agricultural structures have not been investigated. Therefore, the amount of fallow land is depicted in a reference scenario (Figure 3). The basic assumptions for this scenario are:

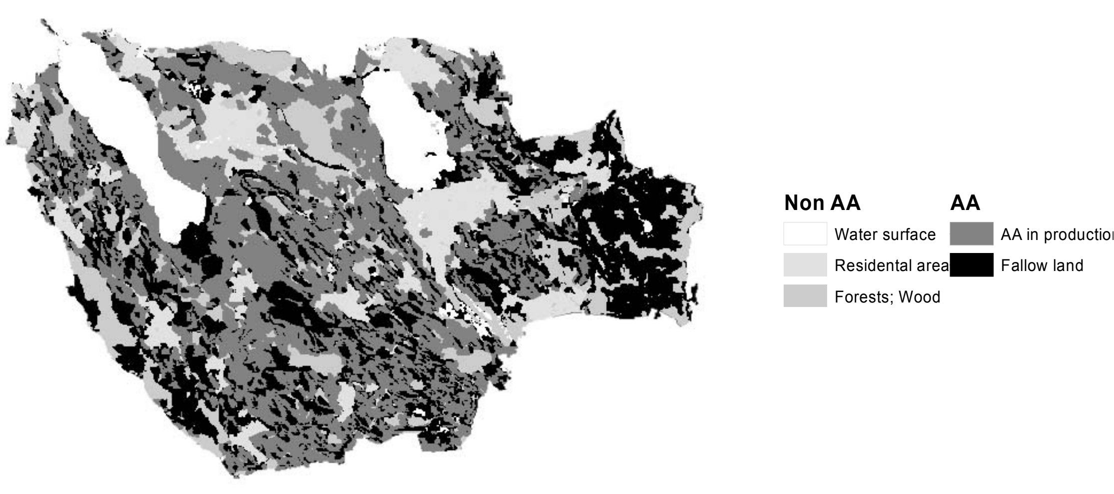
- Surface suitable for crop rotation (60% of agricultural area) remains in production due to food security aspects. Again this is assumed in order to avoid duplicating provision costs. In this way, estimated costs can be linked directly to landscape maintenance and are not confused with the other goals of multifunctionality in the Swiss constitution (BLW, 2004).

- Surface less suitable for agricultural production is more likely to be abandoned under lower output prices. Therefore, the calculations are made stepwise: firstly, the costs are estimated for surfaces with low agricultural productivity, such as extensive grassland and wet meadows. It is then assumed that areas with a higher suitability, such as moderately suitable grassland and grassland where forage production is preferred, are also abandoned (labelling see Zgraggen, 2005).

- Since the study carried out by Schmitt *et al.*, 2005) demonstrates public willingness to accept a moderate forest expansion, 5% of the surface is assumed to leave agricultural production.

Figure 3 shows a GIS map of the case study region. On the one hand, it depicts agricultural areas (AA), *i.e. s*urface still cultivated by agriculture (for efficiency or food security reasons) and on the other hand, non-agricultural areas (Non AA), such as settlement areas, rivers and forests.

Figure 3. Fallow land under world market prices in the case study region



Source: Szerencsits *et al.* 2004

Calculation

Based on the first section, provision costs of landscape maintenance by alternative actors can be divided in two categories: costs for open space amenities (per ha) and costs for the maintenance of landscape elements.

The former depend on the following factors: goal of the maintenance, type of grassland, necessary maintenance measures (mowing, mulching), disposal costs of accumulated biomass and the corresponding cost elements. Total costs can be estimated by adding the cost per parcel and per surface suitability class consecutively. Costs for the maintenance of existing landscape elements are calculated for each surface suitability class, adding up costs per unit of trees, hedgerows and bushes as well as tree rows and crop fields (colour element).

In this case study, the goal of the maintenance is the preservation of existing landscape aesthetics. Therefore, no additional actions for example bio-diversity improvement must be considered. The type of grassland varies with surface suitability, elevation, steepness of the parcel and existing use. Necessary annual maintenance measures are mowing and mulching in summer and in autumn respectively. Whether or not mulching is a suitable measure for maintaining abandoned farmland is part of an ongoing scientific discussion. Briemle (2006), Briemle (2004) and Schreiber *et al.* (2000) show that mulching would suffice for landscape maintenance. Due to an elevated level of airborne nitrogen and the existing intensive land-use in the case study region, mulching is rejected as the sole maintenance activity and only possible in combination with mowing. Cost elements for the different activities are: labour, machinery, facilities and corresponding indirect costs. 30 years ago, Bierhals (1976) already noted that mechanical and agricultural practices in landscape maintenance are comparable but can differ considerably with varying environmental and technical conditions such as scale effects by shifting from small to larger plots, higher engine power, increasing stand density in grasslands, steepness of plots and cost degressions due to wider machines (Bierhals, 1976). These aspects are also integrated into the calculation: scale effects are considered by a maximal workload of all machines, engine power and machine width varies with plot size in order to depict cost degressions. Different yield assumptions are used to make allowance for varying densities in grasslands due to environmental conditions (surface suitability) and finally, steeper plots are associated with higher maintenance costs. Data originates from a German composition of average costs in landscape maintenance (KTBL, 2006) and, for a specification of landscape element costs, from various other German sources (Kapfer *et al*, 2003, LEL, 2006 and Roth and Berger, 1999). German data is used rather than domestic data because it is much more detailed and, under the assumption of world market prices, the provision costs in Switzerland would decrease due to structural changes. An hourly wage of 30 € is presumed for labour costs. With regard to biomass disposal, four different possibilities are taken into consideration: burning in a waste incinerator (KVA), composting on fields, fermenting in a bio-gas plant or in a bio-refinery. The latter produces, in addition to energy, protein forage and insulation material (Grass, 2004). Data for the disposal methods stem from different Swiss studies, which compare the efficiency of the different systems (Schiess, 1999; Leitzinger *et al.*, 2006; Brühlmann, 2003, Oettli *et al*., 2004). Future developments concerning biogas plants and bio-refineries are based on the bio-energy vision 2020 of the Swiss Federal Office of Energy (Angele, 2006). Based on this scenario, a bio-gas plant and a bio-refinery are anticipated with a capacity of 3 000 and 5 000 tonnes of biomass utilisation respectively. A maximum of 5% of the accumulated biomass can be composted; the rest has to be burned in a KVA. Biomass disposal is a crucial task because the legal regulations concerning waste disposal are strict in Switzerland. Due to the high population density, scarcity of space and high environmental standards, Switzerland has a rigorous waste disposal system throughout the country. It is therefore not possible to just build a landfill site in this region.

Results

In the Greifensee region, provision costs of landscape maintenance by alternative actors amount to five million Euro (Table 3). With this sum, an area of 3 580 ha (43% of total area) is cultivated. Mowing and mulching the corresponding area cost nearly one quarter (23%) and the maintenance of landscape elements one fifth of total costs (21%). However, the highest percentage of total costs is generated by biomass disposal (56%).

There is only a small amount of marginal areas (extensive grassland, wet meadows) in this region. Therefore, the associated costs also remain low. However, costs increase sharply if moderately suitable grassland goes out of agricultural production as well.

Table 3 shows that more than three quarters of the total costs are linked to open space amenities. This implies that in this grassland dominated region, the non-allocable input land is much more important as a source of jointness than other complex (economic) interrelationships. In addition, the increasing share of fallow land raises the disposal costs disproportionately because an increasing amount of agricultural area with higher yield potential is abandoned. Sensitivity analysis of the calculations emphasises the key role of biomass disposal costs in landscape maintenance by alternative actors. Different scenarios in biomass disposal possibilities alter the total costs significantly, whereas the influence of alternative assumptions concerning hourly wages or machine workload is low. Thus biomass disposal is the crucial factor in landscape maintenance by alternative actors in the Greifensee region.

Since the calculations are based on average costs and do not include any optimisation, the emerging costs must be considered as an upper limit.

Table 3. De-linked cost of landscape maintenance in the region of Greifensee

Surface suitability	Extensive grassland	Wet meadows	Moderate suitable grassland	Forage production preferred	Total fallow land	Total area
Surface (ha)	246	168	1 866	1 300	3 580	8 357
% of total area	3%	2%	22%	16%	43%	100%
Cost (€ million)					**Total cost**	**% of total cost**
Maintenance	0.14	0.05	0.53	0.43	1.2	23%
Biomass	0.19	0.14	149	0.95	2.8	56%
Landscape elements	0.13	0.03	0.51	0.37	1.0	21%
Total	0.5	0.2	2.5	1.8	5.0	

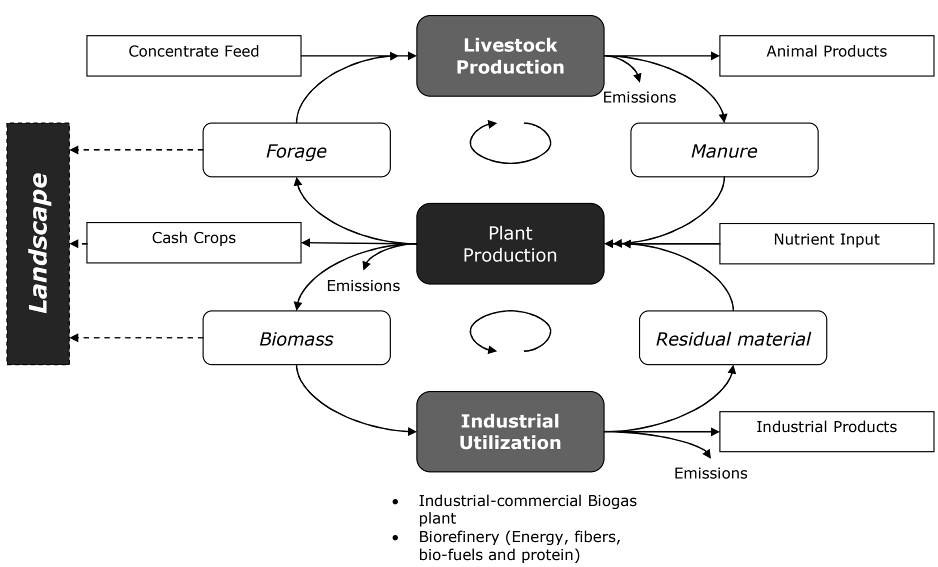
Conclusions

Results from the case study show the importance of biomass disposal in achieving an efficient provision of landscape maintenance. Thus, the potential for economies of scope in agricultural landscape provision do not arise from the maintenance cost but from more efficient biomass utilisation. Alternative actors may have lower costs for mowing and mulching the corresponding areas due to scale effects, but the integration into an agricultural production cycle could well be a more efficient way to dispose of the accumulated biomass. This is illustrated in Figure 4. The upper section shows the general agricultural production cycle including livestock production, manure, plant production, forage and the corresponding marketable inputs and outputs. The primary function of an alternative actor would be landscape maintenance and biomass would result as a by-product which would have to be disposed of by alternative processes. This gives rise to industrial products, such as energy or fibres and waste material (*e.g*. from biogas plants). In a closed system, the latter would have to flow back into the agricultural production cycle. Furthermore, sustainability aspects demand the consideration of all the emissions from the corresponding production cycles.

An in-depth analysis of economies of scope can only be achieved when agricultural and industrial production cycles are considered simultaneously. The conclusions based on Figure 4 are therefore:

- landscape maintenance must be viewed as a dynamic system of production cycles with different actors instead of static cost calculations.
- economies of scope in agricultural provision exist as long as the additional value of the accumulated biomass in an agricultural production cycle is higher than in an industrial production cycle.

Figure 4. Landscape maintenance and agricultural production: a system perspective



This is in accordance with the theoretical analysis that economies of scope add a dynamic aspect to the question of jointness and that in a social optimum, the value of marginal products of the private as well as the public good are equal in both activities. Thereby, changes in price relationships and institutional basic conditions can lead to a relative strengthening or weakening of the jointness between agriculture and landscape. In relation to the case study, this implies:

- relative weakening: technological development and the implementation of new technologies in biomass conversion are a crucial aspect with regard to landscape maintenance. New methods allowing the production of alternative marketable goods result in an increase in biomass disposal efficiency and can lead to a de-linkage of agriculture and landscape maintenance. Research and development in this area indicate a great potential (Tilman *et al*., 2006; Grass, 2004);
- relative strengthening: more efficient (particularly extensive) production methods and productivity gains in agriculture would cause a higher inflow of biomass into the agricultural production cycle and thus strengthen the relationship between agriculture and landscape. The ongoing reform process in Swiss agriculture, which shifts support from market price support to direct payments (BLW, 2006), could generate adequate incentives.

Moreover, calculations with farm optimisation models (Huber and Nebiiker, 2007) show that farmers on different sites also have different potentials for providing public goods such as open space amenities. Above all, there are incentives for specialised dairy farms in the lowlands to use large areas for their production, whereby the comparative advantage of Swiss grassland is emphasised. This leads to another important aspect in the analysis of jointness. Not only the demand side varies in specific areas but the provision side also has a spatial aspect. The latter has two dimensions. Firstly, provision costs depend on geographic and environmental conditions such as topography, climate or surface suitability. Secondly, proximity to markets and consumers plays an important role. In this context, Thünen's land-use model illustrates the spatial variations in market prices (Thünen and Waentig, 1996), which thereby gain importance for landscape maintenance.

Distortion of agricultural markets and current support schemes make it difficult to compare calculated provision costs of alternative actors to those of existing agriculture. To do this, it would be necessary to model and quantify the effects of world market prices on structures and land- use in Swiss agriculture. The present high biomass disposal costs generated by industrial utilisation suggest that, unless new and more efficient technologies are developed, alternative actors can only contribute to landscape maintenance in a small way in the Greifensee region. Even if energy prices remain high in the near future (OECD and FAO, 2006) policy measures would be necessary (*e.g*. investment assistance) to improve the competitiveness of alternative actors. In turn, too much support would also cause new dependencies and inefficient agricultural support would be replaced by new, equally inefficient support for the energy sector. Against this background, new chances emerge for Swiss farmers if they consider landscape maintenance as a primary function and food production as by-product of their activities (see Bromley, 2000; Lehman, 2006), particularly given the high support for ecological activities in Switzerland. For example, less than 1% of arable land is cultivated as flowery meadows, even though the cultivation of one hectare is currently remunerated with an amount of 3 000 CHF. In contrast to this kind of subsidy, bidding to find the most efficient supplier of landscape maintenance could be an alternative solution (see Mann, 2006). This would be an application of the price-standard-approach which permits an internalisation of environmental benefits without knowing their exact value (Rieder and Anwander Phan-huy, 1994). In the case of open space amenities, the government could specify the amount of agricultural area that must be cultivated, and both farmers and alternative actors could submit their proposals depending on their individual cost functions. In this case, economies of scope are not estimated, but are revealed on markets. At the same time, transaction costs are low, because landscape maintenance is easy to monitor. In contrast, problems could emerge from market failure due to existing property rights or an insufficient number of bidders (OECD, 2003).

Beyond this case study, a possible advantage of agriculture in providing landscape amenities is based on the mutual interactions with several environmental benefits in a wide area. A further examination of jointness entails the identification of provision costs for landscapes on a broader level, including several goods and services simultaneously (Antle and Stoorvogel, 2006; Huber, 2005)

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The Cost Relationships Among Various Environmental Benefits: Lessons from Agro-Environmental Schemes

by
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The agricultural sector jointly provides a series of marketed and non-marketed goods, among which environmental benefits play an increasingly important role. This positive characteristic of farming is acknowledged by the European Union's current policy with agri-environmental measures providing public financing of programs under several headings such as extensification, grassland maintenance, landscape, and nature protection. These policies are expected to be continued and even reinforced. They rely on voluntary agreements with farmers: entrants are compensated for complying with a package of prescribed farming practices designed to secure conservation goals. To be effective from an environmental perspective, uptake is a key factor.

Eligible farmers have the opportunity to enter several agreements and to cumulate the corresponding compensations. Farmers' behaviour with respect to environmental programmes depend on economies of scope, economies of scale, site productivity, and payment received. Most papers dealing with this issue focus on the participation decision; other papers also explain the selection of a specific menu embedded in a single scheme.

The study by Bonnieux *et al.* (2001) is more ambitious since it emphasizes both the uptake decision and the simultaneous selection of several schemes. As a theoretical framework, an economic model is derived from the standard profit maximization where the underlying technology is represented by a restricted cost function.

The present paper emphasizes the dual perspective to deal with multifunctionality and restates the output combination issue by considering the cost function. The same framework is used to deal with non-marketed goods as well as marketed goods. The relationship between two outputs is categorized in terms of competitiveness and depends on the curvature of the isocost curve in the output-space: quasi-convexity of the cost function favours the joint production of the two outputs while quasi-concavity leads to a specialization in a single output. It is interesting to note that the nature of this relationship may change with the scale of production and the available amount of fixed factors. From this perspective, positive scope economies refer to technologies which exhibit cost complementarities everywhere; this case is associated strictly with quasi-convex cost functions.

A model of farmers' reaction to an agri-environmental package is derived from the above framework. It relies on profit maximization and links the decision to enter a scheme to the difference between the associated marginal benefit and the increase in cost. The former term equals the premium paid to comply with a series of prescriptions and therefore depends on the current agri-environmental policy. Otherwise the latter component depends on the characteristics of the cost function that imply that cost complementarity may favour participation in a scheme. Farmers have the opportunity to simultaneously enter several schemes so the econometric model includes as many equations as available programs. Providing the vector of error terms follows a multivariate normal distribution, the model is a multivariate Probit one. In addition, the matrix of correlation of error terms provides an estimation of the second order derivatives of the cost function.

The dependent variable is the probability to select or not a vector of environmental schemes and the covariance matrix captures the relationships among these schemes. This matrix reveals the technological links between the benefits theses schemes provide. The estimation procedure is not straightforward because the likelihood function is highly non-linear and is not concave everywhere. Univariate Probits are used to derive consistent starting values, which are entered in a second step in order to obtain the final estimation.

Econometric results from a European sample of 1 770 farms are given. Data is taken from a survey distributed in eight countries: Austria, Belgium, France, Germany, Greece, Italy, Sweden and the United Kingdom. While 32% of surveyed farmers have registered for one scheme only, 18% have registered for two different schemes, 10% for three, and 5% for four schemes or more. Theses schemes have been distributed according to three categories: landscape maintenance, biodiversity protection, and restriction of intensive farming practices. One measure is assumed to target one environmental benefit out of the following categories: water quality, biodiversity, or landscape. (conversion to organic farming is excluded). Available information includes a description of both the farmer (age, education, experience of farming, and environmental attitude) and the farm (area, livestock, labor, income, type of farming). By taking into account the joint participation in different categories of schemes, the multivariate Probit model provides a much better prediction of each type of scheme uptake than univariate Probit procedures.

Table 1. Estimated and observed rates of participation in the different types of schemes

	Water quality	Bio-diversity	Landscape
Simple probit	0.24	0.21	0.30
Multivariate probit	0.27	0.28	0.32
Observed rates	0.28	0.27	0.35

Indeed the correlation between every pair of scheme categories is significant.

Table 2. correlations between types of schemes

Types of schemes by pairs (by expected environmental benefits)	Correlation	T-student
Water quality and biodiversity protection	0.26	4.579
Water quality and landscape maintenance	0.25	4.667
Landscape maintenance biodiversity protection	0.36	7.810

The main significant variables describing farmers have concordant effects on the participation probability whatever the type of scheme. General educational level, environmental friendliness, previous participation in environmental programs and acquaintance with other participants have a positive effect, while the lowest and highest agricultural education levels have a negative one. The effects of farm characteristics, like output mix, livestock density, and area per worker, depend on the type of scheme. In addition, there are significant differences between farmers who inherited their holding and those who bought it. Finally, farmers' age and the number of children are likely to influence uptake.

However, Bonnieux *et al.* (2001) considered the cost complementarities as the only form of jointness between the different environmental outputs. The assumed multiple output technology, characterized by everywhere increasing marginal costs, rules out scope economies due to fixed costs. Fixed costs are usually due to indivisibilities of some production factors. They are responsible for the usual U-shaped average cost function, characterized by economies of size for low levels of outputs and increasing marginal cost for strictly positive output. In multiple output technology, scope economies may be rooted in scope economies of fixed costs, due to polyvalent indivisible production factors (Dupraz, 1996). Since farmers bear a part of policy-related transaction costs to obtain information on the contracts offered, to negotiate their contracts and to carry out the necessary paper work for monitoring and control, these private transaction costs may be partly fixed and may also exhibit scope economies across environmental expected outputs. The study carried out by Arnaud *et al.* (2006) provides statistical evidence of fixed transaction costs.

Fewer research have investigated the private transaction costs of farmers who register for agro-environmental schemes. Dupraz and Rainelli (2004) suggest that such costs may build contracting barriers and may explain why larger farms are more involved in such schemes than are smaller ones. Such an assumption is difficult to test since private transaction costs are not observable for those who do not contract in order to avoid these costs. Arnaud *et al.* (2006) test this hypothesis using first hand data from a 2 000-farmer survey, carried out in 2005, in case study regions of nine EU countries.

The underlying micro-economic model distinguishes the average and marginal farmer's willingness to accept the contract terms. Both depend on farmer's preferences, on the technology represented by a restricted profit function, and on a transaction cost function (Ducos and Dupraz, 2006). Participation is triggered by a per-unit payment which exceeds what the average farmer is willing to accept and the marginal curve reflecting his willingness to accept; this determines the area under contract. The two-stage Heckman method enables the participation probability and the enrolled area to be estimated accordingly. As few explanatory variables are unambiguously determinants of the transaction costs function, it is possible to conclude that transaction costs are mainly fixed costs. Indeed, these determinants significantly affect participation without affecting the enrolled area of contractors. Accordingly, the farmland size increases participation probability but decreases the share of enrolled area. Environmental awareness favours both. However, Arnaud *et al.* (2006) do not investigate possible scope economies rooted in the transaction cost function.

Concluding comments

Cost complementarities are only a necessary condition for joint production under the profit maximising assumption. The results of Bonnieux *et al.* (2006) do not indicate that there are cost complementarities everywhere within the set of possible production plans.

Higher cost complementarities between biodiversity and landscape make sense. Farms involved in corresponding measures have similar characteristics: more area per worker, more livestock oriented, and more woods/hedges in farm area. Taking into account that one measure may target several environmental benefits (rather than one as assumed), cost complementarities are probably underestimated. However, cost complementarities may also be rooted in policy implementation factors: fixed private transaction costs due to information seeking and contract negotiation. The combination of measures with the accumulation of related payments enables the covering of contracting fixed costs. Arnaud *et al.* (2006) support the existence of fixed transaction costs, but cannot conclude that these favour jointness in environmental output provision in the agro-environmental scheme context.

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Degrees of Jointness for Food Security and Agriculture

by
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It was in the early 1990's that the term multifunctionality as such entered the political discussion (for a literature review see Bohman *et al.*, 1999). Due to the increased awareness of the concept of multifunctionality, the OECD has contributed, through a broad process of consulting and coordination, to providing a theoretical framework for this perspective which has the potential to challenge the foundations of welfare economics. In the course of this process, it became clear that the theoretical origin of the perception of multifunctionality lay in the phenomenon of jointness: the production of agricultural goods was connected with the production of non-commodity outputs. *"The key elements of multifunctionality are: (i) the existence of multiple commodity and non-commodity outputs that are jointly produced by agriculture; and (ii) the fact that some of the non-commodity outputs exhibit the characteristic of externalities or public goods, with the result that markets for these goods do not exist or function poorly."*(OECD, 2001) Generalising this notion of jointness, all production processes allowing for all weight and energy flows are characterised by some sort of joint production (Baumgärtner and Schiller, 2001).

It is repeatedly mentioned that one of the major joint products of agricultural production is food security (Abler, 2001; OECD, 2005). The objective of this paper is to examine the causal relationship between food security and agricultural production in more detail. This question is particularly relevant for countries without a comparative advantage in agriculture which currently employ policy tools in order to enhance agricultural production for food security reasons.

"Food security is defined as access by all people at all times to enough food for a healthy, active life" (Campbell, 1991). Apart from fishing and hunting, which together account for less than five per cent of worldwide calorie intake, agriculture is the only source of food. Therefore, there is, *a priori*, a strong jointness between agricultural production and food security. The question to be answered is therefore less general than that. The intertemporal and spatial flexibility of the jointness between agricultural production and food security has to be examined. If food has to be available, to what degree does it have to be produced at the same time and in the same country or even region where demand arises? Is food security a positive externality of self-sufficiency?

The questions are to be answered on two different levels. On the theoretical level, it has to be checked what calculations and considerations have been made in order to examine the jointness between food security and agricultural production and where causal links are still missing. On the empirical level, past experiences of food insecurity and of policies for preparing for food insecurity have to be examined in order to see which conditions with respect to agriculture led to the shortcomings and what side-effects the policies had.

Theoretical concepts

Many economists claim that "the most important strategies for national food security relate to economic growth and widespread improvement in income" (Summer and Buck, 2001). This shows, again, how important it is to distinguish between two different concepts of food security (OECD, 2004) as a brick in the concept of multifunctionality. While the need for economic growth relates to food security in countries with chronic malnutrition, the food security on which this paper focuses has to do with exceptional situations where food security has to be ensured in areas which do not face food shortages during normal times.[9] Food security according to that definition is the most relevant kind for OECD countries, but has continually been maintained in recent decades.

Sources of food insecurity

Flaten (2001a) lists circumstances in which the current situation of abundant food supplies in industrialised countries could change and food security could be challenged for developed countries. His list can be made even more systematic by the definition of three basic dimensions in which food security can be endangered. One, incidents of an interrupted food supply can be of national or global dimension. Two, the origin of the incident can be biological in nature or can have political causes. Three, disruptions to the food supply can be short-term or long-term. All these dimensions deserve further attention.

Global challenges to food security are closely related to the environmental situation. In a much regarded article, Lal (2004) shows the role of carbon sequestration in attaining food security. *Vice versa*, diminishing opportunities for irrigation, erosion and degradation of soils, biological limits to yield increases, diminishing returns from fertilizer use, chemical pest control problems, declining genetic diversity of crops and their wild relatives, falling water tables as well as possible rapid climate change and sea-level rise are cited as global challenges to food security (Ehrlich *et al*., 1993; Brown, 2003).

Dilley and Boudreau (2001) claim that the relation between such hazards and a decreased availability of food has to be very well analyzed. Thresholds of endangered food security should be defined in order to identify situations in which food security is no longer ensured. In general, however, global challenges to food security will still mainly affect poor countries. International trade will often provide an easy solution for countries with sufficient purchasing power. Even if global food production fell considerably, it would still be possible for developed economies to buy sufficient calories for their inhabitants, albeit at increased costs. It may be unfair, but still true, that the environmental crises brought about by unsustainable resource depletion by the North will mainly affect the food security of the South.

More or less the same can be said about national or regional crises caused by biological phenomena like pests and diseases. In particular, much has been written about

9. A third kind of food security is the access of the poorest people in rich countries to food, which is often approached at a community or regional level (Allen *et al*., 2003).

the detrimental effects of HIV infections in Africa and other developing parts of the world on food security (Loevinsohn and Gillespie, 2003; de Waal and Tumushabe, 2003). Likewise, the literature makes it clear that developing countries are more affected than rich countries by the impact of crop pests and animal diseases on food supply (Cassman and Harwood, 1995; Yudelman *et al.*, 1998). The purchasing power of developed nations makes it likely that they will be able to import their food from abroad, even if the (poor) exporting nations suffer from starvation themselves. A biological crisis would have to be extremely severe and endanger human life altogether before food security in rich countries started to be threatened.

The examples which have been chosen so far are all of a biological nature, as are nuclear incidents or other disasters that harm the productivity of the primary sector. While it can be said that such biological incidents are unlikely to threaten the food security of rich countries, the same is not true for political incidents. Politically, embargoes and wars are the usual instruments that challenge national food security. In the case of embargoes, a nation would have to be self-sufficient with respect not only to food, but also agricultural production technology and energy in order not to be harmed by a lack of imports. There are few industrialised countries which meet all these conditions. Wars, be they internal ('civil') or external, deteriorate food security in almost every case (Johnson, 1998; Jenkins and Scanlan, 2001). As summarized in Table 1, money does not solve all the challenges to food security in this case of political crises.

Table 1. A categorization of challenges to food security

	Biological causes		Political causes	
	National	**Global**	**National**	**Global**
Example	Widespread crop pest	Global warming	Embargo	World war
Importance of purchasing power	High	High	Negligible	Some
Importance of national food sources	Low	Low	High, together with equipment factor	Rather high

All the incidents described in Table 1 can be both short-term and long-term. While locust plagues are usually short-term, HIV/AIDS is bound to be a longstanding problem. Global droughts can occur in one particular year, but long-term global warming will have lasting effects on food security. Both embargoes and wars can have shorter or longer durations. It is worthwhile to analyse what implications for ensuring food security are appropriate to all the different kinds of challenges that have been identified.

Strategies for providing food security

In order to counteract situations of food insecurity as described above, agricultural policy-makers generally focus on the following strategies in order to attain food security:

- Establish international trade relations, so that short supply by domestic agriculture can be overcome by imports.
- Establish public and/or private storage facilities to bridge situations of short food supplies.
- Maintain the capability for agricultural production on a defined share of land.

Things are complicated by the fact that these strategies which are developed to attain food security usually respond to one or some, but not to all of the above scenarios. It has been shown, for example, that preserving production capacity in the country may be a strategy that works in the case of international conflicts, but not in cases of environmental disasters. Another example is storage: storage works well as a short-term measure to bridge phases of food insecurity. In the long run, however, storage capacity is limited. These two cases are worth following up in more detail, taking into account the spatial and intertemporal flexibility of jointness between agriculture and food security.

Spatial flexibility

As Paarlberg (2002) notes with some surprise, issues of food security are mostly tackled by nation-states, in spite of the many supranational and regional organizations that exist. Hence, the core question is whether the nation-state is the appropriate level on which some minimum standard of food production should be guaranteed.

It is clear that historical experiences shape the perception of risks connected with food imports. After being cut off from international trade during the World Wars in the 20th century, many nations had a widespread consensus that self-sufficiency was an unquestionable goal for domestic agricultural policy. Balaam (1984) describes for Japan how this consensus became fragile during decades in which international trade was almost undisturbed by political factors.

This leads to a positivistic approach to food security, measured in terms of personal preferences. Anderson (2000) applies this sort of argument, reducing the concept of food security to the subjective feeling of an average citizen. If a population feels food-insecure, he argues, it will have a willingness to pay for increasing domestic production capabilities. The ratio of 78% of the Japanese who were concerned about food security in 2000 might be an explanatory factor for the protectionist approach of Japanese Agricultural Policy.

The alternative approach is to normatively analyze food security. Jae-Ok (2004) develops a model to show the optimum strategy with respect to self-sufficiency. Full self-sufficiency leads to maximum food security, but can only be achieved with very high marginal opportunity costs. Liberalisation in a country without a comparative advantage for agriculture, on the other hand, does not lead to opportunity costs, but according to Jae-Ok to a very low level of food security. As a consequence of his model, Jae-Ok recommends a middle pathway between full liberalisation and full self-sufficiency.

However, Jae-Ok (2004) fails to fill his model with concrete figures. That is not by chance. Although some NGOs deliberately argue in favour of "national food independence" (Greenpeace, 2003), there are far too many uncertainties to be able to state at what level of imports food security is endangered. The following variables would need to be quantified for such a model to make predictions:

- likelihood of war and other events like embargoes isolating a country.
- causal relation between current food production and ability to produce under changed conditions. and
- minimum domestic production to guarantee a sufficient calorie supply.

Only the last factor can be estimated with a reasonable degree of certainty. The others are subject to very vague estimates (*e.g.* Stonebraker and Kirkwood, 1997), or even to pure guessing. Anderson's (1998) remark that a broad diversification of trade partners reduces the risk of isolation is true, but does not say much about the remaining risk.

The likelihood of an embargo on food is only one unknown factor in this calculus. Another, for example, is the likelihood of an energy embargo, which for most countries would have serious implications for the potential of agricultural production. From a scientific point of view, it is one of the "problems" that recent decades have, in industrialised countries, shown such a stable and undisturbed development that an unforeseen paradigm change would be necessary to let war and embargoes occur.

A scenario can be imagined under which a country still has enough access to energy resources to fuel the farming sector, but too few food resources to provide food security, unless farming knowledge and farmland had been cultivated in recent years (Flaten, 2001b). Given the absence of objective information, it should probably be left to individual reasoning how likely such an incident is for the future. The positivist approach to collect WTP to keep agricultural production for times of crises is, therefore, perhaps the most reasonable.

If the idea is accepted that the risk of isolation from food supplies is great enough to justify maintaining agricultural production, agricultural production is likely to be different for times of hardship compared to other times. That applies to inputs and outputs. Given that only a few industrialised countries are self-sufficient in energy, it appears likely that farming's potential to produce its own energy through biofuels and biomass would be fully exploited. Perhaps, a combination between producing energy sources like biofuels and using traditional energy sources like horses and oxen for agricultural work is most likely. For outputs, the significance of animal production would decrease considerably compared to now, while the importance of producing staple foods would rise.

Therefore, simply supporting agriculture now in order to be prepared for times of isolation is probably not an efficient strategy. If they take the argument of food security seriously, governments should pay increased attention to biofuel and staple food production.

Intertemporal flexibility

In recent optimization models to guarantee food security (*e.g.* Hättenschwiler, 1999), storage usually plays an important role. Indeed, storage has some advantages compared to self-sufficiency. Firstly, even if the nature of the disaster is such that agricultural production within the country becomes impossible, releasing food from storage can maintain food security. Secondly, the food can be produced or imported at times when it is cheapest and does not have to match the temporal patterns of demand. Anderson and Cook (1999) even go so far as to use world food stocks as an indicator for global food security.

On the other hand, stocks are useless if they are never released, while stock-keeping involves considerable costs (Macki *et al.*, 2001). Therefore, short-term modelling often comes up with the result that stocks should be considerably reduced (Pickney, 1993) in order to attain cost-effectiveness.

It is obvious that storage capacity has its limitations in terms of time (Sohn, 1984). It is the disadvantage of stockpiling compared with maintaining national production that stocks will run out in the short or medium term. Therefore, the role of stocks in food security is to provide a nutritional base for a limited time, particularly if both imports and national production become impossible for some reason.

Again, the likelihood of this situation occurring for any given country in the near future is open to pure speculation. No lessons can be learned from the past. However, in the case of storage, there are not too many reasons to allocate the duty for that to the state. As Watson and Vespa (1995) use household food storage as an indicator for food security, it is probably advisable to organise storage activities on a household rather than on a public level. That enables everybody to barter the good "food security" against the good "storage room and capital", depending on individual risk perception and attitude.

Empirical evidence shows that private storage activities are very sensitive to perceived risks. In fact, governments in some developing countries have, in certain situations, chosen to enact anti-hoarding laws to limit the degree of private storage (Dillon, 1999; del Ninno and Dorosh, 2001). The general sensitivity of the public to situations of food insecurity means that government intervention can only improve the situation in circumstances where the government does better in quantifying the existing risks than the general public. Most market economists see, in general, few situations where that would be the case.

Should we link sources and strategies by scenarios?

It is good practice among economists to draw some policy scenarios for the future and then to carry out cost-benefit analyses to identify the options that maximize aggregated public welfare under the given conditions. Costs which would have to be compared for such a task include the following:

- costs of stocktaking during times of stability, which have been easy to estimate for some time (Plant and Fowler, 1939);
- costs of subsidising agricultural production in which the OECD (2006) is specialized, including during times of stability; and
- benefits of providing food security during crises.

However, several factors limit the potential of this sort of quantitative analysis in the case of food security.

While it may be possible to estimate the risk of some environmental disasters and types of degradation, it has already been shown that these incidents are of limited relevance to the case of food security in industrialised countries. It would be more important to estimate the probabilities of political disruptions. But although Collier and Hoeffler (1998) have found that the likelihood of civil wars decreases with rising income and Henderson (1997) has identified cultural factors predicting interstate wars, it is all but impossible to make reliable predictions for the likelihood of such incidents in OECD countries. If the history of the last 60 years is a good guide for the future, political incidents threatening food security in OECD countries are very unlikely to occur. Even the few wars in which OECD countries were involved and which occurred on their territory, like the Falklands War, never threatened food security in the slightest. The few embargoes that have happened during the last 60 years have never affected OECD countries. None of this is any guarantee whatsoever that the course of history will not change in the near future. Since we basically have only the past as a tool for predicting the future, we cannot attribute any meaningful probability value to the occurrence of wars and embargoes endangering our food supply.

Even if we are willing to assume political disruption occurring in the future and causing food insecurity, we have no guide as to its likely shape. That makes it very difficult to develop serious policy scenarios. Should we assume that no imports whatsoever are possible anymore? Or should we consider the possibility of illegal imports at increased costs? To what extent? And should we assume the crisis to be short-term or long-term? Fortunate as it is that OECD countries have not been struck by any significant food crisis in the past 60 years, our resulting lack of any reasonable baseline for scenarios is equally unfortunate.

One could choose an arbitrary scenario of any import restrictions and any duration, but one would still run into great difficulties in an attempt to discover by cost-benefit analysis what would be the most efficient strategy for securing food supplies by pre-emptive steps today. Certainly, the discounting of future benefits plays a role, and it is likely that the unresolved conflict about the appropriate discounting rates (Sperry, 1997) will not be easily resolved in the field of food security. It is a far greater obstacle to value the benefits of food security. The benefits of a secure food supply consist of sufficient calorie intake (*i.e.* the joy of not starving) and eventually in preventing deaths by starvation. A broad majority of social scientists agrees that any attempts to put a monetary value on human life are futile or even unethical (Dorman, 1996; Munda, 1997).

Eventually, the combination of arbitrariness in depicting scenarios and the lack of decisive criteria for choosing between policy options would make any attempt to develop best possible policy strategies for attaining food security for industrialised countries relatively useless. The only trivial conclusion that we can draw from the theoretical analysis is that trade and entrepreneurship have been among the most important ingredients in developing economies with a secure food supply.

Empirical experiences

Because the normative-theoretical approach produces so few useful results, it is advisable to observe the empirical connections between food security and agricultural production in two respects. One, it is obvious that real-life cases where disasters or wars occurred are the very test of any successful food security policy. Two, it is worthwhile to look for – perhaps unwanted – side-effects of food security policy approaches in times of peace and stability.

Experience of threatened food security

Taking the situation of Germany's food supply crises during and shortly after the World Wars, Brünker (1959) clearly showed that it would hardly have helped if agriculture had been subsidized to a greater degree before the Wars. Most of the difficulties arose due to a shortage of production factors, notably fertilizer. For more recent history, however, it is difficult to find appropriate case studies for situations where food security was endangered not by sheer poverty, but by disastrous incidents or isolation. In the vast majority of cases, international relief agencies set up assistance schemes, often creating their own problems (Flores *et al*., 2005). Food aid or, for Iraq, the food for oil programme may have provided some relief for the local population; for scientists, however, it eradicated most of the few possibilities for providing evidence to answer the question whether agricultural subsidies during peace times provided food security during crises.

In any case, there is empirical evidence that self-sufficiency and food security are different issues. Simatupang (1999) reports that Indonesia's first food crisis occurred shortly after the country had finally reached self-sufficiency in rice. And "Singapore and Hong Kong produce very little food grain, but they have better records of food security than the major rice-growing countries in the region." (Hossain, 2004)

On the other hand, it is clear that any military or political disruption strongly affects food security, even if no OECD country has been forced to prove that causal connection in recent decades. Any hostility will worsen the food supply, while each cease-fire is reported to relax the nutritional situation (Watson and Vespa, 1995). Empirically, micro-agriculture has been observed as a frequent answer to securing household food security in uncertain times. Agricultural activities, even in highly urbanized areas, have been reported both from Kosovo (Lingard, 2003) and from Iraq (Williams, 1999).

Whereas Iraq used to import a quarter of its staple food (FAO, 1999), Serbia is traditionally a food exporter (Csaki and Zuschlag, 2003). However, during times of embargoes affecting these countries, serious food security problems were reported from both countries (Bishay, 2003; Labhsetwar, 2003). That is an (albeit weak) indicator against the jointness of agricultural production now and food security for the future. More thorough case studies of the embargo phase of the two countries might, however, reveal detailed insights into a possible jointness that this paper has so far failed to discover.

Experience of precautionary policies

It is well known that promoting domestic agriculture with the objective of self-sufficiency carries considerable welfare costs (Beghin *et al.*, 2003). Four OECD countries have in particular chosen the pathway of emphasizing the need for self-sufficiency in the food sector, putting forward food security arguments: Japan, South Korea, Switzerland and Norway. However, in addition to the general welfare losses, it can be observed that this sort of policy has in each case resulted in a peculiar focus on one single commodity.

In the case of Japan and Korea, this commodity is clearly rice. While Korean self-sufficiency is 8% for soybeans, 60% for beef and 38% for barley, Korea is a net exporter of (highly subsidised) rice (Beghin *et al*., 2003). Japan attained a similar position, with domestic rice prices more than ten times above world market price. When Japan had to open its market to some rice imports, it either re-exported the imported goods as food aid or the government sold them as an import to food processors (Fukuda *et al.*, 2003). In recent years, Japan has tried to encourage the diversification of Japanese agriculture away from rice production by diversion payments costing more than USD 1 billion per year.

In Switzerland, the potato is considered the staple crop most central to food security. As for most crops, high tariffs secure the competitiveness of domestic production. In addition, however, the government has launched a scheme that guarantees public funds for every ton of potatoes fed to animals. Against a background of 40% self-sufficiency in the arable sector, this has led to a unique situation. Swiss self-sufficiency in potatoes is around 150%. The surplus, however, is not exported but instead, for reasons of low quality, is fed to animals.

In Norway, the critical product for food security appears to be milk. Since a government target of a minimum of 1 700 million litres of milk production was abandoned in 2000, production levels have fallen only slightly (Rogstad, 2005). The policy of self-sufficiency in milk while self-sufficiency is below 50% for other food products comes at a price, with a PSE of 72%.

These examples indicate that craving for food security entails the danger of concentrating very heavily on one particular commodity. This does not seem to be an economic necessity, as food security could well be achieved with a fair mix of staple crops. Potatoes and milk, in particular, are not well suited to long-term storage. Therefore, the observed concentration should be seen rather as a psychological phenomenon connected with food security policies.

Implications for providing food security

A high degree of jointness between current agricultural production and food security in times of crisiscould neither be strongly supported by theoretical considerations nor by empirical evidence. It is possible to construct situations in which current support for agriculture increases food supply in times of hardship (Hättenschwiler, 1999). The probabilities of the underlying assumptions are open to speculation.

Empirically, the question of jointness between agricultural production and subsequent food security at critical times has not yet been examined in depth. From what we know, however, there is no indication that a level of close to or complete self-sufficiency during normal times is of much help when an embargo is enforced. The results are, however, more unequivocal in that policies for achieving food security tend to focus on one single commodity, resulting in an unbalanced production structure as a negative externality.

For short-term disturbances, storage will be an adequate answer. The amount of stocks one wants to keep will be strongly related to risk-friendliness. The solution to this calculus is perhaps not so much to be found on a societal level, but rather on a household level. In industrialised countries, most households have enough room to store food in accordance with their personal risk calculus.

For longer-term crises, current agricultural production may be a tranquillizer, but probably not a panacea. We know too little about the nature, duration and extent of such possible fallout to strongly assume that agricultural production in our nation-state today would contribute significantly avoiding hunger.

As more than 95% of human calorie intake comes from agriculture, jointness between agricultural production and food security is almost what has been described as perfect jointness in the multifunctionality framework. However, the analysis has shown that a great degree of spatial and intertemporal flexibility of agricultural production is likely. There are not many reasons why food should be produced precisely at the time and at the location where it is needed. The probability that the self-sufficiency of nation-states contributes considerably to food security is rather low. In addition, storage can, at least in richer nations, be organized by households themselves, according to their risk perception.

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Optimal Provision of Public Goods: implications for Support to Agriculture

by
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Agriculture is a heavily supported industry in most developed countries and is widely perceived as a hindrance to economic growth and development and a major source of distortion of international trade. It has become one of the main focuses of OECD and has been a continuing concern in WTO negotiations.

Agricultural policy can interact with economic growth in two ways. First, one could expect the proportion and intensity of subsidised agriculture in a regional economy to attenuate the movement of labour and capital to other sectors (and/or regions) with higher returns, conserving structures of factor allocation at the cost of those paying for the subsidies. Secondly, the subsidies may also reduce or distort farmers' incentives to change their mixes of products and/or methods of production. In this sense, subsidies are counter-productive as they hamper growth of GDP. Bivand and Brunstad (2003, 2006), in investigating convergence in economic growth in Western Europe, found empirical support for this view.

Recent discussion on the so-called multifunctionality of agriculture may, however, indicate that agricultural activities produce benefits over and above the market value of agricultural production (Peterson *et al.* (2002); Brunstad *et al.*, 1995a,1999 and 2005). In terms of Pigouvian welfare economics, agricultural production may have positive external effects or perceived public goods such as the amenity value of the cultural landscape (see, for example, Drake, 1992). If this is the case, and if agricultural support is used as Pigouvian subsidies to internalize these externalities, growth is reduced only because we are measuring the wrong thing: traditional GDP instead of an extended GDP which includes the value of such amenities.

To a certain extent, the amenity value could become a positive externality for other industries, particularly tourism. Indeed, the link between agriculture and tourism in this respect has been pointed out by several authors (*e.g.* Pruckner (1995). In this case, the amenity will be included in GDP as part of the GDP in tourism. However, to the extent that the amenity is a public good that affects the local population, it is not included in GDP even if its contribution to the general welfare is positive. This paper explores the link between agriculture and public goods.

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Main issues

It is widely accepted that there are externalities and public goods related to agricultural activity, such as the amenity value of landscape, food security, and the preservation of rural communities and rural lifestyle (Winters, 1989-1990; OECD, 2001; Hediger and Lehman, 2003). The implications these externalities have on national agricultural policy is a controversial issue. What support levels can be defended by the so-called multifunctional role of agriculture, and what policy instruments are efficient? In the ongoing WTO negotiations, for example, several developed countries have used multifunctionality to argue for continued high support levels, including in the form of tariffs and output subsidies. Less developed countries reject such arguments as protectionism. This view was recently supported in Peterson *et al.* (2002), who derive an efficient set of policies for a multifunctional agriculture while demonstrating that efficiency cannot be achieved through output subsidies.

Present agricultural policy in OECD countries involves the distribution of significant support. This support, however, is not targeted as Pigouvian subsidies that offer possible positive externalities emanating from agricultural products or inputs, but are in general inherited from the past when they were based on traditional protectionist arguments. This paper sums up our efforts to give some empirical contributions to the debate on the multifunctional aspects of agriculture.

In earlier papers, we examined the food security and landscape preservation arguments as separate issues. In Brunstad *et al.* (1995a), the food security argument was examined. A numerical model was applied to compute what Norwegian agriculture would look like if the only purpose of support was to provide food security. Compared to the actual activity in agriculture, the analysis indicated a decline in employment and land use of about 50%.

Brunstad *et al*. (1999) dealt with the landscape preservation argument. A method for incorporating information on the willingness to pay for landscape preservation, as inferred from contingent valuation studies, was presented and implemented in the objective function of the model mentioned above. To illustrate this method, Norwegian agriculture was used as a case study, and optimal levels of production, land use, employment and support were calculated. Based on various simulation experiments, it was shown that only a minor fraction of today's generous support level would be maintained, and production and employment would drop to low levels. However, even if the landscape preservation argument could not be used to defend today's levels of production and employment, the argument remained strong enough to keep a substantial part of today's agricultural area under cultivation.

Finally, in Brunstad *et al*. (2005) the focus was on cost complementarities (jointness) between these two public goods, as well as between public and private goods. We discuss the optimal policy when food security and landscape preservation are simultaneously taken into account. To what degree are these public goods complementary in the sense that supplying one of them more or less automatically would lead to the supply of the other(s)? What is the link between public goods and traditional food production? How much support is necessary to sustain reasonable levels of public goods, and what policy instruments are efficient, when cost complementarities are considered?

An agricultural model with public goods

To quantify the cost of providing public goods as well as cost complementarities we use a model of the agricultural sector in Norway.[2] This model is extended by incorporating a willingness-to-pay function for landscape preservation, and by including provisions for food security. The model, whose base year is 1998, covers the most important commodities produced by the Norwegian agricultural sector, in all 13 final and eight intermediary product aggregates. Of the final products, 11 are related to animal products whereas three are related to crops. Inputs needed to produce agricultural products are land, labour (family and hired), capital (machinery and buildings), concentrate feed, and an aggregate of other goods. Furthermore, we distinguish between tilled land (T) and grazing on arable land and pastures (G), so that $G + T = L \leq \overline{L}$ where $\overline{L}$ is total arable land available. Domestic supply is represented by about 400 'model farms'. Each model farm is characterised by a Leontief technology, *i.e.* with fixed input and output coefficients. Although inputs cannot substitute for each other at the farm level, there are substitution possibilities at the sector level. For example, beef can be produced with different technologies (model farms), both extensive and intensive production systems, and in combination with milk. Thus, in line with the general Leontief model in which each good may have more than one activity that can produce it, the isoquant for each product is piecewise linear. Also, production can take place on small farms or larger, more productive farms. Consequently, there is a degree of economies of scale in the model. The country is divided into nine regions, each with limited supply of different grades of land. This introduces an element of diseconomies of scale because, ceteris paribus, production will first take place in the "best" regions. Domestic demand for final products is represented by linear demand functions. Economic surplus (consumer surplus plus producer surplus) of the agricultural sector is maximised, subject to demand and supply relationships, policy instruments and imposed restrictions. The solution to the model is found in terms of the prices and quantities that give equilibrium in each market. More details are given in Brunstad *et al*. (2005). Column 1 in Table 1 below presents a model simulation of Norwegian agriculture based on the current support system, using parameters based on actual subsidies and tariffs.

2. An early version of the model is described in Brunstad and Vårdal (1989), but the model has been considerably improved since then. A technical description of the model is given in Brunstad *et al.* (1995b). Details are given in Gaasland *et al.* (2001). The model is constructed to perform policy analyses, and has as such been used by the Norwegian Ministry of Finance and the Norwegian Ministry of Agriculture.

Table 1. Production and main input levels in Norwegian agriculture*

	Base solution	Landscape preservation	Food security	Landscape preservation and food security
Production (*millions kg or litres*)				
Milk	1 671.5	139.1	832.1	709.6
Beef and veal	82.1	5.6	33.6	28.6
Pig meat	100.1	-	-	-
Sheep meat	23.0	28.0	18.4	29.7
Poultry meat	27.8	-	14.8	-
Eggs	43.8	-	16.7	9.8
Wheat	210.5	114.8	151.1	150.0
Coarse grains	1021.3	255.1	367.8	339.1
Potatoes	298.0	310.3	307.1	312.3
Land use (millions hectares)	0.85	0.36	0.48	0.54
Tilled land	0.31	0.09	0.13	0.12
Grazing and pastures	0.54	0.27	0.35	0.42
Employment *(1 000 man-years)*	59.7	9.8	17.3	17.7
Rural areas	40.1	7.0	n. a.	8.0
Central areas	19.6	2.8	n. a.	9.7
Total support *(NOK billion)*	15.3	3.3	5.5	6.0
Border measures	6.7	-	-	-
Budget support	8.6	3.3	5.5	6.0
Composition of budget support				
Area planted or animal number	35%	100%	n. a.	58%
Other input use	52%	-	n. a.	42%
Output	13%	-	n. a.	-

n.a. not available.

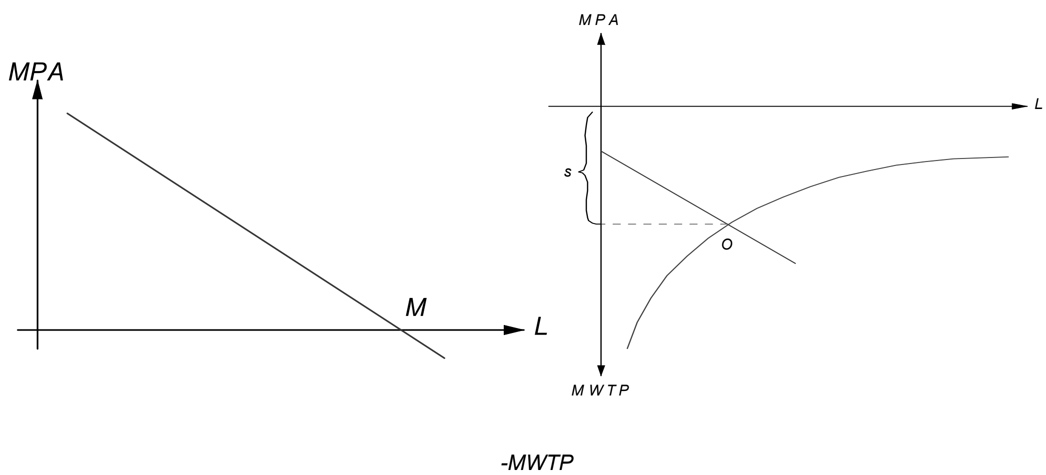
The table is adapted from Brunstad *et al.* (2005).

Cultural landscape

Assume that we have an agricultural aggregate L, representing both production and amenity benefits. Exposed to world market prices and receiving no support, the market solution would be at M in panel a of figure 1 below, where the marginal profit from agriculture (MPA) is zero.

Assuming further that the curve in the second quadrant in panel b represents the positive but falling marginal willingness to pay (MWTP) for the amenity benefit, and also that agriculture is not profitable at any positive level of production without support, the optimal level of production would be at O, where MWTP would be equal to the negative MPA. A subsidy of *s* per unit of the agricultural aggregate would then represent the optimal support to agriculture.

Figure 1. Socially optimal level of agriculture



Panel A **Panel B**

Several studies have attempted to estimate the willingness to pay for the amenity value of the cultural landscape. Lopez *et al.* (1994), using data from Beasley *et al.* (1986) and Foster *et al.* (1982), have calibrated the following willingness to pay function for the amenity value of the agricultural landscape:

$$\text{WTP} = BL^{e1}P^{e2}y^{e3}$$

where L is a quantity index for landscape amenity, here assumed equal to cultivated area, P is population, y is income per capita, and B is a scaling parameter. From economic theory one would expect the marginal willingness to pay for the landscape amenity to be diminishing, implying that $0 < e1 < 1$, and also that the willingness to pay should be income elastic, meaning that $e3 > 1$. Furthermore, if the landscape amenity were a pure public good, like the famous lighthouse example, $e2 = 1$, implying that the per capita willingness to pay is independent of population size.

In fact the elasticities were calibrated to: $e1 = 0.172$, marginal willingness to pay for the landscape amenity is strongly diminishing; $e2 = 0.796$, landscape amenity is close to a pure public good, but some crowding effect is present; and, $e3 = 3.877$, landscape amenity is highly income sensitive. Even if the empirical foundation of these estimates is extremely meager, amounting to four observations from US counties, they are within the ballpark of "acceptable" figures, albeit the income elasticity may seem unreasonably high.

Obviously, it is hard to model all the attributes that enhance the value of the agricultural landscape, like openness, variation, biodiversity and type of agricultural technique. We follow Lopez *et al.* (1994) and assume the following willingness-to-pay function for landscape preservation:

$$WTP = \Theta L^{\varepsilon}$$

where Θ (>0) is a constant. In our approach, the amenity value of tilled land, *T*, is allowed to differ from that of grazing and pasture, *G.* The aggregate for landscape preservation is postulated by the following CES function:

$$L = \Lambda\left[\alpha_G G^{(\kappa-1)/\kappa} + \alpha_T T^{(\kappa-1)/\kappa}\right]^{\frac{\kappa}{(\kappa-1)}}.$$

Following Brunstad *et al*. (1999), the parameters *Θ, Λ,* α_G and α_T are calibrated to estimates of amenity benefits taken from Drake (1992) who makes a similar distinction between tilled and arable land. Based on Lopez *et al*. (1994), the elasticity of scale, *ε*, is set equal to 0.172. This means that the marginal willingness to pay is strongly decreasing for rising levels of *L*. Moreover, the elasticity of substitution between pasture and tilled land, *κ*, is assumed to be equal to 3.0, reflecting a relatively high degree of substitution.

Adding this willingness to pay function to the model and removing all tariffs and subsidies other than those generated by the MWTP, we get the hypothetical figures for Norwegian agriculture which are presented in the second column of Table 1.

Compared to the actual support regime (column 1), the activity in the agricultural sector is substantially reduced, especially production and employment (16% of level in the base solution). Naturally, since land use enters into the WTP function it declines less than the other indicators. Nevertheless, the computed level of land use is only 43% of the present level. Land intensive grazing, *i.e.* extensive sheep farming, keeps up better than grain production on tilled land. Necessary support, in the form of acreage subsidies, is NOK 3.3 billion, or about one fifth of the support in the base solution.

Food security

The ability to provide food under all contingencies is referred to as *food security*. Food security can, following Ballenger and Mabbs-Zeno (1992), be defined on a global, national and individual level.

Global food security is defined as:

Pr [(world production + world stocks) ≥ world needs] ≥ *π*.

Pr symbolizes probability, *π* is the minimum acceptable likelihood and 'needs' is the necessary consumption. This means that the sum of world production and stocks in every year must exceed the necessary consumption by a minimum acceptable likelihood.

National food security, formulated as:

Pr [(domestic production + domestic stocks + imports + aid) ≥ domestic needs] ≥ *π*,

is less restrictive since consumption can be based on imports and aid from other countries. Therefore, even if global food security is below reasonable limits, rich countries like Norway will normally have enough purchasing power in world markets to secure a sufficient share of world production. The same logic applies to individual food security, which can be secured if a person has enough income or purchasing power, even if the nation's food supply is insufficient.

It follows that if global food security is fulfilled, then national and individual food security is a matter of distribution or poverty relief. A special case is a blockade in connection with war that rules out distribution between countries (infinite import prices), *e.g.* as during World War II. This traditional argument for national food security seems to be outdated thanks to strong defence alliances and the way modern warfare is pursued. Nevertheless, it seems unwise to dismiss totally the need for a minimum of activity within the agricultural sector in order to diminish the negative effects of unknown crises in the future.

A more rational argument concerns global food security. Some kind of ecological crisis or man-made disaster (*e.g.* Chernobyl fall-out) is less likely to be detrimental to global food security if production capacity is spatially diversified throughout the world. Although rich countries would be able to finance the high food import bill under adverse situations, it can be argued, for ethical reasons, that most countries should contribute to the global production potential. As agreed by a vast majority of economists, this is not an argument for national self-sufficiency.[3] Import tariffs and production subsidies are not only costly, but may also impair the purchasing power and food security in countries with comparative advantage in food production, *e.g.* many developing countries. It is, however, an argument for keeping necessary factors of production available with a minimum distortion on trade. In the forthcoming simulations, we take the view that Norway should at least have the capacity to feed its own population if a crisis occurs.

Gulbrandsen and Lindbeck (1973) attacked the self-sufficiency goal stressing that production in normal times does not have to be equal to production during a crisis. Some switching of production when the crisis has arisen, will be possible. The crucial condition for switching of production is, however, that the necessary factors of production are available, especially agricultural land, but also skills, livestock and capital equipment. Then, according to what could be termed the *Gulbrandsen-Lindbeck principle* a rudimentary measure of food security could be obtained if there are enough acreage, labour (*i.e.* agricultural skills) and livestock available to produce a crisis menu containing sufficient nourishment to feed the population. The point is not that this basket of goods should actually be produced, but that sufficient quantities of the agricultural inputs should be available so that the crisis menu could be produced. To the extent that actual production deviates from the menu, this can only happen after some necessary period of transition, to prepare for which some stockpiling would also be necessary.

For Norway such a crisis menu has actually been computed in an official report to the government, see NOU (1991). The crisis menu is given in Table 2.

In line with the Gulbrandsen-Lindbeck principle, we first employ the agricultural model to calculate how much land and labour is needed to produce the quantities of food required by the crisis menu. These levels, calculated to be 56% and 29% of the base levels, must be kept continuously available in order to be prepared to produce the crisis menu if the need arises. In addition to keeping land and skilled labour available, livestock has to be available for meat and milk production. This limits the extent to which the current production of animal products can be reduced relative to the crisis menu. This is

3. Using an index of national food security, Sumner (1990) showed that trade barriers are detrimental to food security in most conceivable situations, mainly due to adverse effects on real income. Beghin *et al*. (2003) showed that the welfare costs for South Korea of pursuing food self-sufficiency (trade barriers) are substantial, and that food security can be achieved at much lower costs using more targeted policy instruments. An improved international trading environment, *i.e.* for agricultural products, is considered to stimulate economic growth, and thus strengthen food security, in developing countries that depend heavily on agriculture, *e.g*. Anderson and Morris (2000); Davis *et al*. (2001); and Sumner (op.cit).

taken care of by assuming that the production of meat, cow milk and eggs must not fall below the levels of the crisis menu. Furthermore, if a crisis occurs, current import of grain will have to be replaced out of stocks for the time that is needed to cultivate the land such that sufficient grain can be produced. In Brunstad *et al*. (1995a) the stockpiling costs were estimated to be negligible compared to the production cost of grain.[4]

Table 2. Crisis menu compared to actual consumption in the base year 1998 (million kg per year)

	Consumption 1998	Crisis menu
Grains	463	335
Potatoes	309	461
Cow milk	1 400	853
Meat	247	63
Eggs	44	17
Fish	72*	335

*Average consumption (product units) in the period 1995-99 (Gaasland, 2003)

In a second run of the model we impose the quantities derived above as minimum restrictions. The necessary subsidies then follow from the shadow prices.

In column 3 of Table 1 we present the hypothetical figures for the Norwegian agricultural sector when all tariffs and subsidies other than those necessary to implement the Gulbrandsen-Lindbeck principle are removed. We can see that food security can be provided at a considerable lower cost than is the case today. Agricultural support decreases to NOK 5.5 billion, or about one third of the base solution. The support follows endogenously from the constraint on food security, and is, thus, targeted at the underlying factors of the food security production function, *i.e.* acreage, skilled labor and livestock. Employment and land use decline to 29% and 56% of the base line levels. Compared to the landscape preservation scenario, however, activity levels are higher, especially production and employment, but also land use. This reflects the fact that food security requires a wider specter of inputs than landscape preservation.

Cost complementarities

Assume now that we want both landscape preservation and food security. This brings us to the concept of jointness in production. In general, joint production exists if the production of two or more outputs is interlinked in some way, *e.g.* through technical interdependencies or non-allocable inputs (Boisvert, 2001). Jointness gives rise to cost complementarities, also referred to as economies of scope, which means that it is more expensive to produce the outputs separately than together. For agricultural public goods, jointness is mainly related to the existence of non-allocable inputs. By definition, it is difficult to determine a non-allocable input's contribution to each output. In agriculture, land is the most obvious non-allocable input since land enters into the production of both

4. The computation was based on the assumption that four years were needed to make enough land available to supply the quantity of wheat and coarse grain required by the crisis menu. Consequently, the necessary stocks needed to be twice the current level of imports

landscape preservation and food security, as well as private goods. But? also labour and livestock have such characteristics. Besides being key inputs in food production, these inputs contribute to food security and they affect the amenity value of the landscape.

In our final model simulation we include both the WTP function for the amenity value of the cultural landscape *and* the minimum restrictions derived from the Gulbrandsen-Lindbeck principle. The result of this simulation is presented in column 4 of Table 1.

The necessary support for providing both public goods is only 40% of the costs of the actual support scheme (column 1). In the base solution tariff support and budget support proportional to output accounts for more than 50% of total support. However, as the jointness of private agricultural products and the public goods is due to non-allocated inputs, support should be targeted at the inputs and not at the products, which is indeed the case in column 4.

We also see that the necessary support for jointly producing both public goods is much less than the sum of the support needed to produce each one of them separately. The percentage extra costs of producing optimal levels of the two public goods separately, compared to joint production, is more than 80%. This reflects the existence of complementarities between the two public goods: due to common inputs, support to obtain a desired level of food security also reduces the costs of keeping up the cultural landscape.

Concluding remarks

Without support, the levels of agricultural public goods like food security and landscape preservation will fall short of the demand in high cost countries like Norway, Finland, Iceland and Switzerland. However, as demonstrated, the current level of support is well out of proportion from a public goods perspective. Furthermore, the present support, stimulating high production levels, is badly targeted at the public goods in question. Since agricultural land is a major component of both food security and landscape preservation (as well as in the production of private goods), thus giving rise to a high degree of cost complementarity, it would be more efficient to support land-extensive production techniques, than production *per se*. With optimal policy instruments, the simulations show that at most 40% of the current support level can be defended by the public good argument. Naturally, production and trade will also be affected by support to sustain public goods, but, as illustrated by the simulations, to a far lesser extent.

Finally, it should be noted that our analysis considers only food security and landscape preservation. In principle, there may be other public goods that could affect the optimal policy, *e.g.* biodiversity, animal health, preservation of rural lifestyle or occupation of land for territorial defence.

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The Relationship Between Domestic Agricultural Production and Food Security: a Japanese Case

Osamu Koyama[1]

The modern concept of food security is not an old one, being first used in a series of FAO conferences held in the 1970s. In Japan, it first appeared in a policy document of 1980 when policymakers began to worry about the future of world food supply and Japanese agriculture. Since then, the idea has occupied a major position in Japanese agricultural and related trade policies. It has often been used as a rationalization to protect Japanese domestic agricultural production, which has been challenged by cheaper imports resulting from trade liberalization policies.

Japanese appeals concerning food security, however, did not receive wide support in various international forums, partly because there was no consensus on the concept of food security as applied to industrialized countries, and partly because food security was misinterpreted as promoting the need to defend domestic production rather than securing stable access to food.

Since the 1990s, however, the idea of food security has appeared in a different context. It has become an important externality of agriculture, along with other functions such as environmental conservation, biodiversity, rural landscape, and so on. There has been much debate to clarify whether and how agricultural activities provide public goods in terms of national and individual food security. There has also been much discussion on the appropriate policy measures to guarantee these functions.

This paper tries to clarify the relationship between domestic agricultural production and food security in general by introducing a concept of food security developed over the years. It examines the results of several statistical analyses made to identify and clarify the factors affecting this relationship. It also tries to quantify how domestic agriculture is linked to food security in comparison with imports which can provide an alternative to goods produced domestically. Finally, an example of the measurement of a demand curve of food security is given.

Food security issues in Japan

During the Edo era (1603-1868) when Japan followed a policy of isolation (closure), all foodstuffs were produced within the country. This situation continued until the end of the 19th century, when Japan was a net exporter of rice in the last decades. However, there were many cases of famine in the 19th century due to natural disasters, such as volcanic eruptions, and unseasonably cool summers. Regional separation caused by the feudalistic

1. Japan International Research Center for Agricultural Sciences (JIRCAS).

system accelerated the consequences of these natural disasters which overall caused the deaths of millions of persons. In 1918, nationwide large-scale rice riots broke out. It was triggered by a severe price hike caused by market failure and the structural changes of supply and demand provoked during the First World War.

At the end of the Second World War, Japan faced severe food shortages caused by losses in the provision of domestic production as well as shortfalls in colonial regions from where large amounts of food were imported. A famous anecdote recounts how urban dwellers had to beg for a bag of rice from provincial rice producers in exchange for very expensive kimonos.

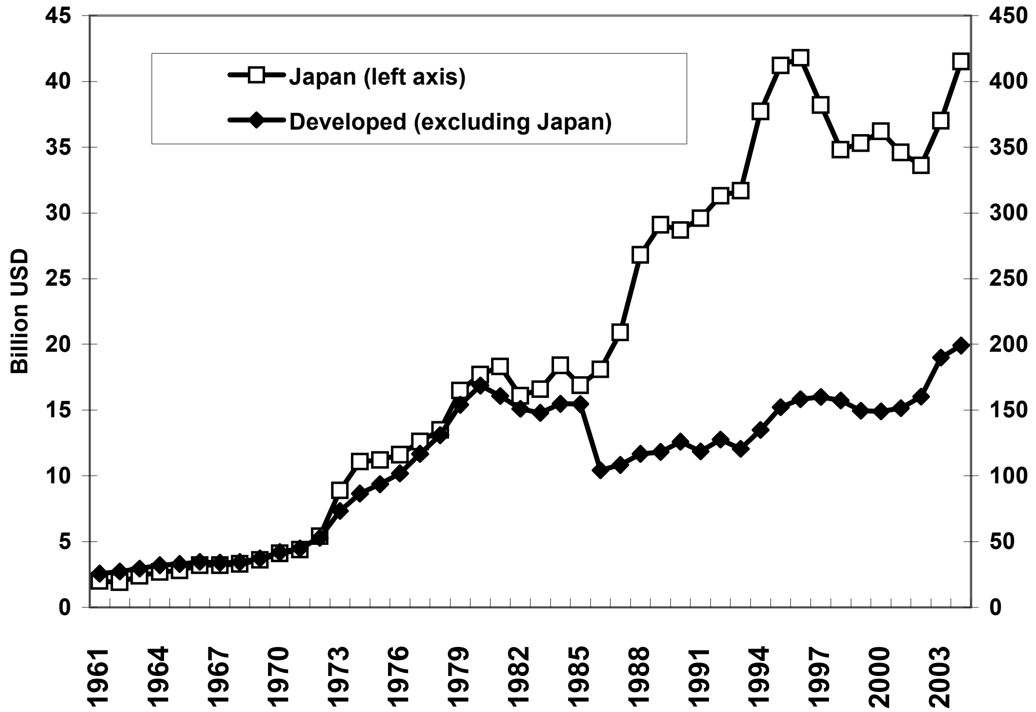
Japan, thus, placed high policy priority on increasing food production. Although rice production gradually recovered, the government implemented policies that subsidised producers and gave them price support as wages in other sectors rapidly increased along with the high economic growth. In 1973, a food crisis occurred at the same time as the hyper inflation caused by the oil crisis. It became clear to the Japanese the extent to which their food needs were dependent on the world market. For example, most soybean products disappeared from the market after the embargo declared by the United States. Since then, food self-sufficiency (comprehensive national food policy) has become a priority of the government's agricultural policy.

A rice shortage in 1993 was another important event. This shortage was caused by the unseasonably cool and rainy summer of that year which resulted in a 27% decline in rice production. It also coincided with a time when government rice stocks were very low. The government, which was fully responsible for rice supply at that time, imported rice from several countries, including *indica* type rice from Thailand, in order to stabilize the market. Japan learned two lessons from this event. First, Japanese consumers were very conscious of quality even in critical situations: imported *indica* rice was left unsold and wastefully piled up in government warehouses. Secondly, the sudden importation of foodstuffs by rich countries led to adverse effects on the food security of poor importers, as international rice prices soared.

In addition to rice, Japanese imports of agricultural products increased both in quantity and in dollar value (Figure 1) after the Plaza agreement in 1985, which caused a steep appreciation of the Japanese yen. Japan has been a leading promoter of the world agricultural trade expansion and, as a result, its dependency on import has increased. Currently, the country imports approximately 60% of its needs on a calorie basis, and 30% on a value basis. Since field crops, such as grains, animal feeds and oilseeds, are heavily imported, dependency on foreign agricultural resources, such as land and water, is estimated as much higher than the numbers in calorie terms (Figure 2).

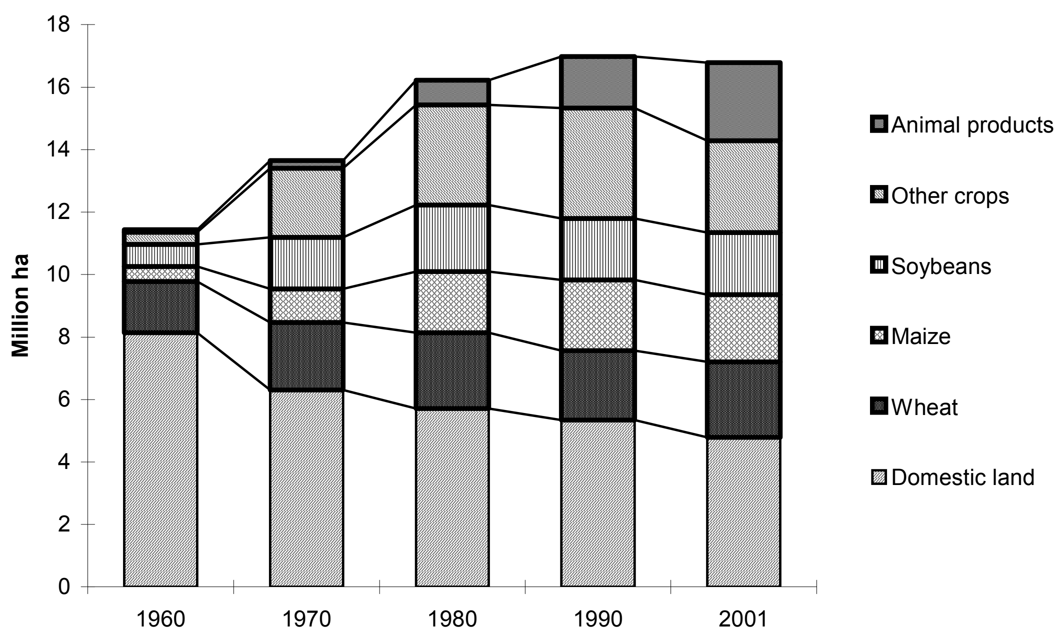
These developments, along with concerns on food hygiene, safety, and climate change, have created a sense of food insecurity amongst Japanese consumers. A recent national opinion poll reveals their anxieties about future food supplies (Figure 3).

Figure 1. Import values of agricultural products



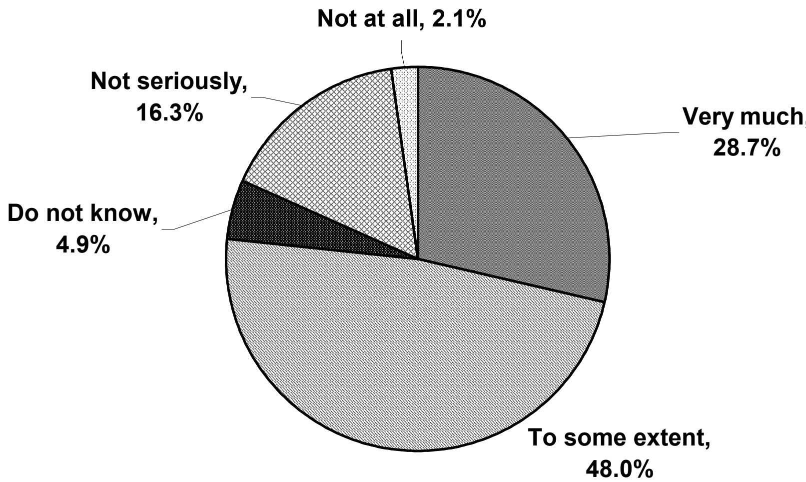
Source: FAOSTAT (FAO, 2006)

Figure 2. Planted areas required to meet Japan's total food demand (Estimates)



Source: Food Balance Sheet (MAFF, Yearly).

Figure 3. Result of national opinion poll on food supply[1]



1. Answers to the question: Do you worry about future food supplies?

Source: Cabinet Public Relations Office, Japan (2006)

Factors concerning food security

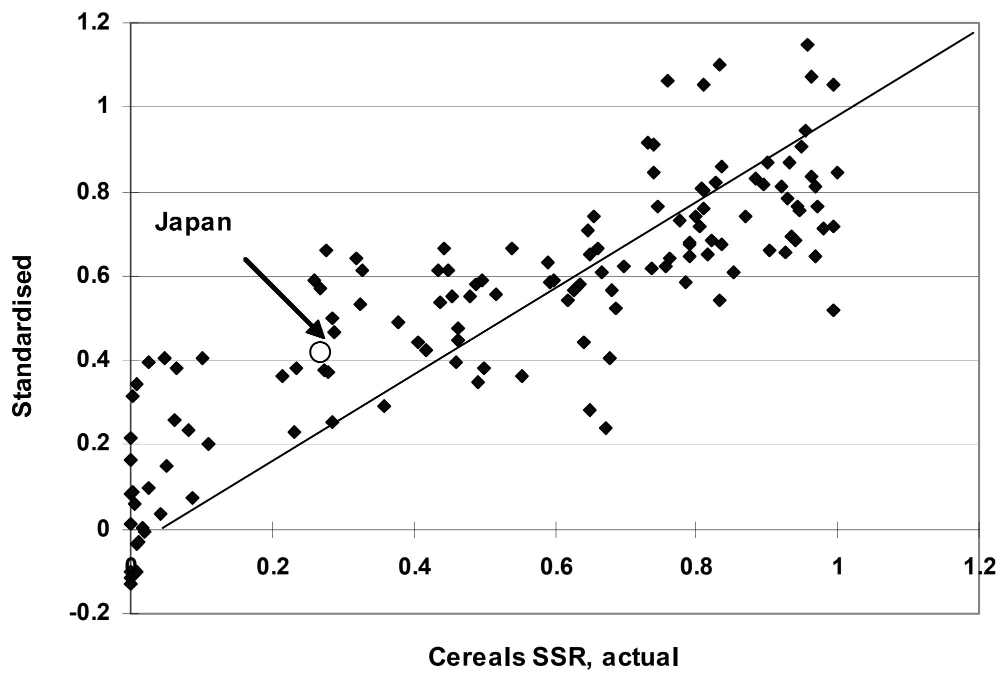
The widely accepted definition of food security is that which was endorsed by the FAO/WHO International Conference on Nutrition, held in Rome in December 1992, namely "Access for all people at all times to enough food for an active, healthy life" (FAO, 1996). Accessibility to food is often determined by the situation of individuals, families and social groups. However, it is also a national issue, especially where related national policies are concerned and when national borders have effective control over migration and food transfer. There are many ways and means to achieve food security, but there are only two ways to secure the supply of material foodstuffs, either by domestic production and/or import/aid. Stockpiling of food, either locally produced or imported, can only reduce short term risks. Income-generating activities, including agricultural production of cash products, such as non-food commodities or food for foreign export, are equally important in order to raise the national economic and social power; in other words "entitlement" (Sen, 1981) to the access to food.

In addition, distribution and transportation systems, as well as various social institutions are also indispensable. The whole chain of long processes that enable actual food intake must be secured. Energy supply, for example, is essential for importation, transportation, processing, and cooking. Energy requirements for food production practices at the farm level are also a matter of concern, although much less so than the requirement for post-harvest processes. However, these various factors should be separately argued from those which directly influence the quantity of food supply.

Dependency on import or domestic production by a country or a region can vary. The most obvious conditions which influence this dependency are population size, income level and agricultural resources. If the population is large, it is more difficult to rely on the international market for food. For example, big countries in Asia, where 60% of the world population lives, cannot import their food from the rest of the world. The world market is large enough for the total consumption of smaller countries, which may wholly rely on import. In the same way, rich countries will find it relatively easier to procure foreign foodstuffs. Meanwhile, resource-rich countries tend to meet their own food requirements.

Figure 4 demonstrates standardized import dependency or self sufficiency rates of cereals in view of the conditions outlined above. From this statistical calculation, it can be said that the Japanese import dependency is slightly too high considering the size of its population, its income level and its land resources (Koyama, 2001). However, other factors, such as geopolitical conditions, dietary habits, and food quality/safety, must also be taken into consideration in order to develop a more accurate picture of people's concerns on import dependency.

Figure 4. Estimation of standardized self-sufficiency rates



Regression was made for 134 cereal importing countries (1994-96 average).
Standardized SSR = 0.334 + 0.259 L - 0.203 log Y + 0.183 log P
t value: (2.85) (9.83) (-7.93) (9.58) R square: 0.848
Where, L: potential cereal production per person, Y: GNP per person, P: population

Source: FAOSTAT (FAO, 2006), World Development Indicators (World Bank, 2003)

Measurement of jointness

Although the optimum combination of domestic production and import for supplying the food requirements of a country depends on many factors as described above, we can identify the general characteristics of both means to find out how the two channels of food supply, domestic production and imports, work differently in the context of food security. The best indicator to show the degree of ease in procuring food is market price.

If domestically produced food is cheaper than imported food, it would be logical that the country could depend on domestic production for its food needs. However, there is another dimension to food security which is future risk; in other words, the degree of stability or reliability of food sources. Such risks are not often reflected in the market price. This could be a reason why food security is classified as an externality (OECD, 2003). The degree that a country must rely for its food security on domestic production can be considered as 'jointness' between the provision of food security, which can be defined as a part of multifunctionality, and domestic food production. Jointness would be evaluated by assessing the relative effectiveness of the two means, domestic production and import, in achieving the values of food security, as there is no other way to supply food.

First, the cost of food supply is a matter of concern. If food prices are low, people will have easier access to it. If other factors, including the quality of food, are the same for import and domestic production, the cheaper food is the better means. However, as mentioned above, there are other aspects to consider. Reliability of access to food can be an important component of food security. General ideas regarding reliability can be obtained by comparing the distribution channels of both domestic and imported foodstuffs. Access to imported food requires much longer channels than those for domestic food production. Imported food must go through foreign distributors, traders, transporters, and so on. Therefore, risks and uncertainties are higher than for domestic production. It is clear that eggs in your basket and eggs imported from another country cannot be compared.

Stability of supply is another important concept of food security. Table 1 shows the annual fluctuation of rice volume and prices in Thailand in terms of standard deviation. In this case, export prices are more volatile than domestic prices. It is a widely observed tendency in national food transactions to place priority on domestic self-consumption and then sell the remainder. Policy measures for stabilization of domestic products are more easily implemented than those for imported products. In addition, fluctuation of exchange rates and other risks can be added and sometimes multiplied (OECD, 2000). Offsetting of variations cannot always be expected.

Table 1. Annual fluctuation (standard deviation) of rice export in Thailand

	From trend	From previous year
Production volume	0.071	0.104
Export volume	0.284	0.308
Producer price	0.191	0.213
Export price	0.327	0.315

Trends were estimated by linear (price) and log-linear (volume) regression.

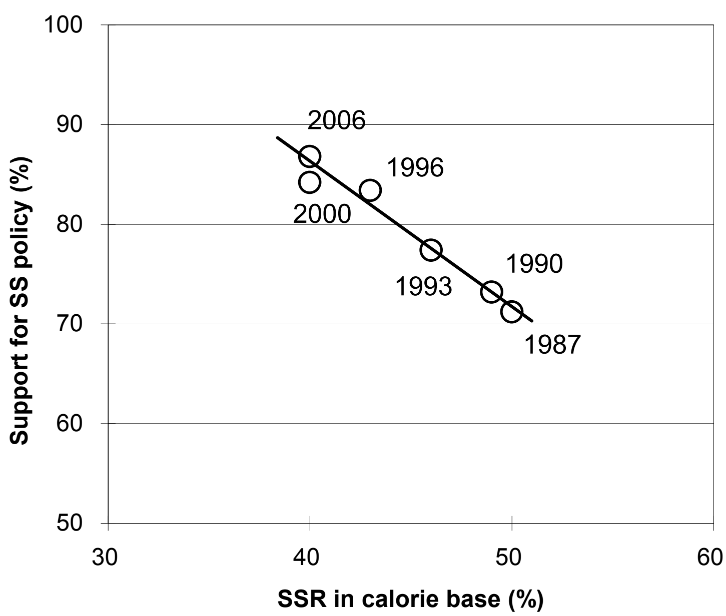
Source: FAOSTAT (1961-2000) (FAO, 2006) and others.

Food stocks are only a temporary solution for achieving food security, but they highly affect the overall feeling of security. Therefore, stockpiling is an indispensable means for food security in different stages of the food supply channels. However, stocks of imported food and those of domestic products are different in terms of direct costs and transaction costs. Stockpiling of domestic food is somewhat automatic as half of the annual production is stored on average before being consumed. Stocks of domestically produced food are available at distributed places, whereas cost for stockpiling of imported food must be explicitly accounted for.

There are other factors to be considered such as the economy of scope against other components of multifunctionality of agriculture. Summation of prices, reliability, and stability etc. will be the measurement of jointness. However, summing up these multi-dimensional factors is not easy. At this stage, an overall evaluation can only be measured by consumers' or people's perception which is thought to take many factors into account. Figure 5 shows the results of national opinion polls regarding the future food supply in Japan by comparing it with self-sufficiency rates of food on a caloric basis. Support for self-sufficiency policies increase along with the decline of domestic food production. This relationship clearly shows that the less domestic production that is available, the greater the fear about food security. Thus, it shows that the marginal benefit of domestic food production in terms of food security exists. This relationship can be interpreted as demand for food security by means of domestic production, which has long been said to be difficult to capture.

For the next stage, however, we must compare these marginal benefits with the costs required to maintain the level of stable domestic food production. Japanese consumers generally accept higher prices of domestically produced food, but the degree of allowance is not accurately measured in the opinion polls.

Figure 5. support for domestic food production and SSR



Support is expressed in the policy, "We had better produce food inside the country even though it is more expensive than import".

Source: *Public Opinion Poll on Food Supply* (Cabinet Public Relations Office, 2006), *Food Balance Sheet* (MAFF, Annual).

Conclusions

This paper has made clear that when Japan relies heavily on foreign agriculture, the Japanese worry significantly about possible food insecurity and that policy options which try to secure food supply depend on many factors which are different from one country to another. A statistical calculation indicates that Japanese food importation might be too high considering those factors. In so far as "jointness" is concerned, it showed that the importation of food is not necessarily superior to domestic production in terms of stability and reliability. In the Japanese case, at present, the greater the level of imports, the more people worry.

In conclusion, jointness between food security and domestic food production does exist in the Japanese case, particularly in the situation where more than half of the country's food supply is imported. However, the degree of jointness varies from one country or region to another. It is, therefore, suggested that the degree of jointness is ultimately determined by the people's perception or willingness to pay WTP). At this stage, however, this WTP cannot be measured easily. Thus, policy options should also be determined by democratic or political choices, which in turn should represent the majority view with respect to food supplies. In other words, like other security policies, food security policy is also a sovereignty issue.

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An Evaluation of Agriculture's Contribution to Food Security

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The Federal constitution of Switzerland guarantees the national security of food supplies. Under the terms of Article 102, the Federal Government must ensure that, in the event of a crisis or a shortage, essential goods and services that the economy is unable to provide by itself will be guaranteed by the government. The objective is to overcome any supply crises by means of precautionary measures in six sectors: food, energy, medical supplies, transport, industry as well as information and telecommunications infrastructure. Supplementary to Article 102 of the Federal Constitution, Article 104 states that agriculture shall contribute "to securing food supply for the population." The term "supply security" can be understood to cover both food safety and food security. In Switzerland, food safety is subject to food laws and is based primarily on Article 118 of the Federal Constitution on the protection of public health. Agricultural policy measures deal mainly with the food security aspect.

According to current agricultural policy, Swiss agriculture contributes to food security. In addition to the production of storable foodstuffs, foodstuffs with limited storability, foodstuffs which are only storable in processed form or which are not suitable for storage, the multifunctional services provided by agriculture ensure that food security also includes maintaining a certain level of production. Depending on the time span, agricultural food production and processing have a differing degree of importance in so far as the level of security in supplies of food is concerned:

- *Short-term* (1-6 months): seeks to ensure that a certain volume of domestic agricultural goods is available if necessary.

- *Medium-term* (3-12 months): maintains the possibility of using, refining and processing of raw products in other ways if necessary.

- *Long-term* (>12 months): maintains the possibility of changing, adapting or increasing production if necessary.

While the short-term period relates to the physical availability of foodstuffs rather than to its production, the possibility of changing and expanding production is pre-eminent from a medium- and long-term point of view. Domestic production gains importance when supplies cannot be guaranteed by imports or by the stocks available. From an economic point of view, however, this approach is criticized in that the current support for agricultural production and the associated higher degree of self-sufficiency would not, in a crisis, contribute to food security and that the support measures are therefore inefficient. This criticism is based on the idea that, in crises of long duration, food security does not depend on high domestic production, but rather on maintaining agricultural production capacities (Henrichsmeyer and Witzke, 1994).

Within the context of the discussions on multifunctionality and food security, the question arises as to the extent to which food security can be guaranteed if it is de-linked from agricultural production. At the same time, in order to identify the most efficient measures, the costs of alternative ways of guaranteeing supplies in a crisis must be compared with those of linked production. If linked production exhibits cost advantages when compared to an alternative source of supply which is de-linked from agricultural production then it is efficient to support agriculture for the provision of food security.

In the present study, agriculture's contribution to food security is evaluated by focusing on food security at differing domestic production volumes. Today's production and the associated supply security in a crisis are compared with those which can be expected from domestic production under world market conditions. However, it is not the purpose of this study to estimate the costs of food security and to compare the costs of today's linked production with those which would arise in a system without agricultural support.

This study is divided into five parts. The first presents the Swiss food security strategy and forms the basis for the methodology used for estimating domestic production under world market conditions and for the evaluation of food security as described in the second part. The third part contains the results of the evaluation. These are then discussed in parts four and five and, in the conclusions, are applied to food security.

Swiss food security strategy

The aim of the Swiss food security strategy is to ensure that, in a crisis, the population can be provided with food over a six-month period. This security is to be ensured mainly by means of supply control measures — in particular distribution from mandatory stockpiles — and afterwards by means of control measures to meet food demands. In this way, food rationing can be kept at a low level.

In extraordinary situations, the food security strategy is based on the following measures (EVD 2003):

- implementation of import measures and assuring transportation of foodstuffs;
- mandatory stockholding of foodstuffs, fodder and fertilisers;
- production control in agriculture and foodstuff industry;
- imposition of quotas;
- restriction of quantities sold; and
- rationing.

These measures, the result of a collaborative effort between private enterprises, the Federal Government, the Cantons and boroughs, are designed to overcome short- and medium-term shortages (for periods up to 18 months) to ensure that during the first six months of a crisis the needs of the population can be fully met without resorting to food rationing. It should be possible to introduce other measures to overcome a longer, more serious supply crisis within this time-frame. Furthermore, by focussing supply security on the first six months, it should be possible to avoid sharp economic slumps. After six months, it will no longer be possible in every case to guarantee that market supply corresponds to demand and therefore additional demand control measures must be implemented if necessary.

Mandatory stockholding plays an important role in supply security. The Federal Government therefore concludes contracts with companies that specify the type, quantity, quality, the period of time, products or foodstuffs for which stocks must be maintained. These are the property of the company and not of the State, and are traded within the scope of the company's normal business operations. Those products for which a stock is to be maintained are those which are likely to be in short supply in the event of a crisis and which are either not available in Switzerland or not available in sufficient quantities. In the food security sector, the mandatory stockpiles cover normal consumption of selected products and foodstuffs (bread and meal grains, sugar, edible oils and fats, rice, coffee) for a period of four months. From an energy point of view, the share held by mandatory stockpiles is at present the equivalent of 800 Kcal per person/day. In addition, sufficient fodder is kept in stock to cover three month's requirements and enough fertiliser is kept in stock to cover the needs of one vegetation period (BWL, 2006).

The food security strategy makes allowances for structural supply risks, political and economic developments both inside and outside of Europe, or for consequences arising from global, demographic and natural changes (EVD, 2003). The likelihood that these risk factors will materialise cannot be substantiated. Likewise, the risks do not merely involve the national level, but much larger areas. Therefore, the planning of food security measures is based on the assumption of scenarios which involve shortages which are more or less severe depending on the respective crisis. In a medium-term scenario, it is assumed that 50% of the productive agricultural surface would no longer be available for production, foreign trade is restricted to 50% of normal trade relationships. In addition, the scenario assumes that the mandatory stockpiles are used in the first six months of the crisis.

In addition to those measures designed to overcome short- and medium-term crises, the long-term assurance of agricultural build-up capacities is important when it comes to increasing domestic production. Production capabilities (know-how) and capacity must be maintained, and productive land must be kept available so that domestic production can be increased in the event of a long term supply crisis. Therefore, land devoted to crop rotation is the basis upon which the long-term expansion potential of domestic production can be maintained and upon which substantial changes in production can be undertaken. It follows that the maintenance of land devoted to crop rotation is an important element of the food security strategy. Another reason for this is that in view of the steadily growing population, new risks, such as soil contamination, could be detrimental to agricultural production.

Method for evaluating food security

The evaluation of food security is based on Switzerland’s substantial domestic production and the need to ensure a degree of supply security in the event of a crisis. This applies not only to a short-term crisis, but also to the medium- and long-term ability to guarantee adequate supplies by either modifying or increasing production as necessary. In order to evaluate the level of food security needed, the current strategy assumes that there is substantial integration within agricultural production. In view of the goals of the current strategy, if agricultural policy did not include support of agriculture and there was a lower level of domestic agricultural production, additional measures (*e.g.* higher stocks) would have to be implemented to ensure food security in a crisis. However, as mentioned in the introduction, it is not the purpose of this study to estimate the costs of food security under various agricultural systems.

The procedure to evaluate food security is a two-step process. The first step consists of estimating domestic production under world market conditions. This is done by means of a written survey involving experts from the administration, agricultural organisations, producer associations and science. The second step involves the optimisation and evaluation of food security under the decision supporting systems that are currently in force in Switzerland.

The assessment of domestic production under world market prices assumes a complete cutback of agricultural support with, in particular, the discontinuation of all direct payments. Producer prices fall to the level of world market prices. Direct input factors (fertilisers, fodder, etc.) are also affected by the cutback in support. Consequently, the prices for these inputs fall to world market level. A two-stage survey covering four sectors is used to estimate domestic production under these basic conditions: yields in crop and fodder production; livestock yields; land-use; and numbers of animals. Production quantities can be estimated from the combination between yields, areas and numbers of animals. This survey method, which is based on the expertise of those working in the agricultural sector, is used as there are no models to calculate Swiss domestic production under world market conditions. In the first step of this survey, experts give their independent estimate of production yields, land-use and number of animals based on current production and the relationship between domestic and world market prices. The evaluation of these expert opinions serves as the basis for the second step of the survey in which the experts can correct the assessments of the first group.

Due to wide price differences and the fact that current structures are not competitive under world market conditions, there is a great deal of uncertainty regarding the estimations of domestic production at world market prices. Three scenarios, therefore, are evaluated for domestic production with a view to defining the production quantities which can be expected:

- a pessimistic scenario defines the lowest limit of expected Swiss domestic production under world market conditions;
- a neutral scenario defines expected domestic production; and
- an optimistic scenario defines the upper limit of expected Swiss domestic production under world market conditions.

Switzerland has a comprehensive support system for optimising food security developed at the Computer Technology Department of the University of Freiburg (DIUF). The system is divided into three parts:

- an information system regarding available food resources;
- a decision support system for planning and implementing demand control measures; and
- a decision support system for supply control (provides tools to aid in decisions to increase or modify domestic supply). Using this system, measures taken in the

fields of foreign trade, domestic production, processing, in the utilisation and storage of agricultural goods can be simulated and their consequences determined.

Food security is thus analysed using this decision support system, and which has the objective of exploiting the supply-side potential to its maximum. Five objectives (listed below in order of importance) are sought. An objective can be put aside if this is necessary in order to achieve optimization of the following, higher-level objective:

- Seek supply flexibility whereby infringements of the known production and supply rules applicable in normal times should be kept to a minimum.
- Aim at predetermined quantitative energy supply targets.
- Strive to achieve a healthy, balanced nutrient mix based on the shares of the principal nutrient units as recommended by nutritionists.
- Keep added value losses in the exploitation of the quantitative and qualitative supply potential (targets 2 and 3) as low as possible.
- The eating habits of the population are respected in that the composition of the resulting product mix resembles the normal shopping basket as closely as possible.

The initial quality of the solutions for food security based on the multistage optimisation ranges from good to very good. The solutions are characterised by a high degree of target achievement. Thus, the decision support system allows a consistent evaluation of food security for the scenarios investigated within the scope of the evaluation with regard to domestic production and supply emergencies.

For evaluation purposes, domestic production under today's basic conditions with agricultural support and domestic production at world market prices is applied to the medium crisis scenario. Supply security is then assessed using the decision support system. This standardised crisis scenario has been used in Switzerland over the last ten years as a monitoring function to document supply developments and how to establish how to orient government reaction capability. As described above, the medium scenario is also based on the assumption that both foreign trade and domestic crop production fall by 50% over a period of six months. In the following year, the scenario reckons with a 70% recovery in both production and foreign trade, and a 100% recovery in the year after that.

Agricultural production and food security today

The evaluation and assessment of food security in the scenarios under world market conditions are based on the appraisal of supply security provided under basic conditions as they exist currently. As described above, in addition to domestic production, the mandatory stockpiles, the raw products and foodstuffs available in the supply chain, and the processing capacities play a decisive role in food security.

Due to the climatic, economic and political conditions prevailing in Switzerland, agricultural production is focused on livestock:

- In Switzerland, 617 000 hectares or 59% of the total productive agricultural land amounting to 1.048 million hectares is cultivated as natural meadowland. Open arable land is comprised of about 27% of total productive land.

- Approximately 40% of total arable land is cultivated as temporary pastures or for growing maize for silage or fodder for animal feed.
- Approximately 54% of the total arable land is used for growing cereals, root crops, rape, sunflowers, or soya.
- The cultivation of vegetables, fruit, berries and vineyards account for a 7% share in the total arable land.
- Bovines play the principal role in livestock-keeping. Cattle account for about three-quarters of the total number of animals, amounting to 1.27 million LUs. Pig-keeping holds a share of 15%, while sheep and goats together as well as poultry account for a share of 4% each in the total number of animals.

The marked orientation of livestock-keeping is also evident in domestic supplies and provisions of agricultural goods. While domestic production of vegetable products held a share in consumption of 45% in 2004, animal-based foodstuffs accounted for 94%. Over the whole spectrum of foodstuffs, 60% of food consumption is of foodstuffs produced in Switzerland (SBV 2005).

Based on actual production and stocks, today's food security in the medium scenario can be assessed as follows (Table 1):

- *Short-term food security*: thanks to domestic production, mandatory stockholding and goods in the pipeline coupled with high numbers of animals, domestic supplies can be maintained at an adequate but high nutritional level of over 3 300 kcal per person per day for the first six months of a crisis. This means that it would be possible to refrain from introducing measures, such as food rationing, on the demand side during the first four to seven months. Consequently, the main objective of today's food security strategy is achieved.

- *Medium-term food security*: an adequate level of nutrition with excellent nutritional quality and an attractive range of products can be guaranteed for the following 12 months. A "reasonable" form of distribution which does not endanger the requirements of the population can be guaranteed by simple quotas at the wholesale level and by selective sales restrictions at the retail level. It is most likely that measures such as food rationing can be avoided.

- *Long-term food security*: from the 19th to the 30th month after the start of the crisis, a level that corresponds closely to the normal supply situation will be returned to. The number of animals and supplies will have been recomposed, thus ensuring once again a sustainable supply of foodstuff.

Table 1. Coverage of energy requirement according to relevant nutrition-physiological units based on current production (absolute and relative to today's consumption)

		First 6 months		7th to 18th months		19th to 30th months	
	Today's consumption	Absolute coverage	Relative to today	Absolute coverage	Relative to today	Absolute coverage	Relative to today
Starch units	721	1 380	191%	883	122%	1 169	162%
Vegetable units	83	34	41%	60	72%	76	92%
Fruit units	94	40	43%	76	81%	96	102%
Sugar units	631	315	50%	302	48%	399	63%
Protein units	712	741	104%	677	95%	471	66%
Fat units	688	799	116%	695	101%	750	109%
Beverage units	171	93	54%	74	43%	103	60%
Nutrient units	3 100*	3 403	110%	2 767	89%	3 063	99%

* At present, effective consumption in Switzerland is 3 300 kcal per person and day. The difference to the 3 100 kcal logged in the decision support system can be explained by products which are not taken into account in the system.

In the crisis scenario described here, which foresees a 50% reduction in both foreign trade and domestic crop production over a period of six months and a recovery of respectively 70% and 100% in the following two years, the number of animals will decline to ensure food security over the first six months and will be built up again during the recovery phase. Animal and crop production structures will be optimised between the 7th and the 30th months to ensure food security. During the first six months, food security is based mainly on mandatory stockholding, goods in the supply chain (warehouses), the high number of animals before the beginning of the crisis, and additional slaughtering to reduce the livestock units. Even if foreign trade remains at 50% of normal import levels, adequate supplies are available to guarantee that the physiological requirement of 2 300-2 600 kcal is covered on a sustainable basis. However, under these circumstances, demand-side measures, *i.e.* food rationing, is essential to ensure that distribution is properly oriented.

The results of the decision support system serve as a basis on which both the quantitative evaluation of food security and the quality of the nutrition mix can be reviewed (Table 1). The assessment is based on the nutrition units consumed today, whereby only the units registered in the decision support system with a total energy consumption of 3 100 kcal are taken into account. Effective overall consumption is approximately 3 300 kcal per person per day.

The results show that from a short-term point of view, vegetable, fruit, beverage and sugar units are below the current consumption level. On the other hand, requirement coverage clearly exceeds normal consumption in the case of protein, fat and starch units. The high coverage in fat and protein units is primarily due to the reduction in the numbers of animals which at the same time facilitates a transfer of starch units away from animal production into human nutrition. On a medium- and long-term basis, the nutrient mix of vegetables, fruit and fat once again approaches normal nutrition levels. By way of contrast, requirement coverage with regard to sugar and protein, in particular, is below normal consumption levels, while starch units are above this level. The structural modification of the mix is part of the food security strategy because the production of starchy foodstuffs such as cereals or potatoes is significantly more efficient in relation to land and the variable factor input than the production of (animal) protein.

Viewed as a whole it can be stated that at present, given actual domestic production and the associated supply and adaptation potential, food security can be guaranteed in the medium crisis scenario. From the short- and long-term point of view, supplies exceed or reach normal levels with respect to total food energy. In the case of certain products or product categories, it is possible that market supplies cannot be maintained at today's level or that the structural composition of the foodstuffs does not entirely correspond to today's eating habits.

Agricultural production and food security under world market conditions

Under world market conditions, a noticeable decline in domestic production can be expected in Switzerland (Tables 1 and 2). Experts anticipate restricted land-use and a correspondingly lower number of animals. The extent of this limitation will depend on the difference which exists today between domestic producer prices and world market prices and from the general assessment of agriculture's competitiveness.

In the neutral scenario for domestic production at world market prices, roughly 50% of productive land is cultivated, while in the pessimistic estimate experts anticipate a decline in land-use of over 70%. The optimistic estimate reckons with slightly more than 50% of today's area. Comparable limitations can be expected in crop production, especially in the case of cereals, sugar beet and oil seeds. This reduction is problematic in that a decline in production endangers sugar and oil seed processing capacity; if these come to a complete halt, it is possible that domestic production would be abandoned. In contrast to crop production, the cultivation of vegetables and especially the growing of fruit and berries and permanent crops is, as a whole, less subject to limitations than land-use. The anticipated fodder production area is slightly higher than expected with regard to total land-use. In the neutral scenario an area of 55% of actual natural meadowland was used accordingly, while approximately 60% can be expected in the optimistic case.

The experts' estimates of the number of animals can be divided into two groups: in the neutral scenario, the experts expect the number of cattle, sheep and goats kept on a grazing/roughage-based regime to decline by at least 50%, while in the case of concentrated livestock-keeping approximately 60% of today's pig and poultry population could be kept under world market conditions. On the other hand, a decline of at least 70% is to be expected for all categories of animals in the pessimistic scenario.

The experts believe that in the neutral scenario under world market conditions, it can be expected that yields from livestock-keeping are at least equal to, or in certain cases up to 10% above current levels. Pig-keeping is the only exception with slightly lower yields. Yield estimates for the pessimistic and optimistic scenarios deviate from the neutral scenario by, respectively, about 10 percentage points upwards and downwards.

The yields from crop production and livestock-keeping, together with the anticipated areas and number of animals, are used to create three databases for the decision support system that is applied to the medium crisis scenario. Other data, such as stockpiles, processing capacity, and raw materials and foodstuffs available through the supply chain, are obtained from current conditions. A change in domestic production under world market conditions would lead to structural changes in foreign trade. In principle, such changes cannot be assessed precisely. However, due to noticeably higher imports when domestic production is subject to world market prices, these were corrected by means of plausible and consistent assumptions.

The results concerning the coverage of food energy requirements in the different scenarios and with different time horizons are presented in Figure 1. When interpreting energy requirements one must note that 2 300-2 600 kcal is necessary to ensure sustainable coverage of physiological requirements. As discussed above, given today's production it can be assumed that good to very good food security can be guaranteed in the medium crisis scenario. In the long run it is possible to regain a supply level which corresponds to today's situation.

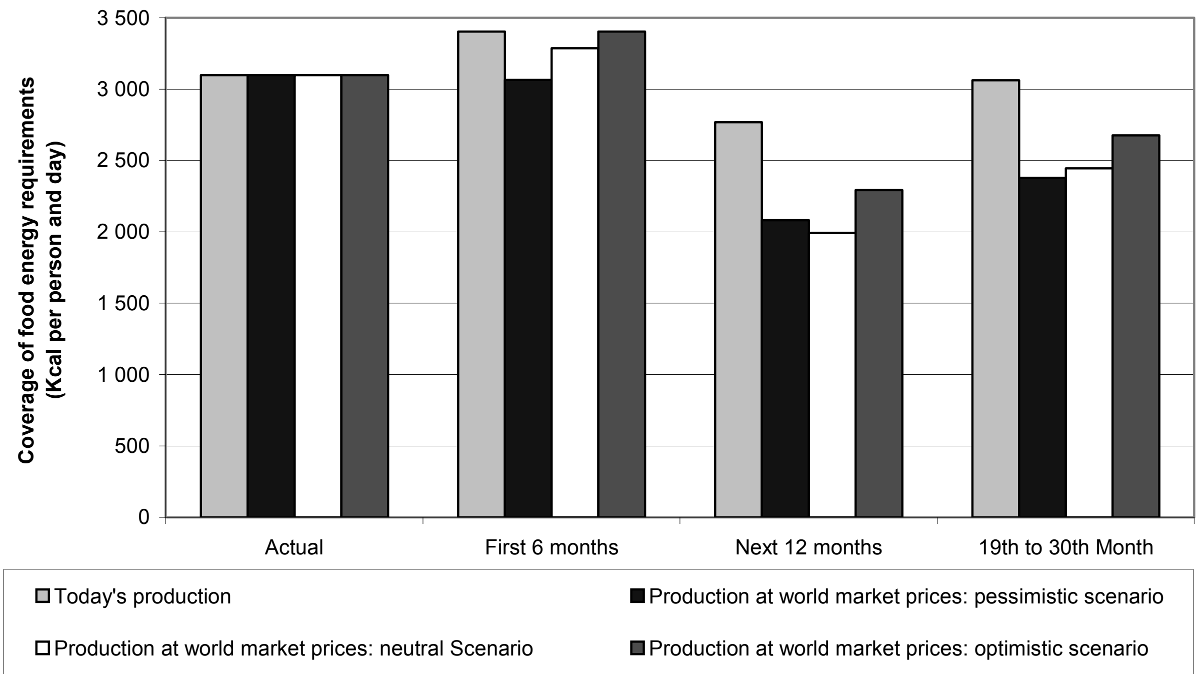
Table 2. Estimated land-use under world market conditions

	Estimated land-use under world market conditions					
	Pessimistic scenario		Neutral scenario		Optimistic scenario	
	Area (in ha)	Relative to today	Area (in ha)	Relative to today	Area (in ha)	Relative to today
Cereals	8 333	5%	31 804	20%	44 479	28%
Sugar beet	725	4%	1 633	9%	2 177	12%
Potatoes	2 222	18%	4 475	36%	6 221	50%
Rape, sunflowers, soya	1 740	8%	3 353	15%	4 690	20%
Other arable crops	8 389	16%	16 628	33%	22 974	45%
Outdoor vegetables	2 856	33%	5 350	62%	6 522	75%
Orchards, berries, vines	13 706	65%	18 326	87%	19 959	95%
Open arable land	25 070	9%	64 790	23%	88 950	32%
Arable land	66 868	17%	130 196	33%	160 294	40%
Permanent crops	15 874	68%	20 494	88%	22 128	95%
Natural meadowland	204 562	33%	34 1570	55%	378 387	61%
Vegetables grown under shelter	240	51%	369	78%	407	86%
Productive agricultural land	292 544	28%	501 148	48%	570 541	54%

Table 3. Estimated numbers of animals under world market conditions

	Estimated numbers of animals under world market conditions					
	Pessimistic scenario		Neutral scenario		Optimistic scenario	
	Animals (in units)	Relative to today	Animals (in units)	Relative to today	Animals (in units)	Relative to today
Dairy cows	155 290	28%	305 030	55%	354 950	64%
Non-milk producing cows	1 530	3%	1 530	3%	4 090	8%
Veal calves	17 910	19%	37 700	40%	49 010	52%
Suckler cows	19 490	25%	41 320	53%	53 790	69%
Calves from sucklers	15 530	25%	32 920	53%	42 860	69%
Heifers and young females	130 070	26%	255 140	51%	305 160	61%
Bulls and steers	7 320	24%	14 950	48%	18 420	59%
Cattle for fattening	30 110	21%	64 530	45%	83 170	58%
Cattle total		25%		50%		60%
Breeding sows	46 060	31%	98 070	66%	111 440	75%
Pigs for fattening	420 060	29%	912 550	63%	1 071 890	74%
Pigs total		29%		63%		74%
Horses total	12 120	22%	24 160	44%	28 630	52%
Sheep and goats total	117 500	23%	224 300	44%	284 470	55%
Laying hens	527 170	26%	1 176 000	58%	1 520 700	75%
Pullets	1 454 160	29%	3 209 190	64%	3 911 200	78%
Poultry total		27%		61%		77%

Figure 1. Development of coverage of food energy requirements in the medium crisis scenario assuming today's production together with production under world market conditions*



* The minimum physiological requirement amounts to 2300-2600 kcal per person and day.

This cannot be achieved in the scenario under world market conditions. In the optimistic and neutral scenarios, the short-term food security situation is good, but is dangerously or inadmissibly low from a medium- and long-term point of view. There is no sustainable long-term supply guarantee. As a whole, in the event of a supply disruption as foreseen in the medium crisis scenario, medium- and long-term food security cannot be guaranteed by domestic production in the neutral scenario with today's measures. This assessment is even more severe in the pessimistic scenario since short-term supply security is barely ensured and is insufficient in the medium and long run.

The short-, medium- and long-term assessments of supply security in the scenarios with domestic production at world market prices are as follows:

- *Short-term supply security*: thanks to mandatory stockholding and goods in the supply chain, sufficient supplies are available to ensure an adequately high food level of at least 3 000 kcal per person per day during the first six months for all scenarios. This means that it would most probably be possible to refrain from introducing demand-side measures during the first four to seven months of a crisis. Therefore, the objective of the current official food security strategy would be met.

  However, short-term supply security is overestimated in the decision support system because the freely available stocks and structure-related stocks in the supply chain are based on current quantities of raw products and foodstuffs. Under world market conditions, domestic production is considerably lower and imports are higher. Therefore, these quantities are likely to be significantly lower since declining domestic production entails a reduction of warehouse and processing capacities and the retail trade would be supplied directly with imported foodstuffs.

- *Medium-term supply security*: In the optimistic scenario, the food supply situation just barely covers the minimum requirement from a medium-term point of view. On the other hand, supplies are clearly below the physiological minimum requirement of 2 300-2 600 kcal in the pessimistic and neutral scenarios. The productivity, health and, in particular, the morale of the population would suffer greatly at this supply level. Comprehensive food rationing would have to be introduced. Comparatively large quantities of food would have to be made available from alternative sources in order to avoid a breakdown in supplies.

- *Long-term supply security*: From a long-term point of view, from the 19th to 30th month, there is only a slight recovery in the neutral scenario and the population would continue to be under-supplied. Minimum supply is not ensured on a long-term basis in the pessimistic scenario. In the optimistic case, physiological requirements could just be met on a long-term basis with comparatively high domestic production under world market conditions.

If imports stagnate at 50% of the normal level, it is impossible to ensure a sustainable supply status which would suffice to meet physiological requirements. It is questionable whether there are comparable, reliable, alternative measures to ensure sustainable supplies.

In addition to the quantitative evaluation of the food situation in the scenarios with domestic production at world market prices, the quality of the nutrition mix must also be reviewed. Table 4 illustrates coverage of energy requirements, based on the relevant nutrition-physiological units, in relation to supply in the medium crisis scenario assuming today's domestic production. Given production at world market prices, supplies of starch, sugar and protein units are clearly not as good as supplies based on current domestic production. In both the pessimistic and neutral production estimates at world market prices, medium- and long-term supplies of starch and protein are considerably below normal. From a short-term point of view, the same applies to vegetable and fruit units whereby in the medium- and long-term supplies of vegetables and fruit reach the same level as current domestic production. The deficit in starch and sugar units together with the occasional of protein units are decisive factors in the noticeably worsened supply situation found in the pessimistic and neutral scenarios.

On the whole, it is apparent that, even with optimistic assessments of domestic production under world market conditions, medium- and long-term food supplies cannot be guaranteed with today's food security instruments and measures should there be supply disruptions as foreseen in the medium crisis scenario. In contrast, in the pessimistic and neutral scenarios, it is impossible to provide the population with food supplies that meet the minimum requirements recommendations. Developing a sustainable supply to a level of over 2 300-2 600 kcal per person and per day is questionable and would certainly take several years.

Table 4. Coverage of requirements based on relevant nutrition-physiological units assuming domestic production under world market conditions (in relation to supply security today) - medium crisis scenario

	Pessimistic scenario			Neutral scenario			Optimistic scenario		
	< 6 months	7-18 months	19-30 month	< 6 months	7-18 months	19-30 months	< 6 months	7-18 months	19-30 months
Starch units	101%	55%	50%	101%	55%	55%	100%	67%	65%
Vegetable units	103%	130%	107%	109%	123%	107%	121%	132%	116%
Fruit units	155%	137%	134%	140%	116%	119%	143%	122%	123%
Sugar units	113%	45%	43%	108%	39%	39%	107%	43%	42%
Protein units	40%	58%	80%	62%	71%	101%	79%	91%	112%
Fat units	100%	110%	119%	111%	94%	112%	112%	98%	117%
Beverage units	127%	158%	144%	123%	128%	128%	125%	135%	133%
Nutrient units	90%	75%	78%	97%	72%	80%	100%	83%	87%

Evaluating the results of food security scenarios

The evaluation of food security is based on assumptions concerning crisis situations which could jeopardise supplies. The purpose of maintaining a national supply is to be prepared to face a crisis situation. In this paper, food security as provided for by different agricultural systems is evaluated using a standardised crisis scenario with restricted foreign trade and domestic production. In Switzerland, the same scenario is used to monitor the national supply strategy. Putting aside the question of the probability that one of these crisis scenarios will actually materialise, the conditions they presuppose allow a consistent comparison of differing agricultural systems with regard to their contribution to food security.

The classification of the results on food security is based on the fact that Switzerland would have no supply problem in the event that an incident affecting only Swiss national territory should occur. Swiss food supplies are more likely to be jeopardised in crises which involve a larger area. Consequently, it cannot be assumed that Switzerland would benefit from preferential supplies through imports in a crisis regardless of international supply contracts and its high purchasing power compared to other nations.

The importance of agriculture and food production and processing for supply security differs depending on the time horizon involved. Those raw products and foodstuffs which are physically available in mandatory stockpiles and in the supply chain are decisive for short-term supply security, whereas processing capacities and the quantities available in stock are linked to domestic production. A decline in domestic production would probably be accompanied by a reduction in the (decentralised) processing and warehousing capacities of private companies. Therefore, if the population is supplied with a greater share of direct imports, it follows that this also leads to a reduction in the quantities available in stocks and in the supply chain. In order to ensure an equivalent supply level, it must be possible to draw these quantities from mandatory stockpiles. In addition to the short-term effect, a reduction in processing capacities would impede on the medium- and long-term possibility to adapt and expand production, and as a consequence it would take longer to re-establish an adequate level of supply.

In addition to the indirect impact on short-term supply security, a decline in domestic production under world market conditions would inhibit the build-up capability of domestic production. On the one hand, this is due to the short-term inertia of the production system. The most important point is the minimum time requirement of approximately 12 months between the decision to change production and the effective availability of food from crop production. This adaptation time can also be increased by lack of production goods, such as seed, fertiliser, herbicides or pesticides, by crop rotations which cannot be done in a short period of time, or by a lack of know-how. In livestock production, and in particular in the case of cattle, the gestation period leads to short-term inertia. On the other hand, a reduction in the number of animals is also limited by the time required to prepare an animal for slaughter, especially if premature killing is to be avoided.

In the long run, the potential and the time required to adapt and expand agricultural production depends primarily on the (crop rotation) land available and on the existing infrastructure. On the one hand, infrastructure includes the processing and warehousing capacities of the downstream operators and the foodstuff industry. On the other hand, production potential is also influenced by the number of qualified workers, the effective machinery and animal housing capacities available as well as by the investments which can be realised within the scope of crisis management. The time required to adapt to a change in production towards sustainable food supply is also prolonged by necessary modifications to farms and sections of farms. The latter will be aggravated by the organisational problems of inter-farm exploitation of available machinery capacities because under world market conditions competitive farms, in particular, usually make full use of their machinery for economic reasons. At the same time, this mechanisation is not necessarily organised in the best possible way for production aimed at ensuring long-term food security. This makes it difficult to change production without additional investments.

Conclusions

The fundamental point of departure for the conclusions on food security is the fact that, globally speaking, agriculture is the greatest raw materials producer and that therefore there is complete jointness between agricultural production and food security (Mann, 2006). However, on a national level the degree of this link must be viewed in relation to space and time. Both dimensions are associated with potential supply crises which can affect either domestic production, or access to imports or stocks. Depending on the time and space dimensions of the crisis, there is a relationship between agricultural support, the resulting increase in domestic production, and food security.

The evaluation of food security by means of comparing different agricultural systems shows that in a standardised crisis scenario in the short run there is only an indirect relationship between food security and agricultural production. This is due to the fact that high domestic production and pre-crisis imports generate comparatively high volumes of raw product and foodstuffs in stocks and in the supply chain. On the other hand, in the medium- and long-term cases, there is a direct relationship since medium- and long-term supplies cannot be guaranteed for the population by production at world market prices as foreseen in the assumed crisis scenario. However, given today's production level, a sustainable supply is possible; in the assumed crisis scenario there is a relationship between production and sustainable supplies for the population.

Basically, in an approach which focuses on short-term supply crises it is possible to de-link food security from agricultural production. The foodstuffs required to ensure that the population is supplied can be drawn, for example, from mandatory stockholding. Technically speaking, it is possible to store practically all kinds of products. However, from an organisational and economic point of view, it is difficult to implement a quantitative and qualitative increase in the volume of mandatory stockpiles, as the private companies which currently guarantee stockholding would probably reduce their storage capacities if there was a decline in domestic production. This leads to a shift in the relationship between mandatory stockpile quantities and the ideal operational stock levels, which would result in noticeably higher costs for stockholding. In addition, a decline in agricultural production would probably lead to an increase in imports of instant/ready-to-use foods. This would also mean that there would have to be a switch from stocks of raw products to the storage of instant/ready-to-use foods, which in turn would lead directly or indirectly to higher storage costs. The additional storage costs for the assurance of short-term supply security were not quantified. Therefore, it is not possible to comment here on the efficiency of either the current system or on an alternative system.

Medium- and long-term supply security is linked to the upkeep of production and processing capacities together with the availability of the necessary production goods. In the case of agricultural production capacity this applies in particular to the land available; this is outlined in the plan for crop rotation areas which seek to safeguard areas for potential agricultural production by developing a series of planning measures. Basically, the land does not have to be cultivated intensively in order to maintain agricultural production capacities, but can be used extensively or even just kept open. At the same time, it is possible that the area required to ensure sustainable supplies is probably somewhat smaller than the area used today. The presence of a minimum number of animals is also linked to the cultivation of the remaining area and this too is an important factor for sustainable food security. The latter also applies to the maintenance of assets, such as the necessary machinery and buildings, as well as to the available production goods.

In contrast to agricultural production capacity, the reduction of processing capacity which would accompany a decline in domestic production would have an adverse effect on the possibility to adapt and expand production because it would not be possible to accomplish the necessary investments required within the scope of crisis management. A reduction in capacity is particularly problematic for those product branches which are currently characterised by a high concentration of the processing industries (*e.g.* two sugar refineries in Switzerland) or whose products are essential to providing food security. Basically, however, it should be possible to de-link processing capacity from production and to adopt alternative measures to ensure their maintenance. As in the case of short-term storage, alternative measures for the maintenance of processing capacity were not investigated. In particular, there is no estimate of the costs of alternative measures; this also applies to the costs of maintaining agricultural production capacity. Consequently, no comments can be made on the efficiency of today's system for ensuring food security as compared to an alternative system under world market conditions.

When defining policy measures to ensure public food security, the question of costs alone is not the only decisive factor. Societal demand must also be given due consideration. In the case of Switzerland, both production of foodstuffs and secure food supplies are regarded as essential agricultural functions[1]. Other positive effects of food security are, for example, a feeling of national well-being arising from the certainty of guaranteed food supplies (Rude, 2000), maintaining economic stability in crisis situations, and avoiding the breakdown of normal market supplies. In the assumed scenario, the latter is not guaranteed with production at world market prices because the population cannot be supplied on a medium- and long-term basis. However, the population can be supplied on a sustainable basis at current levels of production.

1. In a representative survey carried out in 2004, 62% of those questioned rated food production to be extremely important and a further 30% rated it as important. Forty-five of the respondents rated food security in times of crisis as extremely important and 44% felt it to be important (Univox, 2004).

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Rural Viability, Multifunctionality and Policy Design[1]

by
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According to OECD (2001), the fundamentals of multifunctionality are defined by *i)* the existence of joint production of commodity and non-commodity outputs and *ii)* the fact that some of the non-commodity outputs exhibit the characteristics of externalities or public goods (OECD, 2001). Non-commodity outputs include the impacts of agriculture on the environment, such as rural landscape, biodiversity and water quality but also socio-economic viability of rural areas, food safety, national food security and the welfare of production animals together with cultural and historical heritage.

As for a research strategy, OECD (2001) emphasizes that in developing the notion of multifunctional agriculture, it is useful in the first phase to focus predominantly on positive and negative agricultural environmental non-commodity outputs; we call this *agri-environmental multifunctionality*. In the second phase, rural viability and other non-public good items could be introduced to the analytical framework, although it is acknowledged that including food security and rural viability in multifunctionality is disputed and they do not fit well in the framework of multifunctionality (OECD, 2001).

Almost without exceptions, the notion of agri-environmental multifunctionality has been the starting point of the sparse academic research on multifunctionality (see Boisvert 2001; Romstad *et al*., 2000; Guyomard *et al*., 2004; Anderson 2002; Paarlberg *et al.*, 2002; Vatn 2002; Peterson *et al.*, 2002; Lankoski and Ollikainen, 2003; Havlik *et al.*, 2005; and Brunstad *et al.,* 2005). None of these papers has focused on the rural viability aspect of multifunctional agriculture. The reason is evident. Pareto optimality requires that all positive and negative externalities should be internalized, giving thus a firm theoretical basis to the concept of agri-environmental multifunctionality.

OECD (2001) lists various aspects of rural viability, which relate to agriculture's contribution to economic and social viability of rural areas and communities. Rural viability is linked to the attractiveness of life in rural areas for both rural and urban population. This attractiveness includes especially income levels, possibilities for employment and income creation, physical infrastructure, social capital and quality of the environment. OECD lists some ways rural viability aspects may generate costs or benefits to society that justify its inclusion in the concept of multifunctionality (OECD, 2001).

1. This is a summary of the Workshop presentation.

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We take the dimensions of rural viability suggested by OECD as given. Following the analysis strategy outlined in OECD (2001), we include rural viability in the framework of multifunctionality. We investigate the policy design implications of including rural viability in the framework of multifunctionality.

The framework and results

We incorporate rural viability in the agri-environmental multifunctionality model under heterogeneous land quality, developed by Lankoski and Ollikainen (2003), where biodiversity benefits and runoff damages represent public good and externality aspects of crop production. Nutrient runoff and biodiversity are affected by the optimal choices of inputs and land allocation between alternative crops, as well as entry-exit decisions between agriculture and forestry. In line with OECD (2001), we describe the core economic content of rural viability by employment in agriculture and in the rural sectors serving agriculture. Thus, both direct and indirect labor input is taken into account through optimal choices inputs and land allocation. The sum of direct and indirect labor input is then an argument in the social valuation of rural employment and we call it the rural viability valuation function.

The theoretical analysis shows that introducing rural viability entails adjusting agri-environmental policy instruments (fertilizer tax and buffer strip subsidy) below their environmentally first-best Pigouvian levels to reflect the social benefits from direct and indirect employment effects of agricultural production. Moreover, when non-agricultural land use, such as forestry, is present, an additional, non-agricultural policy instrument is needed to adjust the amount of land allocated to agriculture to its optimal level. In a parametric analysis conducted for Finnish agriculture; we assess how the socially optimal provision of viability-enhancing multifunctionality relates to socially optimal agri-environmental multifunctionality, when forestry is included as another rural land-use form. We show that due to the higher share of non-polluting forestry under agri-environmental multifunctionality makes it the best solution for the society as a whole, even when rural viability benefits are included in the social welfare assessment. The economic intuition behind this result is the following. Rural viability promotion is restricted to agricultural land use only. This favors agricultural land-use relative to forestry, even though forestry has much lower runoff. Increased nutrient runoff damage outperform increased viability benefits leading to lower social welfare than under agri-environmental multifunctionality. Thus, if rural viability is to be promoted, it should be done through other rural land-use forms as well to prevent distortions.

Policy implications

In sum, there are many challenges to design rural viability policies. First, the optimal level of conventional agri-environmental instruments must be adjusted. Moreover, when all land use forms are included, promoting viability just by using agricultural policy instruments and not emphasising viability aspects in non-agricultural land use results in social welfare losses. Thus, policy instruments used to promote rural viability should be extended to non-agricultural activities as well.

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Domestic and International Implications of Jointness for an Effective Multifunctional Agriculture: Some Evidence from Sheep Raising in Lozère

by
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When agriculture is effectively multifunctional, the optimal policy is to provide society with an adequate level of non commodity output (NCO) at the lowest cost. Whether or not this policy affects the welfare of trading countries does not alter this definition of optimality from a national standpoint. For large trading countries, the terms of trade effects of domestic environmental policies on national welfare may alter the optimal levels of instruments (Krutilla, 1991; Peterson *et al.*, 2002). In this case, the international dimension of environmental policies cannot be overlooked.

OECD work on multifunctionnality has emphasized the importance of the existence of jointness between agriculture and environmental services. This paper addresses the issue of ensuring an effective multifunctionality of agriculture in the case of jointness, reports the results of an empirical test, and describes the possible trade effects of the relevant policies. As the concept has emerged in a context of trade negotiations (Paarlberg *et al.*, 2002), policies have been assessed not only on the basis of domestic optimality, but also of trade-neutrality (OECD, 2000a,b; OECD, 2003). The WTO agreement on agriculture recommends the use of instruments which have zero or minimal effects on trade. Whether the least costly instrument corresponds to the least trade-distorting instrument is not necessarily straightforward for all technologies and situations. Although the principle of instruments targeting the market failure at stake is fairly robust, high administrative costs may justify considering second best instruments. Among the relevant elements to design efficient policies, jointness between commodity and non commodity outputs is critical (different types of jointness are proposed by Vatn, 2002). When jointness is strong, the optimal policy to provide the non commodity service is likely to have an impact on agricultural production, and if the quantities at stake are significant, relative to trade volumes, this optimal policy is likely to have an impact on trade and on world markets. We define jointness as a non zero cross derivative of the cost function between two outputs: agriculture and an NCO. In a "normal technology" which corresponds to the long run, this cross derivative is negative (complementarity between outputs) and the cross price elasticities between outputs in the supply system is positive, hence the notion of "positive jointness" which is sometimes used for this case. The

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opposite case which may correspond to short run or fixed factor situations is respectively labelled substitution or "negative jointness".[2]

To assess jointness empirically, modelling assumptions are critical. Although some authors recognise that the nature of jointness between environmental services and agriculture may depend on the production level or on the intensity of agriculture (Romstadt *et al.*, 2000), few have tested this hypothesis in econometric models. Most models seek to estimate average jointness, *i.e.* the average relation between commodity and non commodity output, at average observed levels of production of the sample. But jointness is related to substitution and expansion effects in response to changes in output prices (Sakai, 1974; Moschini, 1989). Therefore, it should be sensitive to the production level for a given availability of fixed factors (*i.e.* to the intensification in variable inputs of the production process). In particular, if the intensification of the production process decreases the complementarity and increases the substitution effects between outputs, this will be ignored by models with constant elasticities of substitution. Furthermore, a relation between a commodity and a non commodity output can be complementary for some farmers and substitute for others, just like the relation between private outputs can differ between farmers. Hence, these models possibly underestimate the magnitude of negative jointness for low levels of production intensity, and the magnitude of positive jointness for high levels of production intensity.

To test the impact of intensification on jointness, we have used data on sheep breeding in highlands located in the Lozère (France), where landscape services can be provided by farmers and remunerated with public payments proportional to the managed surface (see Curt *et al.*, 2003 for an agronomic analysis). The service we focus on is farmers' contribution to preventing harvestable pastures from being invaded by bushes.

We estimate a cost function including (agricultural) commodity outputs and this non commodity output with data from two sub-samples: extensive and intensive farms. We find that the relation between the pasture conservation and sheep production is sensitive to the production level per hectare. The NCO is a significant complement with agriculture in the extensive sub-sample, and a substitute in the intensive sub-sample.

These findings support the stated assumption that the type of jointness should be allowed to vary with the production level, and not blurred into an average situation for the sample. One important policy implication is that a given public payment can have opposite trade effects depending on the level of intensification of the recipient farms.

The model

The model is designed to describe the technological relation between sheep breeding in highlands (*les Causses de Lozère*) and to identify potential environmental services provided by this type of agriculture, namely open rural space and landscape values.[3] We

2. At a very fine level of disaggregation, one may also observe substitution between similar outputs

3. In the late 1990s, scientific studies raised concerns regarding landscape degradation in the area due to the colonisation of old pastures by bushes and woody species. This agro-ecological evolution was viewed as a threat to the emblematic landscape of the *Causses* and to related wild species. The government decided to grant a public payment to farmers committing to prevent the colonisation of existing pastures by woody species (harvestable pastures).

estimate a cost function including two commodity outputs : sheep (y_1) and an aggregate of all other commodity outputs (y_2), and a non commodity output: the prevention of bush taking over pastures, z. Variable z is measured by the area of pasture land that the farmer is committed by contract to maintain as a bush-free pasture. The purpose is to limit the recently observed tendency among farmers to replace grazing by indoor feeding, leading to the abandonment of natural pastures and to an increase of cultivated grass for fodder. A payment p_z per hectare of managed pasture is granted for this service of preventing bush intrusion. Since p_z is proportional to the non commodity output provided, z is formally treated as a regular output of a production function.

The multi-product cost function is as follows:

$$C(y_1, y_2, z, w, F) = \underset{x}{Min}\{w.x; (x, y_1, y_2, z, F) \in T\} \quad (1)$$

where x stands for the vector of input quantities, w stands for the vector of input prices, F stands for the fixed factor (family labour), and T is the production set.

To identify and measure the implications of jointness in production, we also consider as a reference the non joint provision of the same non commodity outputs. The cost of this non joint-technology given by equation *(2)* is the cost of providing the same level of non commodity output by non farm enterprises facing the same factor prices and fixed factors.[4] Alternatively, it is the cost for farmers who quit sheep production but keep on tending the countryside.

$$C(0,0, z, w, F) = \underset{x}{Min}\{w.x; (x, z, F) \in T\} \quad (2)$$

As shown below, which of the two technologies provides the desired level of non commodity output at the lowest cost depends on the complementary/ substitution relationship between z (the NCO and the y's (farm) outputs).

When jointness between a commodity output and a non commodity output is of the complementary type over the whole production set, the marginal cost of non joint production of the NCO is superior to the marginal cost of providing the same level of non commodity output jointly with agricultural products.

For instance, a relation between y_1 and z which is complementary everywhere implies (dropping some arguments) that $C_{y_1 z}(y_1, y_{2,}, z) < 0$, which implies that the joint marginal cost of z decreases when y_1 increases. On the contrary, the non joint marginal cost of z remains unchanged as y_1 varies. Thus, non joint production is less costly, *i.e.* setting y_1 to zero entails the following ranking of marginal costs functions:

$$C_z(y_1, y_2, z) \le C_z(0, y_2, z)$$

Conversely, when jointness is a substitution everywhere, the marginal non joint cost of providing the NCO without agriculture is inferior to the marginal cost of the NCO with a positive level of agricultural activity.

The optimal organisation of the supply of both farm products and NCO's can be found by maximising the difference between the social value of all outputs (total

4. Such a comparison could be discussed in more detail, but should normally address two sectors facing the same economic environment.

willingness to pay) and the sum of the cost of farmers and other rural enterprises. The social welfare maximising problem can be written as:

$$\underset{y_1, y_2, z_a, z_f}{Max} \left\{ \int_0^{y_1} p(u)du + \int_0^{y_2} p(u)du + \int_0^{z} p(v)dv - C(y_1, y_2, z_a, w, F) - C(0,0, z_f, w, F) \right\}; z = z_a + z_f \quad (3)$$

where *p(y*$_1$*) and p(y*$_2$*)* are the inverse demand functions for commodity outputs, *p(z)* is the marginal willingness to pay for the non commodity output, z_a is the quantities of NCO provided by agriculture (or joint provision) and z_f is the quantity of NCO provided by forestry enterprises (or non joint provision).

The first order conditions are:

$$p(y^*_1) = C_{y_1}(y^*_1, y^*_2, z^*_a) \quad (4)$$

$$p(y^*_2) = C_{y_2}(y^*_1, y^*_2, z^*_a) \quad (5)$$

$$p(z^*) = C_z(y^*_1, y^*_2, z^*_a) \quad (6)$$

$$p(z^*) = C_z(0,0, z^*_f) \quad (7)$$

$$z^* = z^*_a + z^*_f \quad (8)$$

An efficient organisation of procurement of all outputs can be supported by a market for farm products supplemented with an optimal subsidy for the NCO: $p(z^*)=p_z$. From the multiproduct cost function and the unit payment p_z, one can derive z^*_a, z^*_f, y^*_1, and y^*_2.

A few authors have suggested that jointness between commodity outputs and NCOs is likely to vary with intensification, measured by the level of commodity output (assuming fixed factors such as land) (Gatto et Merlo, 1999; Romstad *et al*., 2000). Nevertheless, to our knowledge, this has never been tested empirically. To do so, conventional functional forms used to estimate jointness (see for instance Peerlings and Polman, 2004) assume constant jointness between outputs, *i.e.* the type of jointness stays the same within the sample when outputs vary[5]. In order to test the sensitivity of jointness to intensification, we estimate a cost function with the data from the sub-sample of extensive farms (83 farms with a total product below 500 per hectare[6]), and from the sub-sample of intensive farms (28 farms with a total product above 500 per hectare).

After a series of econometric tests, only family labour proves to be a fixed factor. Land and capital prove to be variable inputs. Land availability is such that a large part of total land is not used, which is at the root of the landscape pattern. Capital also appears to be variable across farms (early tests assuming fixed capital gave wrong signs). Land price w_L is approximated by the total expenses regarding land divided by the cultivated land surface (including pastures), and capital price w_K is approximated by the expenses linked to the use of equipments;

5. Jointness is allowed to vary only with prices and fixed factors.

6. This threshold was decided on the basis of different empirical tests based on jointness.

The functional form of the cost function is quadratic and chosen as follows:

$$
\begin{aligned}
C(y_1, y_2, z, w_L, w_K, F) = a_0 &+ b_1 y_1 + b_2 y_2 + b_3.z + b_4.w_L + b_5 w_K + b_6.F \\
&+ 0{,}5.b_{11} y_1{}^2 + b_{12}.y_1 y_2 + b_{13} y_1 z + b_{14} y_1 w_L + b_{15} y_1 w_K + b_{16} y_1 F \\
&+ 0{,}5.b_{22} y_2{}^2 + b_{23} y_2 z + b_{24} y_2 w_L + b_{25} y_2 w_K + b_{26} y_2 F \\
&+ 0{,}5.b_{33} z^2 + b_{34} z w_L + b_{35} z w_K + b_{36} z F \\
&+ 0{,}5.b_{44} w_L{}^2 + b_{45} w_L w_K + b_{46} w_L F \\
&+ 0{,}5.b_{55} w_K{}^2 + b_{56} w_K F \\
&+ 0{,}5.b_{66} F^2
\end{aligned}
$$

First, we selected the specification of the above functional form that fits the whole sample of data and satisfies regularity conditions of this cost function (and second order conditions of problem defined in (3) (Annex 1) and which is simple enough to fit correctly to each sub-sample and to yield significant parameters. Because of the limited size of the samples, particularly the intensive one, it is not surprising that explanatory variables appearing several times in linear and quadratic combinations, raise problems related to multicollinearity?[7]. For this reason, we dropped many cross-variables which are not as significant in both sub-samples, in order to keep the main effects that are stable when changing the level of intensification. The jointness between y_2 and z does not appear significant and we also drop it, as well as land price w_L. For similar reasons, we also dropped the first order derivatives with respect to outputs. Finally, the only change in the specification between the intensive and the extensive sub-samples is the fact that, in the intensive subsample, we have kept the term in $(w_K)^2$ (which is significant only in this sub-sample) and the cross effect z x F (which is not highly significant but too significant to be omitted).

The cost estimation of the whole sample (Annex 1) shows that sheep production is complementary with z (prevention of bush spreading on pastures). This implies that, according to an *average picture* over the whole sample, a payment p_z has a positive impact ON the marginal cost of sheep production.

Splitting the sample in two subsets of extensive and intensive farms does provide a different picture of jointness. In the sub-sample of *extensive farms* (Annex 2) jointness of sheep production with z is *complementary* with z, but estimation for the sub-sample of intensive farms (Annex 3) shows sheep production and z_2 to be significantly substitutes.

For extensive farms, y_1 and z are complementary. Harvestable pastures provide a valuable source of fodder and the opportunity cost of maintaining pastures bush-free is low.

This implies that for all $y_1 < 500$ per hectare, $C_z(y_1,y_2,z, w_L,w_K,F) < C_z(0,0,z,w_L,w_K,F)$. Joint production of bush limitation is therefore less costly than non joint production. Therefore, p_z could be partly replaced by a production subsidy for these farmers, as a second best tool. Such a subsidy, as well as p_z, would increase both y_1 and z.

7. These data limitations also led us to drop from the analysis another environmental measure (called "measure 19") for which the statistical results were not significant as well as unstable over the various specifications tried.

By contrast, for intensive farmers, y_1 and z appear to be substitutes. When these farmers engage in producing z, they cannot convert pastures into alfalfa, which is the natural trend for intensive systems. These farms have a non zero opportunity cost of producing z.

This implies that for all $y_1 > 500$ per hectare, $C_z(y_1,y_2,z,w_L,w_K,F) > C_z(0,0,z,w_L,w_K,F)$. Hence, joint production of the prevention of bush spreading is more costly than non joint production. For these farmers, a production subsidy instead of p_z would be counter-productive in terms of environment: it would further encourage farmers to convert pastures into alfalfa plantation. A production tax, however, or a ceiling on intensification would work in the right direction.

Table 1. The level of intensification and the nature of jointness between sheep production and NCO

Related outputs	Extensive farms	Intensive farms
Sheep and bushes prevention on pastures (*z*)	$C_{y1z} < 0$ *(t=-1,95)* complementarity	$C_{y1z} > 0$ *(t=2,40)* substitution

Efficient supply of NCO's and policy analysis ensuring multifunctionality

In spite of the data limitations, our empirical results support the often claimed assumption that it is less costly to produce NCO's jointly with agriculture when it uses extensive techniques, and more costly when the technique is intensive. Such a situation has implications for the efficient supply of NCO's and in particular for the relative contributions of farms and non farm enterprises in the provision of the adequate level of NCO's in rural areas. When the amount of NCO's is easily measurable (and when the nature of the NCO is a public good with market failure) a public subsidy targeting the NCO could ensure efficiency. A second best policy tackling the market failure can work through taxes/subsidies or regulations such as standards of intensification. Such measures, as well as the first best policy, cannot avoid having an impact, which may be either positive or negative, on production, and therefore on trade.

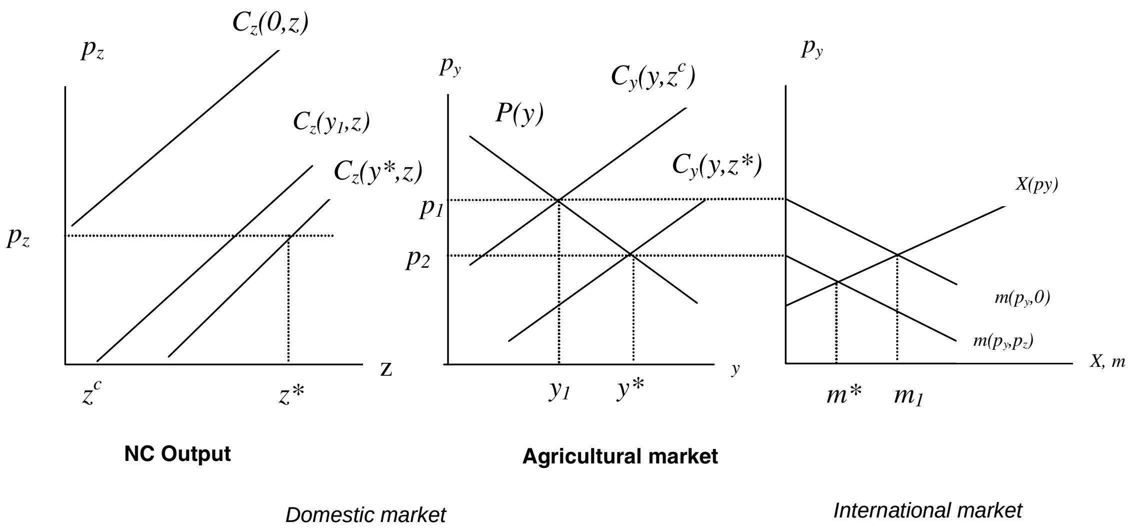
In this section, we examine the domestic and international policy implications of complementarity and substitution (which we will also respectively call, in regard to the implied cross price elasticities of supply that they imply, positive or negative jointness). This section is only formal and is not meant to illustrate the international implications of sheep production in Lozère which would of course be negligible. It would be relevant to a large country case producing a significant share of the world market.

Cost complementarity and extensive production systems

When commodity and non commodity outputs are complementary, $C_{yz}<0$ and joint production is more efficient than production by two separate firms $C_z(y,z,) < C_z(0,z)$. On the left panel of Figure 1, the marginal cost of z, the NCO, is higher for non farm enterprises ($y=0$) than for farms producing positive agricultural goods. When NCO's are observable and measurable and valued by society at p_z, the optimal level of agricultural output and NCO are respectively y^* and z^* (central panel on Figure 1) which result from marginal cost pricing. The left panel exhibits a situation where the provision of NCO by non farm enterprises (who could only provide the environmental service without any farming activity — non joint technology — and have the $C_z(0,z)$ marginal cost curve) is not economically efficient since marginal cost at zero z output is greater than p_z. It is conceivable that even with positive jointness both farmers and other non farm enterprises would provide positive levels of NCO. But the latter would then supply less services than farmers under positive jointness.

Suppose now that multifunctionality is denied or that it is not measurable, or can only be administered at prohibitive costs. This situation can be illustrated by the inefficient equilibrium y_1 on the central panel and z^c on the far left panel. It is produced by setting p_z to zero in the left panel. The figure assumes that marginal cost of z is still zero for non zero level of z. The empirical works partly reported above reveals that this is possible and even likely for low levels of intensification (see note in Annex 2). In that case, even if the environmental service z is not paid for, a positive amount can still be supplied if an agricultural activity is sustainable. Because of the positive jointness, some positive level of NCO is provided free. z^c is given by the point where the marginal cost of z (evaluated at agricultural output y_1 where marginal cost of y is equal to $p(_y)$) crosses the z axis, *i.e.* is null. Starting from the first best y^* and z^*, driving p_z to zero decreases the equilibrium z, but this shifts the marginal cost of y to the left, generating a fall in equilibrium level y. The marginal cost curve of z shifts as well to the left until the stated joint inefficient equilibrium (y_1, z^c) results.

Figure 1. The effect of an environmental payment on the domestic and international equilibrium of agricultural markets (complementarity-positive jointness- extensive case)



When the first best policy is not economically feasible, a second best instrument can be used to increase both the level of z and y. A conditional payment on the farm activity y, can be designed to alleviate the market failure. It can also be shown that this second best solutions are smaller than y^* and z^* (Le Cotty, 2007).

Since environmental services, such as open rural space and other rural amenities are often public goods, the market cannot ensure either the first or the second best solution. A targeted direct payment or an indirect subsidy would therefore have an unavoidable effect on agricultural output and hence on trade.[8] This is reflected in the right panel of Figure 1. In the case of positive jointness there is an economic argument to admit efficient policies in spite of the fact that a trade effect can't be avoided. But of course, such economically sound measures would have to be rule-based and would never provide a smoke screen to justify disguised restrictions to trade. The practicality of such rules may raise difficult problems, in particular if quantification is required, but principles can be justified by both empirical and theoretical considerations, in some designated areas and circumstances.

Substitution (negative jointness) and intensive production systems

This situation corresponds to the relation between the preservation of pasture from bush invasion and sheep production in intensive farms. The situation is basically the reverse of the previous one at least in some respects. With intensified techniques, it has become more costly to produce both the NCO and sheep, than to provide them separately. The situation is illustrated in Figure 2.

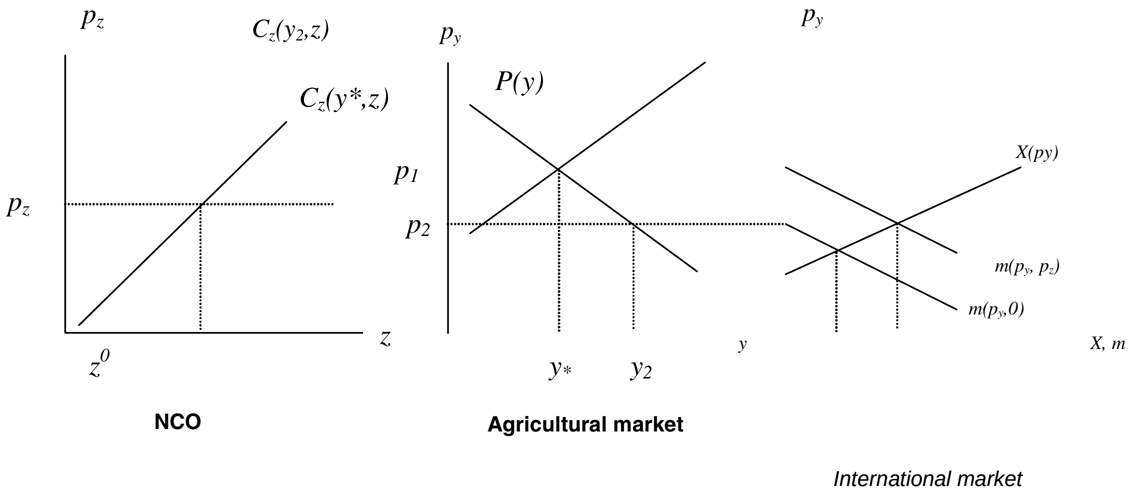
The optimal solutions are again y^* and z^* which follow from marginal cost pricing of both the agricultural commodity and the NCO. When the quality of the environment is overlooked or when a payment is deemed unfeasible, the provision of the NCO will decrease towards z^0 (left panel), where the marginal cost of z is zero. A lower or zero reward for environment quality to the intensive farmer also decreases his marginal cost of raising sheep, *i.e.* the $C_y(y,z)$ curve shifts down. The output of sheep increases (even if a lower price occurs from an inelastic demand as in Figure 2). This in turn shifts up the cost curve of NCO on the left panel. A possible equilibrium is y_2 and $z=0$. The result is too much farm product and too few environmental services. Note that in this case, compared to the first best optimal policy, *laisser faire* or free market shifts the import function to the left and restricts trade in agricultural products, for the large importing country. On the contrary correcting market failure would enhance trade.[9]

If the first best optimal policy is unfeasible, second best instruments should work in the direction of limiting farm output, and of enhancing trade. In doing so, such instruments would improve the quality of the environment. Taxes on farm output or regulations limiting intensity on agriculture are possible candidates.

8. The magnitude of this trade effect depends on the country's excess demand elasticity, and the share of multifunctional farms in national agriculture.

9. When the NCO is exclusively provided by non farm enterprises at the non joint cost defined above, market equilibrium on the domestic market is set at *y2*, as in the laisser-faire case. This would happen if $Cz(0,z=0)<p_z<C_z(y,z=0)$. In this case only is the optimal policy effectively trade neutral.

Figure 2. The effect of an environmental policy on the domestic and international equilibrium of agricultural markets (substitution- negative jointness- intensive case)



Conclusion

The empirical results support the opening assumption that jointness can be sensitive to the intensification level. The estimation of jointness only for an average case in a given production system including farms with a wide range of intensity can fail to account for the variability of jointness across farmers. The switch from complementarity to substitution can even be observed within a given production system. Policy recommendations should take the intensification level into account. Recent developments in farm policies in the industrial world are consistent with these empirical results.

From a wider perspective, we show that the objectives of efficient public policy and of trade neutrality should be distinguished. Whenever good information and low administrative costs allow for this, the optimal policy is always an agri-environmental payment proportional to the NCO. This optimal policy will have effects with opposite signs for extensive and intensive situations. For the most extensive farming systems where the commodity and the non commodity outputs are complementary, such a targeted payment increases the private output and therefore increases trade in the exporting country case and decreases trade in the importing country case. A non joint provision of the public good would meet the trade neutrality objective but increase the domestic cost of NCO provision in this case. There is a clear conflict here between domestic efficiency and international rules. When the two productions are substitutes, a non joint provision of the NCO is less costly, and domestic optimality is possibly compatible with the trade neutrality objective. Moreover, in the case of substitution, a public payment to farmers proportional to the NCO would decrease the commodity output provision, and therefore increase trade in the importing country or decrease trade in the exporting country.

Therefore, under jointness, although optimal policies may have paradoxical effects they do not have to be output and trade neutral. Although we have not addressed this issue, extensive systems are likely to provide a small share of farm products in the developed countries and trade effects of such systems may turn out to be limited.

From a WTO perspective, the disciplines based on decoupling of commodity production and non commodity production defined by the trade neutrality of public policies can be more consistent with economic efficiency for intensive production systems (although not in a strict sense as seen above). Strict decoupling is more likely to be inconsistent with economic efficiency for extensive production systems.

Annex 1.

Cost function estimation for the whole sample

The results of the cost function estimation for the whole sample (111 farms) are presented below. The nature of jointness is given by the cross elasticity b_{13}, *i.e.* $C_{y_1 z}$. When b_{13} is negative the technology shows complementarity between sheep production y_1 and the non-commodity output z.

r^2=0,835

Coefficient	Unstandardized Beta	Standardized beta	T
a_0 constant term	30 834,75		7,59
b_5 (w_K) w_K= capital price	1,31	0,41	7,79
b_6 (F) F= quantity of family labour	-926,99	-0,024	-0,485
b_{11} ($0,5y_1^2$) y_1= quantity of sheep production	$5\ 76,10^{-6}$	0,63	9,44
b_{22} ($0,5\ y_2^2$) y_2=aggregate of other productions	$5\ 10,10^{-5}$	0,129	2,9
b_{33} ($0,5\ z^2$) z=quantity of non commodity output	8,73	0,279	2,84
b_{13} (y_1.z) y_1.z =jointness between sheep production and non commodity output	-0,003	-0,26	-2,34

One can check that $C_{y_1 y_1} > 0$, $C_{y_2 y_2} > 0$, $C_{zz} > 0$. The convexity is guaranteed by the Hessian matrix determinant non negativity ($2,10.10^{-9}$).

Furthermore, $C_{w_K} > 0$ and $C_F < 0$

$$C_{y_1} = 5{,}76.10^{-6} y_1 - 0{,}003z = 0{,}36 \text{ (in average)}$$

$$C_{y_2} = 5{,}10.10^{-5} y_2 = 0{,}17 \text{ (in average)}$$

$$C_z = 8{,}7z - 0{,}003y_1 = -25 \text{ (in average)}$$

The marginal cost of z estimated at the mean values of the sample is negative. This implies that the average farm would produce the NCO even without payment. This may be partly due to the fact that the supply of the NCO is constrained by the existing surface of pasture eligible for the payment. The case where $C_z=0$ occurs when $z = 25{,}7$ hectares (when y_1 is kept at the mean value i.e. $y_1 = 75329$), which is slightly above the mean value ($z= 23$ hectares).

Annex 2.

Cost function estimation for the sub-sample of extensive farming systems

This annex presents the result of the cost function estimation for the sub-sample of extensive farms (83 observations). The negativity of b_{13} indicates that sheep production and the NCO production are complementary.

r^2=0,806			
coefficient	**Unstandardized Beta**	**Standardized Beta**	**t**
a_0 constant term	37 702,23		7,37
b_5 (w_K) w_K= capital price	0,98	0,32	4,4
b_6 (F) F= quantity of family labour	-3 382,66	-0,09	-1,32
b_{11} ($0,5y_1^2$) y_1= quantity of sheep production	$7,90.10^{-6}$	0,65	7,63
b_{22} ($0,5\ y_2^2$) y_2=aggregate of other productions	$5,68.10^{-5}$	0,18	3
b_{33} ($0,5\ z^2$) z=quantity of non commodity output	10,85	0,35	2,87
b_{13} ($y_1.z$) $y_1.z$ =jointness between sheep production and non commodity output	-0,003	-0,24	-1,95

$C_z = 10,8.z\text{-}0,003y_1 = -56$ in average (of the sub-sample)

$C_z = 148$ *euros if* $y_1 = 0$, which would be the theoretical non-joint marginal cost of z *(*for the extensive sub-sample average).

Annex 3.

Cost function estimation for the sub-sample of intensive farming system

This annex presents the cost function estimation for the sub-sample of intensive farms (28 observations). The cross elasticity b_{13} is positive, which accounts for a substitution between sheep production and the NCO.

Coefficient ($r^2=0,968$)	Unstandardized Beta	Standardized Beta	t
a_0 constant term	-10 605,1		-0,69
b_5 (w_K) w_K= capital price	3,47	0,999	3
b_6 (F) F= quantity of family labour	8 420,28	0,211	0,83
b_{11} ($0,5y_1^2$) y_1= quantity of sheep production	$4,14.10^{-6}$	0,57	7,65
b_{22} ($0,5\ y_2^2$) y_2=aggregate of other productions	$15,07.10^{-5}$	0,062	1,04
b_{33} ($0,5\ z^2$) z=quantity of non commodity output	6,24	0,166	0,55
b_{13} ($y_1.z$) $y_1.z$ =jointness between sheep production and non commodity output	0,004	0,43	2,4
b_{55} ($0,5\ w_K^2$) w_K= capital price	$-3,6.10^{-5}$	-0,64	-1,85
b_{36} (z.F) z.F= cross elasticity between the NCO and the fixed factor	-311,18	-0,7	-1,38

$C_z = 6,24.z+0,004.y_1= 657,91$

$C_z= 272$ *euros if* $y_1=0$

In this intensive sub-sample, the negativity of C_F is ensured only for $z > 27$ hectares. Theoretically, family labour should not be treated as a fixed factor for those farms with small surfaces of protected pastures.

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Jointness, Transaction Costs and Policy Implications

by

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The goal of policy measures is to ensure that the outcome of the policy is close to the desired goal, *i.e.* that the policy is targeted. If no costs were involved in designing, implementing and managing the policy, this would be no problem. In such a case all policy goals would be met by using one (or more) instrument for each policy goal. However, due to natural uncertainties, actions and states that are not observable, as well as the costs of implementing the policy, we need to balance the precision — how targeted the policy is — and the transaction costs of the policy. This paper will discuss these issues in situations where there is jointness.

All production is joint production

Various definitions of jointness exist. A commonly used definition is provided by OECD (2001): “Joint production refers to situations where a firm produces two or more outputs that are interlinked so that an increase or decrease of the supply of one output affects the levels of the others”. While this definition is rather wide, it covers only jointness between outputs. In order to develop a more complete analytical framework, jointness between inputs should also be included. When designing policy instruments it is important to include both the inputs and outputs of agricultural production.

The existence of jointness in agriculture is well documented. At a fundamental level, we know that the laws of thermodynamics (conservation of mass and energy, and non-decreasing entropy) form the natural science basis of production. Thus, it can be concluded that “… every process of production is necessarily joint production. This means that every process of production yields at least two outputs and requires at least two inputs” (Fabler *et al.*, 1998). The inputs and outputs can be material or immaterial (*e.g.* heat), and the value may be negative (*e.g.* pollution), zero (*e.g.* N_2) or positive (*e.g.* meat).

The proposition that all production is joint production is only helpful in the sense that we know that jointness exists, *i.e.* there is no need to discuss whether or not there is jointness in agriculture. The main challenge lies in indentifying the different linkages between outputs and inputs, and to evaluate the outputs.

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Types of jointness

Thermodynamics is a purely physical concept at a basic level. As such, it may be impractical to use it for the analysis of agricultural production. We need concepts that work at a more complex level when discussing different types of jointness. OECD (2001) lists three main sources for jointness in production: technical interdependencies, non-allocable inputs, and fixed allocable inputs.

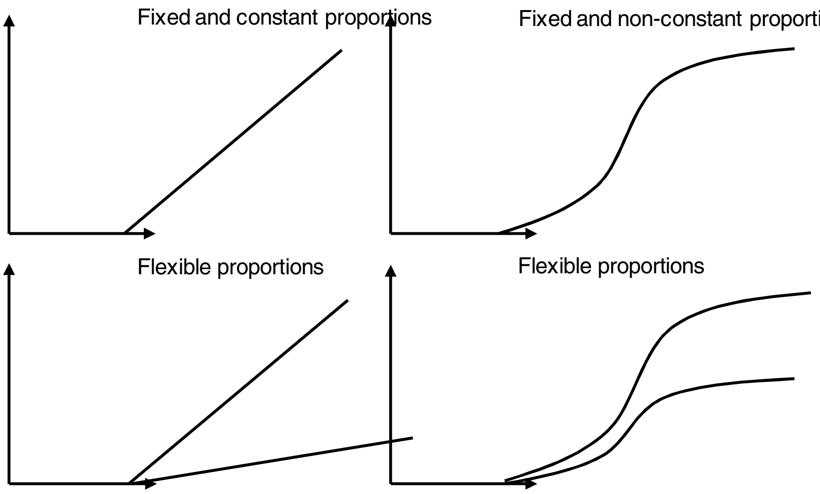
While the first two are primarily physical and/or biological, the third has another origin. At the farm level, land, capital and labour are often considered fixed, at least in the short-run, and these fixed inputs may be used in different types of production. Due to their fixity, using more of one input in one type of production leads to reduced input use in other types of production. In general, this means that increasing one output will reduce at least one of the other outputs. This situation fits the OECD definition of jointness. Even though the fixity of the inputs is physical, the source of the jointness is economic. The use of an input in one production versus another is mainly driven by the relative prices, but the productions are still (normally) separable. In this case, the main challenge for the policy maker is to set the relative prices at the right level. This may not be an easy task, but it is no different from the "normal" situation without jointness.

Another dual (*e.g.* economic) source of jointness is demand and supply uncertainties (Vermersch, 2004). While it is generally clear that risk management may lead to jointness between different commodity outputs, it is harder to envisage that this could lead to jointness between commodity outputs and non-commodity outputs.

When there are technical interdependencies, the linkages between different outputs may take on different forms. Baumgärtner (2000) divides the interdependencies into four different groups (Figure 1). In the first group the linkage is fixed and constant (upper left graph). Fixed means that it is not possible to alter the proportions of the two outputs produced given the level of production. Constant means that the proportions are the same for all levels of output. If we have non-constant proportions, the relationship between the two goods in question is non-linear. In the upper right graph of Figure 1 proportions are fixed for a given level of production, but varies with the level of production.

In the lower part of Figure 1, the proportions are said to be flexible. This means that technology is such it is possible to alter the proportions of the outputs. For a given level of production of that good on the x-axis, the output of the other good will lie somewhere between the two lines. However, once the "parameters" of the technology (controls) and the input mix are chosen, we are back in the upper part of the figure.

Figure 1. Different types of jointness between different outputs (x and y axis)



Source: Baumgärtner (2000).

One example of flexible proportions is the production of mutton and wool. Different sheep breeds yield different proportions of these two goods. The proportions may depend to some extend on feed, the shed, the length of the pasture season, etc. Once these are chosen, an increase in the amount of mutton will lead to a (fixed) proportional increase in wool.

In the case of fixed proportions, the relationship between two outputs (y_1 and y_2) may be described by:

$$y_2 = f(y_1) \qquad [1]$$

In the case of flexible proportions the corresponding formulation is:

$$y_2 = f(y_1, x, \alpha) \qquad [2]$$

where x is inputs and α is a vector of technological parameters.

In the case of a non-allocable input, the simplest example of production of two outputs may be described by the following equations:

$$y_1 = f_1(x_{na}) \qquad [3]$$

$$y_2 = f_2(x_{na}) \qquad [4]$$

If one of the two functions is monotonic in the relevant range of x_{na}, it is possible to invert it to an expression for the non-allocable input:

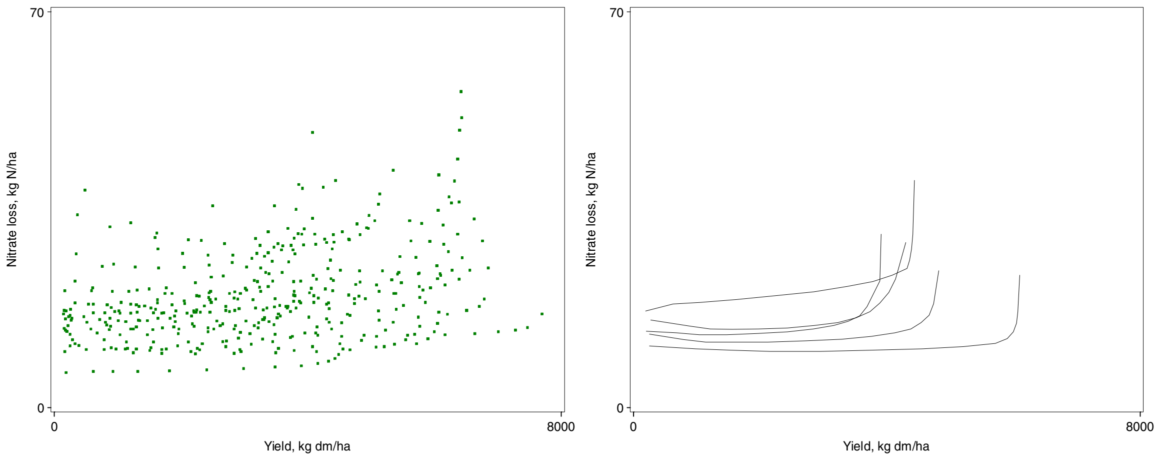
$$x_{na} = f_1^{-1}(y_1) = x_{na}(y_1) \qquad [5]$$

If we now use this in equation [4], we get the relationship between the two outputs:

$$y_2 = f_2(x_{na}(y_1)) = g(y_1) \qquad [6]$$

We now have a framework for analyzing the two types of physical/biological jointness. However, it should be noted that the measurement of jointness is not always straightforward. In order to illustrate this point, let us assume that we want to determine if there is jointness between barley yield and nitrate loss (pollution). Due to the lack of empirical data, we will use model simulations. The crop growth model KONOR (Bleken, 2001; Vatn *et al*., 2006) was used to generate data for barley in south-eastern Norway. The model is run for 30 years and for different N-fertilization levels. The relevant results are shown in Figure 2.

Figure 2. Results of model simulations for barley in south-eastern Norway



The left part of Figure 2 shows a scatter plot of the results. The plot shows a large variation and a rather weak correlation between yield and nitrate loss. The right part of the figure shows the results for some randomly selected years. We see there is a clear link between the two outputs. However, we also see that the years differs both regarding level and form of interlinkage. The biology behind this result is straightforward. At low fertilizer levels, growth is low and any increase will increase the marginal N-absorption. Thus, at low yield levels marginal nitrate loss is negative. At higher N-levels marginal N-absorption decreases and nitrate losses increases. At some point yield reaches the maximal level. At that point marginal N-absorption reduces to almost zero, and almost all additional fertilizer is lost to the environment, hence the vertical part of the curves.

Real world data would contain much more noise than the data from a simulation model. This means that it would be even harder to reveal the relationship between the two outputs. The main point here is that spatial and temporal variation may obscure jointness.

In the above example both the outputs are observable. However, it is (very) costly to monitor nitrate losses. This would therefore not be the appropriate point to implement policies. The jointness in this case may be described as a combination of technical/biological interdependencies and a non-allocable input. Regarding policy measures, both a tax on yield and nitrogen in fertilizer would lead to reduced losses.

Both yield and nitrate loss may be measured in physical units. Other multifunctional goods are more “diffuse” as to how to define and measure them. One example is biodiversity, and it may be measured using different indices, *e.g.* Shannon index and Simpson index. Both are calculated from the relative abundance of each species, but their functional forms are different. This means that not only may the level differ, but also the shape of the curves describing the relationship between biodiversity and other outputs and inputs. For an example, see Table 1 of Hadjigeorgiou *et al.* (2005). For both indices there is a positive relationship with stocking density up to about 0.65 NOK/ha. Above this point the Simpson index is still increasing while the Simpson index is slightly decreasing. If we want to implement a policy that promotes biodiversity and the current state is above 0.65 NOK/ha, the choice of index is crucial for policy recommendation (*i.e.* aimed at increasing vs. decreasing the stocking rate). This should not be taken as an argument against using indices, but one should be aware of the possible problems when using them.

We have so far seen that that jointness exists in different forms and is an inherent property of all production. Let us now turn to a stylized example of optimal production and a discussion about policy instruments to bring the about the optimal production.

Optimal joint production — a simple example

Let us assume we are in a situation where the (agricultural) economy is small and open.[2] Open means that imports and exports are allowed, and small means that whatever is produced in the economy (*e.g.* the level of import and/or export) does not influence the world market. The agricultural sector of this economy produces one market good ("meat", y_n) and two non-market goods: food safety (z_{fs}) and biodiversity (z_{bd}). These two goods are produced jointly with the domestic production of "meat". It is also possible to import "meat", y_i. Imports will have a negative effect on domestic food safety. This does not mean that domestic production is "cleaner", but that the imported "meat" may contain illnesses that are not common domestically and that these would result in societal costs. By controlling imports, the negative impact on domestic food safety may be reduced (and eliminated).

Transaction costs may play an important role when choosing policy instruments, as mentioned in the introduction. They are real costs and should therefore be included in a complete analysis of the problem at hand. If they vary with the level of transfer and/or production (*i.e.* non-zero marginal transaction costs), they will affect the optimal level of production. Since transaction costs may vary between different policy measures, all types of measures must therefore be included in the optimization problem in order to be complete. Although possible, this would lead to an overly complex model formulation in our case. Transaction costs are therefore assumed away for now.

The society wants to maximize the surplus, defined as welfare in monetary units minus costs, from the production and consumption of the four goods (y_i, y_n, z_{fs} and z_{bd}). The problem may be formulated as:[3]

$$Max W(y_i, y_n, z_{fs}, z_{bd}) - C \quad [7]$$

The welfare function ($W(\ )$) is assumed to have the usual properties, *e.g.* concave and strictly increasing in all elements. The total cost is defined by:

2. Others have analyzed multifunctional agriculture in large economies. One example, using a different framework, is Peterson *et al.* 2002.

3. It may not be commonplace to include the costs directly in the objective function. Normally, costs are included as an inequality constraint to the problem. However, since the level of cost is not an important issue here, the problem is modeled as an unconstrained problem. This will also simplify the notation, and in this case there is no loss of generality.

$$C = C_n(y_n) + p_i y_i + C_{fs}(q, y_i) \quad [8]$$

The first term on the right hand side is the strictly increasing domestic cost function, the second term is the cost of imports with p_i being the world market price, and the last term is the cost of controlling imports where q is controlling intensity. The cost of controlling imports is assumed to be increasing in both arguments.

The level of food safety is assumed to be governed by the following equation:

$$z_{fs} = f(y_n) + g(q, y_i) \quad [8]$$

The first function on the right hand side is the effect of domestic "meat" production, *i.e.* the jointly produced food safety. $f(y_n)$ is assumed to be strictly increasing in y_n. The last part is the negative impact of imported "meat". $g(\ )$ is therefore negative, and $g(\ )$ is assumed to increase in q and decrease (*i.e.* become more negative) in y_i.

Biodiversity is produced jointly with domestic "meat". It is assumed that up to a certain point the relationship between the two goods is positive and thereafter negative:

$$z_{bd} = h(y_n) \quad [9]$$

If we assume that societies preferences for domestic and imported "meat" are the same, except for the food safety issue that is captured by z_{fs}, the first order conditions for the four goods may be written as:

$$\frac{\partial C_n}{\partial y_n} = p_i + \frac{\partial C_{fs}}{\partial y_i} + \frac{\partial W}{\partial z_{fs}}\left(\frac{\partial f}{\partial y_n} - \frac{\partial g}{\partial y_i}\right) + \frac{\partial W}{\partial z_{bd}}\frac{\partial h}{\partial y_n} \quad [11]$$

The interpretation of this condition is rather straightforward: the marginal cost of domestic production should equal the world market price (which is equal to the marginal welfare of "meat" consumption) plus the marginal cost of controlling imports plus the marginal welfare of food safety plus the marginal welfare of biodiversity.

Regarding the optimal level of import control (q), the FOC is

$$\frac{\partial W}{\partial z_{fs}}\frac{\partial g}{\partial q} - \frac{\partial C_{fs}}{\partial q} = 0 \quad [12]$$

This is a straightforward optimality condition: marginal gain should equal marginal cost. We could solve this expression for the marginal welfare of food safety and plug the resulting expression into [11], but in our case we would not gain any additional insight by doing so.

Equations [11] and [12] represents the conditions for socially optimal production (and consumption) of the four goods in question. The aim of a policy is to induce the producers (farmers) to produce at the level implied by the above optimality conditions. We therefore need to look at the choices of the farmer. For simplicity we will assume that there is one representative farmer in the economy, and that his/her objective is to maximize income from agricultural production. It will also be assumed that it is possible to "regulate" the prices for all three goods produced ("meat", food safety and biodiversity). The optimization problem is then:

$$Max\ p_y y_n + p_{fs} z_{fs} + p_{bd} z_{bd} + LS - C(y_n) - FC \quad [13]$$

where p_y is the price the farmer receives per unit of "meat" produced, p_{fs} is the price of food safety, p_{bd} is the price of biodiversity, LS is a lump sum payment, $C(y_n)$ is the cost function, FC is fixed costs, and other terms as previously defined.

The first order condition for this problem imply that

$$\frac{\partial C}{\partial y_n} = p_y + p_{fs}\frac{\partial f}{\partial y_n} + p_{bd}\frac{\partial h}{\partial y_n} \quad [14]$$

In order to induce equality between [14] and [11], the so-called first best solution is to let prices equal the marginal welfare, *i.e.*

$$p_y = p_i = \frac{\partial W}{\partial y_n} = \frac{\partial W}{\partial y_i},\ p_{fs} = \frac{\partial W}{\partial z_{fs}},\ p_{bd} = \frac{\partial W}{\partial z_{bd}} \quad [15]$$

Since imported "meat" leads to external costs in the form of reduced food safety, imports should be taxed equal to:

$$t_i = \frac{\partial C_{fs}}{\partial y_i} - \frac{\partial W}{\partial z_{fs}}\frac{\partial g}{\partial y_i} \quad [16]$$

In the absence of transaction costs the two above equations represents an efficient policy. However, since food safety and biodiversity are produced jointly with "meat", there may be other efficient solutions. If for example *f*( ) is a monotonic functions in y_n it is easy to show that

$$p_y = \frac{\partial W}{\partial y_n} + \frac{\partial W}{\partial z_{fs}}\frac{\partial f^{-1}}{\partial z_{fs}},\ p_{fs} = 0,\ p_{bd} = \frac{\partial W}{\partial z_{bd}} \quad [17]$$

is also an efficient policy. It is of course also efficient to let $p_y = 0$, and increase p_{fs} accordingly, but this would be harder to enforce since "meat" is a market good.

In the analysis above it is implicitly assumed that there is no uncertainty and no spatial and temporal variation, which is not the case in the real world. This means that [17] may not be efficient for the economy as a whole. On the other hand, with spatial variability [15] may not lead to an efficient outcome either. They are only efficient as long as we are able to set the prices equal to the marginal welfare gains, and for [17] we also need to know the "marginal jointness". Ultimately, [15] and [17] are producer specific conditions.

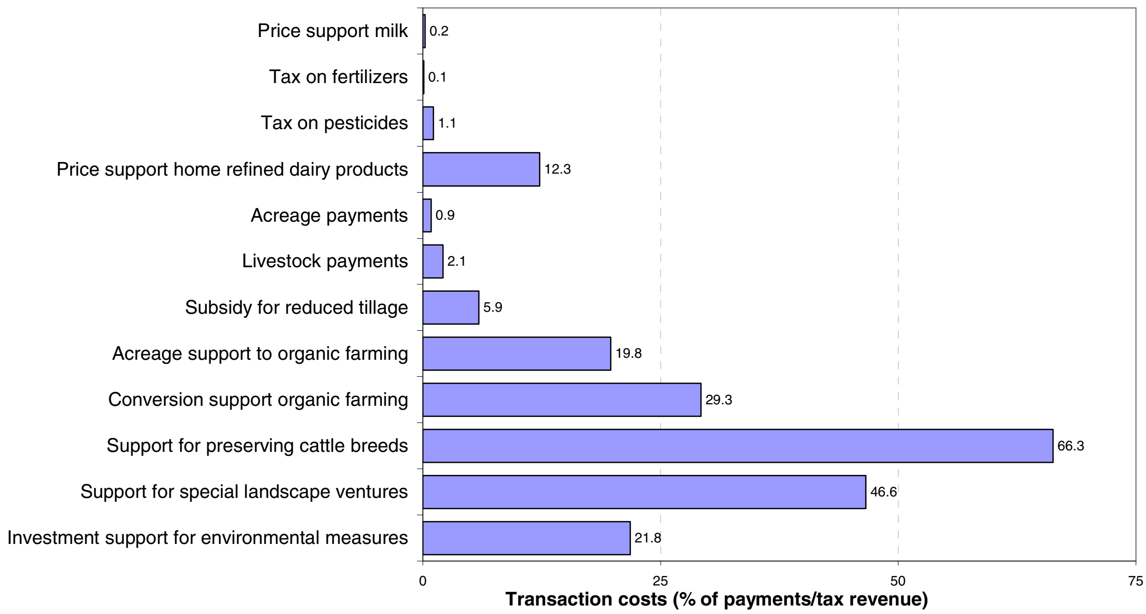
Due to positive transaction costs, among other things, detailed regulation at farm level is not a viable path to follow. This leads us back to the problem of balancing precision (targeting) and transaction costs. Nevertheless, if there is jointness between two or more outputs this will increase the number of available policy options.

Transaction costs

Arrow (1969) has defined transaction costs as the "costs of running the economic system". Dahlman (1979) operationalized the concept by splitting transaction costs into three elements: the cost of information gathering, the cost of contracting and finally the cost of control. Both are rather wide, and there seems to be no consensus in the literature over how to measure them and what elements to include (McCann *et al*., 2005).

Rørstad *et al*. (2007) have studied transaction costs of 12 different policy measures in Norwegian agriculture. The measures were chosen to cover the most important measure and a wide range of different policy characteristics. Transaction costs were quantified through interviews with representatives from different public administrations, market participants and farmers involved. The costs cover labor costs, general overheads, computer cost, costs related to information material and postage. The transaction costs of the different policy measures are shown in Figure 3.

Figure 3. Transaction costs (in % of transfer to or from farmers) for some Norwegian policy measure



Source: Rørstad *et al*., 2007).

In general the figure indicates that transaction costs increase as the complexity of the measure increases. Policies targeted at easily observable objects (*e.g*. milk, fertilizer and acreage) have fairly low transaction costs, while targeting more idiosyncratic goods (*e.g*. old cattle breeds and special landscape ventures) is more costly per monetary unit transferred.

The policy measures were classified along three dimensions:

- Point of policy application, *i.e.* whether the policy measure is applied to a commodity or not,
- The degree of asset specificity involved, and

- Frequency: how often the transaction is undertaken and how many transactors or agents can be treated similarly.

Their analyses show that all three dimensions are significant in determining transaction costs (in percentage terms).

One problem when using transaction costs in percentage terms is that this measure may not be invariant with respect to the total transfer, and the results also show that this is the case. However, the main aim of the Rørstad *et al.* (2007) study was to compare different policy instruments along the three above-mentioned dimensions. Due to data limitations, there was a need to normalize the data.

The classification of the policies revealed a correlation between the degree of asset specificity and frequency. If asset specificity is high frequency is generally low, and vice versa. None of the studied policies had high asset specificity and high frequency or low asset specificity and low frequency. For a plausible explanation of this (see Rørstad *et al.,* 2007). Since frequency is closely linked to the total amount transferred to or from farmers, we may use this as a proxy for the two dimensions. As the total amount transferred increases, frequency increases and asset specificity decreases. With this we will have a new look at the data in Rørstad *et al.* (2007).

Since the range of total amount is large, a log-log transformation of the data will be used. Two of the dimensions are assumed to be captured by the total transfer, but we still need to include the last, point of policy application. By using dummy variables, two different regression equations may be specified:

$$Log_{10}(TC) = \alpha_0 + \alpha_{0d} d + \alpha_1 Log_{10}(TR) \qquad [18]$$

$$Log_{10}(TC) = \beta_0 + (\beta_1 + \beta_{1d} d) Log_{10}(TR) \qquad [19]$$

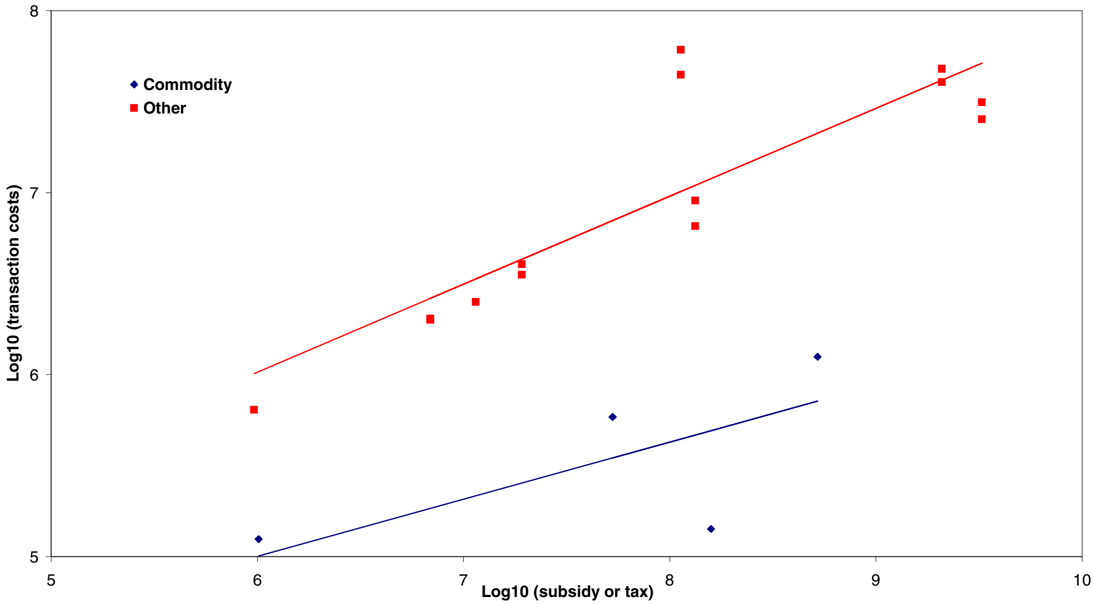
where *TC* is transaction costs (in NOK), *TR* is transfer (tax revenue or payment in NOK) from/to farmers and *d* is a dummy variable for point of policy application (=1 for policies applied to commodities). Parameter estimates and statistics can be found in the appendix, and data and estimated regression lines for [19] are shown in Figure 3

It is also possible to use dummy variables for both the intercept and slope. Under this specification none of the dummy variables have significant parameters. This is not a surprise since we have only four observations for this group.

Transaction costs increases as the transfer increases, and the observations indicate that transaction costs in percentage terms are falling. This means that transaction costs are concave in transfer. If the aim is to minimize transaction costs given a budget constraint, one should have as few and large policy schemes as possible. It must, however, be noted that transaction cost is only one element to consider in policy evaluation. The main point here is that one should minimize the number of schemes without compromising the policy objectives.

The estimated regressions indicate that policies that target variables other than commodities are about ten times more expensive in terms of transaction costs. This conclusion holds for all level of transfers. This means that even though acreage and number of animals are easy to observe, it much cheaper to transfer money to the farmers in the form of price support (at least in Norway).

Figure 4.Observed transaction costs and estimated regression lines as a function of total transfer



Conclusions

I have tried to convey three major points in this short paper:

- There is a positive jointness between some commodity outputs and non-commodity output,
- Given the positive jointness indirect payments for the non-commodity outputs through the commodity price is as efficient as direct non-commodity payments, and
- The transaction costs of commodity-based payments are (much) lower than any other payment method for a certain amount transferred.

Taken together, this means there are situations where price support is the optimal solution.

This does not mean that price support always is the preferred policy instrument or that it should be the only policy instrument to use. Some public goods produced in agricultural are only weakly joint with commodity outputs and some are not joint at all. In some cases there is negative jointness, and price support will certainly decrease the good or increase the bad. However, the analysis above opens up the possibility of taxing the commodity output in such cases.

Spatial variation may be a problem, especially if we have a situation where there is a positive jointness in one range of output and negative in another, e.g. biodiversity. If the production level in one region of the country is at a level where there is positive jointness and in another it is negative, a uniform price support will lead to increased production of the non-commodity output in the first and a reduction in the second. The total effect will be ambiguous. If it is possible to differentiate the price support, this would solve the problem without increasing transaction costs much. If it is not possible, other policy instruments like direct payments for biodiversity may be the preferred option. However, this option should be compared with uniform price support, and all costs and benefits should be included.

To finalize this discussion, I will use Norway as an example. Due to the climatic conditions and the general high cost level, Norwegian agriculture is not competitive at current world market prices. This means that most of Norwegian agriculture and the associated production of public goods would vanish if all support were removed. Since some of the non-commodity outputs are produced jointly with commodities, we need commodity production. Unless combined with some cross compliance requirements, delinked measures like acreage payments would not lead to production. Direct payments for the non-commodity outputs would induce production, but as pointed out above, it would be far less expensive to use price support. Due to plurality of outputs and both positive and negative jointness, it would probably be wise to use price support only up to a certain level, *i.e.* ensuring a certain level of commodity production. On top of that one could use other measures in order to meet the policy goal for the different outputs.

If there is jointness, why not use it?

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Annex

Parameter estimates

Table A1. Parameter estimates and statistics

Parameter	Parameter estimate	Standard error	t Value	Pr > |t|
α_0	3.37637	0.62268	5.42	<.0001
α_{0d}	-1.29606	0.20183	-6.42	<.0001
α_1	0.45005	0.07741	5.81	<.0001
β_0	3.11408	0.59068	5.27	<.0001
β_1	0.48324	0.07378	6.55	<.0001
β_{1d}	-0.16887	0.02483	-6.80	<.0001

Evaluation of Jointness in Swiss Agriculture

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Since the 1990's, the term multifunctionality has served to define those public services provided by agriculture which are linked to production. The concept of multifunctionality is internationally recognised in that multifunctional services serve as the basis upon which instruments for agricultural support are justified and accepted. Indeed, some countries base their agricultural policies on the concept of multifunctionality. In Switzerland, direct payments compensate multifunctional services provided by agriculture under the terms of the Swiss Federal Constitution.

In 2001, OECD analysed the concept of multifunctionality from a theoretical point of view and derived conclusions for the development of policy measures (OECD, 2003). The scope of the analysis covered three central elements, namely jointness, market failure and public goods with the aim of identifying the most efficient measures to achieve policy targets. The degree of jointness between the production of goods and multifunctional services is a key value for defining efficient policy measures. The concept of economies of scope is used to operationalise the degree of jointness, whereby the costs of joint production are compared with those arising from an alternative form of provision. Economies of scope exist when joint production of several outputs is less expensive than the separate provision of agricultural goods and multifunctional services. In this case, linked provision and the appropriate agricultural support are efficient.

In view of the discussions on multifunctionality and the need to identify the most efficient measures to achieve agricultural policy targets, four sub-projects in Swiss agriculture were evaluated for jointness.

- Evaluation of jointness between agriculture and landscape in the lowlands.
- Evaluation of jointness between the production of goods and land-use in mountain areas.
- Evaluation of jointness between agriculture and rural development.
- Evaluation of agriculture's contribution to food security.

In this summary, the results of the subprojects are used to evaluate jointness in Swiss agriculture and conclusions are drawn regarding the development of agricultural policy measures.

Multifunctional services of agriculture

Swiss agriculture provides numerous multifunctional services which are linked to the production of marketable goods. In accordance with the targets defined in Article 104 of the Swiss Federal Constitution, these multifunctional services can be described as follows (Mann and Mack, 2004; Rieder *et al.* 2004):

- Guaranteed supplies for the population by means of the natural, sustainable production of foodstuffs and raw materials as well as the upkeep of production capabilities and (crop rotation) land.
- Conservation of bases for life and maintenance of cultivated landscape by means of sustainable, overall cultivation as well as preservation of the production potential of the soil. At the same time, open cultivated landscape provides the habitats essential for bio-diversity and, furthermore, the landscape gains societal importance thanks to its typical, varied and natural characteristics.
- Decentralised settlement of the land by ensuring decentralised jobs and residential areas in rural regions, the upkeep of open land and the conservation of rural structures within the social, economic and political basic conditions.

Causes of jointness

In the first instance, agriculture and landscape are more closely linked through land-use and agricultural structures than through the production of goods *per se*. The use of land for agricultural purposes inevitably results in a contribution to the conservation and maintenance of landscape; the factor land cannot be assigned definitively to landscape conservation or agricultural production (non-allocable input). In addition, fixed and variable, non-allocable input factors generate elements which influence landscape structures and thus contribute to landscape diversity.

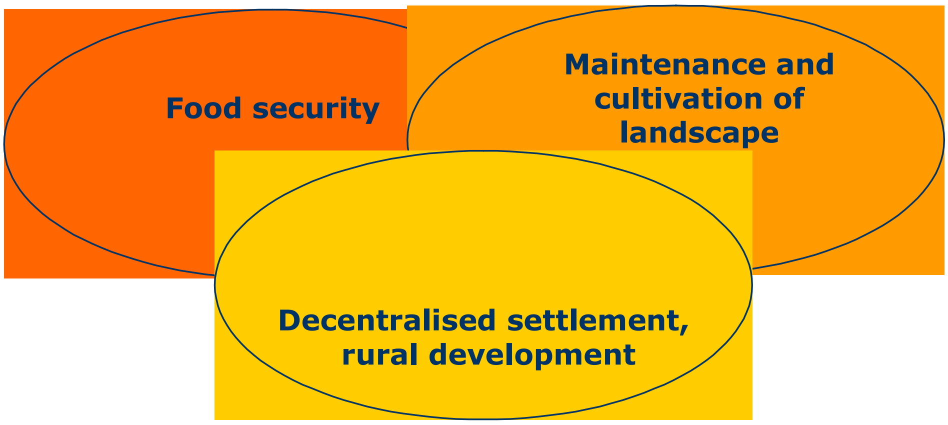
The socio-economic aspects employment and added value together with the (economic) viability of the rural region are decisive for rural development. Agriculture's contribution to rural development is based on the utilisation of the non-allocable factors labour and land. Therefore, it is more closely linked to agricultural structures, land-use and workforce-related land-use intensity than to the production of goods *per se*. The factor labour is primarily an input in agricultural production. Thus it is hardly possible to characterise agriculture's contribution to employment in rural areas as a positive externality (OECD, 2001). This applies in particular to regions in which settlement is assured regardless of agriculture or in areas where society would not view depopulation with disfavour. On the other hand, the preservation of rural culture or agriculture's socio-cultural contribution in rural areas have the nature of multifunctional services which can hardly be de-linked from agricultural production.

Unlike the multifunctional services discussed previously, food security is not only linked to the non-allocable input factors, but is also connected with the output of agricultural production. In addition to the physical availability of foodstuffs, a secure food supply has other implications, such as for example, a feeling of national well-being arising from the certainty of guaranteed food supplies (Rude, 2000) and the avoidance of market breakdowns in times of crisis.

When considering food security on a global level, complete jointness is perceptible since the private good (food) corresponds to the multifunctional service (availability of food). However, on a national level this connection must be viewed in relation to time and space. Time limits arise from the fact that the short- and long-term sources of jointness are not identical. The short-term availability of foodstuffs is linked to domestic production through the stocks in the supply chain and therefore the connection with agricultural output is limited. On the other hand, from a long-term point of view, the availability of the non-allocable production factors (land, capital) plays a role; however, this potential does not have to be linked to today's production so that the factors can also be maintained without (intensive) agricultural utilisation. The space limitation arises from the fact that the foodstuffs available for consumption are more important for food security than domestic production. These foodstuffs can originate from domestic production or also from other sources, such as imports or stockpiles.

The discussion concerning the sources of jointness indicates that the multifunctional services provided by agriculture are basically more closely associated with the utilisation of the production factors labour and land or the maintenance of production and processing capacities and (traditional) agricultural structures than with the production of goods. Only food security is partially linked with the commodity output of agricultural production. Due to the connection via the non-allocable production factors, links exist not only between production and multifunctional services, but also between the multifunctional services (Figure 1). On the one hand, the production factors cannot be assigned definitively to the production of a commodity or non-commodity output. However, it is likewise impossible to assign them clearly to the various non-commodity outputs. The upkeep of open land or cultivated landscape represents a contribution to the maintenance of those production and processing capacities which are essential for food security. Furthermore, the utilisation of the factor labour in land-use promotes rural development in peripheral agrarian regions. The connection between the multifunctional services is significant for the evaluation of jointness since today's costs must be divided between the multifunctional services in order to compare the costs generated by linked production with those arising from an alternative form of provision of the individual services. Therefore, the costs of alternative provision of all multifunctional services must be taken into account when making an overall evaluation of today's costs.

Figure1. System of multifunctional services



Results of the evaluation

The results of the subprojects on the evaluation of jointness are summarised briefly in this subsection. For more detailed information, please consult the appropriate report of the respective subproject.

Evaluation of jointness between agriculture and landscape in the lowlands[1]

The evaluation of jointness between agriculture and landscape refers to the maintenance of cultivated landscape in the lowlands. It focuses on landscape's aesthetic function which is linked to agriculture via the form of land-use and landscape elements, such as trees and hedges. The purpose of the evaluation is to estimate the costs of landscape maintenance provided by alternative suppliers. Provision costs are calculated for just keeping the land in use today in an open condition and for the upkeep of today's landscape with its structure and diversity. For the purpose of the calculations it is assumed that, under world market conditions, 60% of the area, *i.e.* all crop rotation areas, in the case study region would remain in use. Viewing Switzerland as a whole, land-use would probably be even more restricted under world market conditions.

The Greifensee region, where the production of fodder is the main activity, is used for this case study. The average costs of landscape maintenance in Germany serve as the data base for calculating the provision costs. The decline in product prices is accompanied by a fall in factor prices and therefore the data from abroad is likely to represent a better approximation of the effective costs. The costs for keeping land open consist of the upkeep of the respective area and the utilisation of the resulting biomass. The upkeep of today's varied landscape generates additional maintenance costs for landscape elements such as trees, hedges or arable crops.

Annual provision costs for the maintenance of cultivated landscape by alternative suppliers amount to 5 million at the most. The maintenance costs for landscape

1. Summary of the paper *De-linked cost of rural landscape maintenance: A case study from Swiss lowlands* (Huber, 2007).

elements account for only one fifth of the total sum. The amount of land that is no longer used under world market conditions and which must therefore be kept open plays a decisive role in these total costs. Looking at the general direct payments granted to the farms in the year 2002 (area and slope payments) which amounted to a total of 6.5 million , it can be seen that, without taking other targets into consideration, a large share of the productive agricultural land would be have to be left fallow to offset the costs of an alternative supplier. Therefore, it is clear that even in the Greifensee region which is relatively homogenous, general direct payments for the maintenance of cultivated landscape are only efficient if they are accompanied by spatial differentiation.

The costs of biomass disposal account for the largest share of alternative suppliers' provision costs. Consequently, the possible economies of scope resulting for agriculture are not to be sought in land-use but rather in a more efficient utilisation of the resulting biomass. While it may cost less to have fallow land kept open by alternative suppliers, it is quite possible that it is more efficient to use the biomass in the agricultural production cycle. However, if technical progress in the fields of bio-gas or grass-energy plants leads to a more efficient use of biomass for the production of industrial, marketable goods (energy, fuel, fibres) landscape maintenance can be progressively de-linked from agriculture or the production of agricultural commodities.

Evaluation of jointness between the production of goods and land-use in mountain areas[2]

The evaluation of jointness between the production of goods and land-use in mountain areas answers the question of whether or not today's support for agriculture by public funding is the most efficient way of ensuring that land is cultivated. The evaluation is based on model calculations which were drawn up for the Albula case study region in canton Grisons. A static version of the agricultural structure and land-use model SULAPS (Lauber, 2006) is used for the calculations. It allows statements to be formulated regarding agricultural structures and land-use.

The maintenance of open land and landscape by agricultural suppliers is considered to be the most economical alternative in mountain areas. The main reason for this is the fact that livestock-keeping offers the only realistic way of utilising the biomass resulting from mowing or from the pastures. An alternative method of disposing of biomass is unrealistic as this generates comparatively high costs. Therefore, the de-linked upkeep of open land is ensured by means of a fixed, general area payment in favour of the farms. In the case study region, the model calculations indicate that these payments must amount to CHF 2 200 per hectare if the maintenance of cultivated productive land is the declared purpose of agricultural policy. Without agricultural support, land-use goes down by roughly 70% compared to today. On the other hand, 95% of the area in the case study region is cultivated when an area payment of CHF 2 200 is granted. Total direct payments for the region amount to CHF 2.4 million. These payments correspond to a share of 48% of the overall gross proceeds. The services provided by agriculture are currently remunerated with direct payments amounting to a total of CHF 3.6 million.

According to the model calculations, the granting of indirect support for area cultivation by means, for example, of animal-related payments and product price support,

2. Summary of the paper *Evaluation der Jointness zwischen Güterproduktion und Flächennutzung im Berggebiet* (Meier *et al*., 2006).

would result in a net welfare gain of CHF 1.8 million. The region gains this amount if it dispenses to a large extent with the jointness between the production of goods and the upkeep of open land in its current form and remunerates the upkeep of open land by means of general area payments. However, the economic gain must be considered from a relative point of view, since the de-linking of land-use from production leads to a reduction in agricultural employment and added value. This means that agriculture's contribution to rural development and decentralised settlement also falls.

Evaluation of jointness between agriculture and rural developmen [3]

The evaluation of jointness between agriculture and rural development concentrates on the mountain region. On the one hand, the investigation focuses on the importance of agriculture for employment and added value. On the other hand, the costs of current agricultural support are compared with the cost of creating alternative employment opportunities.

In the four regions under investigation, between 14% and 72% of the total workforce depend, directly or indirectly, on agriculture while the share of added value related to agriculture varies between 7% and 49%. Agriculture's contribution to employment and added value is particularly marked in regions with a strong agrarian character. In general, the contribution to rural development is lower in regions with a tourist industry or with a diversified economy. By way of contrast, the indirect and induced multiplier effect generated by the acquisition of intermediate inputs, capital goods and consumption is lower in regions with a high share of agricultural employees. The opportunities to obtain intermediate inputs, capital goods and consumer goods locally are limited and consequently the employment and added value effect generated by agriculture in the rest of the economy is lower.

Depending on the region, the employment effect of agriculture which goes beyond the target of overall cultivation generates costs amounting to CHF 35 000 to CHF 55 000 per full-time equivalent via product-related support and general direct payments. Costs relating to the added value effect lie between CHF 0.52 and CHF 0.73 per franc. Costs are particularly high in agrarian regions due to the low added value generated by agriculture and the low added value multiplier. In comparison, the costs of support for agricultural employment and added value are clearly lower in regions with a more widely diversified economy. In this case, the relationship between agriculture and the rest of the economy is much stronger and this is decisive as it generates higher employment and added value effects in the rest of the economy.

A comparison with the costs of alternative employment opportunities shows that agricultural support to promote rural development is basically inefficient if jobs can be created outside of agriculture. On average, the costs of creating alternative employment opportunities would probably be much lower. However given today's basic conditions, it is hardly possible to create and maintain jobs in the manufacturing and industry sector and the service sector in agrarian regions as the costs are higher than the realisable added value. On the other hand, it is efficient to support agriculture to ensure rural development in regions where it is impossible to create jobs outside of agriculture, even with high contributions. Correspondingly, it should be possible to create alternative jobs at a lower

3. Summary of the paper *Evaluation of jointness between agriculture and rural development* (Flury *et al.*, 2007).

cost than in agriculture in (larger) regions with a diversified economy. Consequently, it is not efficient to support agricultural employment in these regions.

Evaluation of agriculture's contribution to food security[4]

The evaluation of agriculture's contribution to food security focuses on the food security offered by different agricultural systems. Today's supply security in a potential crisis is compared with domestic production under world market conditions.

The Swiss food security strategy is designed to ensure that the population can be fully supplied during the first six months of a crisis. It should be possible to introduce other measures to overcome the crisis in this time. The strategy allows for various risks and developments in and outside of Europe or the consequences of global changes. In a standardised medium crisis scenario it is assumed that half of the productive agricultural land is no longer available, foreign trade is restricted to 50% of normal trade relationships and the mandatory stockpiles have to be maintained to supply the population during the first six months.

It can be assumed that Swiss domestic production will decline noticeably under world market conditions. Experts who took part in a survey expect a 50% to 70% reduction in land-use whereby arable farming could, in part, be even more limited. An optimistic estimate of numbers of animals foresees a reduction of 25% to 40%, a pessimistic forecast expects a decline of as much as 75%. On this basis, today's instruments can hardly guarantee medium- and long-term food supplies in the assumed crisis scenario, even given an optimistic estimate for production. A pessimistic estimate of domestic production under world market conditions indicates that it is impossible to meet the population's minimum food requirements. Sustainable food security, however, can be guaranteed in the medium crisis scenario with today's domestic production and the associated production potential. While it is likely that market supplies of certain products cannot be guaranteed at today's levels and the nutrient mix may not fully correspond to today's eating habits, the total food energy supply exceeds, or reaches the normal level in the short and long run.

The relevant supply crises do not affect Switzerland alone, but upset food supplies over larger areas. Therefore, it cannot be assumed per se that Switzerland can be supplied by imports. Short-term supplies can be guaranteed by the goods available in the mandatory stockpiles and in the supply chain. Domestic agricultural production is of indirect importance since the amount of goods currently available at the onset of the crisis is considerably greater than any possible production at world market prices. However, in short-term supply crises it is basically possible to de-link food security from agricultural production. In the case of low domestic production, the foodstuffs required to secure supplies for the population can, for example, be drawn from mandatory stockpiles.

From a medium- and long-term point of view, the upkeep of production and processing capacities together with the availability of essential production goods become increasingly important as they facilitate the adaptation and expansion of domestic production in the event of a supply crisis of longer duration. With regard to production capacities, this involves the upkeep of the production potential of agricultural land, whereby these areas can basically also be used extensively or just kept open. Cultivation

4. Summary of the paper *Evaluation of agriculture's contribution to food security* (Hättenschwiler and Flury, 2007)

is also associated with a minimum number of animals which represents an essential basis for food security. This also applies to the maintenance of assets such as machinery and buildings as well as production goods.

In contrast to agricultural production capacities, the reduction of processing capacities accompanying a decline in domestic production would have an adverse effect on the capability to adapt and expand production, because it would hardly be possible to realise the investments required for a build-up within the scope of crisis management. However, it should basically be possible to de-link processing capacities from production and to maintain them by implementing alternative measures. As in the case of short-term stockpiling, alternative means of maintaining processing capacities were not investigated in this study. In particular, there is no estimate of the costs of alternative measures; the same applies to the upkeep costs for agricultural production capacities. Consequently, it is not possible to comment on the efficiency of today's food security system compared with an alternative system under world market conditions.

Discussion of the evaluation results

The discussion of the evaluation results focused on the degree of linkage of the multifunctional services, on the question of possible market failure, and on the feasibility of an alternative form of provision of these services. These aspects must be investigated in accordance with OECD analysis framework in order to define the most efficient measures for guaranteeing agricultural policy targets (OECD, 2001).

The multifunctional services provided by agricultural are linked more or less strongly with agricultural production. In grassland areas, land can be kept open mechanically and alternative suppliers can look after the elements which give the landscape its structure. These services are not necessarily linked to agricultural production. However, de-linking is only possible to a limited degree when additional landscape characteristics, such as aesthetic elements or traditional structures are involved. The latter applies in particular to arable regions where the types of crops and their spatial distribution have a direct influence on landscape diversity. Society wishes for landscape diversity in that expansion of extensive areas and nature conservation areas is viewed positively and a reduction of arable land in favour of intensive grassland is viewed negatively (Schmitt *et al.*, 2004). This means that a transition to merely keeping land open would be contrary to society's preferences.

In grassland regions in the lowlands, agricultural land-use would probably exhibit cost advantages when a high share of the land is allowed to lie fallow under world market conditions. On the other hand, when there is only a small share of fallow land, the areas which are not used for agricultural purposes at world market prices can be kept open more cheaply by alternative suppliers. In mountain areas, agriculture is also likely to exhibit cost advantages for maintaining and keeping cultivated landscape open. At the same time, land-use also is associated with a contribution to employment and rural development. On the other hand, agricultural support for employment and added value effects which overshoot the target of overall cultivation is probably only efficient in regions where it is impossible to create jobs in the manufacturing and industry sector and in the service sector and where agriculture therefore exhibits cost advantages.

De-linkage of agriculture's contribution to rural development raises the issue of multifunctional services such as the conservation of rural culture or agriculture's socio-cultural contribution. However, a decline in agricultural employment and settlement in rural areas does not a priori indicate market failure. In a representative survey carried out in 2004, only 20% of those questioned regarded settlement of remote areas as a very important function of agriculture, a further 37% felt it to be important. By way of contrast, the conservation of the rural way of life is viewed more positively in that 76% of those questioned felt it to be very important or to be important (Univox, 2004). The critical attitude towards settlement is also confirmed by the fact that the question of withdrawal from peripheral regions arises with increasing frequency (Simmen *et al.,* 2006).

It is difficult to discuss the food security results since measures for alternative provision and the associated costs were not investigated. Nevertheless, the evaluation shows that in the event of a short-term supply crisis, food security could be de-linked from agricultural production and guaranteed by means of alternative measures, such as larger stockpiles. On the other hand, from a medium- and long-term point of view food supplies cannot be maintained at an adequate level to cover physical needs if there is not support for agriculture.

The upkeep of agricultural production potential is of decisive importance since, in a crisis, the population cannot be supplied sustainably on the basis of production at world market prices. There is a connection between the maintenance of the essential basis for life and the upkeep of cultivated landscape. Cultivation involves a minimum number of animals which represent an important element in sustainable food security. This also applies to the maintenance of assets in the form of machinery and buildings and likewise to production goods. However, production capacities and physical agricultural production are not the only aspects which are linked to land-use. The processing capacities of those downstream businesses which play a decisive role in sustainable supply security are likewise implicated. In Switzerland, both production and food security are regarded as important functions of agriculture. In the survey quoted previously, 62% of those questioned considered the production of food to be very important while 30% felt it to be important. In the case of food security in crises, the respondents' answers were 45% and 44% respectively (Univox, 2004).

Conclusions and prospects

When seeking to define efficient measures to ensure agricultural policy targets, the question arises of whether or not multifunctional services can be provided to a degree which meets societal demands with less support for agricultural production. If this is indeed the case without agricultural support, then there is no market failure and therefore policy measures are unnecessary.

The spatial distribution and importance of the multifunctional services vary depending on the region involved:

- Support for agriculture for the provision of multifunctional services is efficient in regions where there is a demand for these services and where they can only be provided by agriculture or where agriculture exhibits economies of scope.
- Support for agriculture is inefficient and de-linking would make sense in regions where there is a demand for multifunctional services and where alternative suppliers can provide them more cheaply than agricultural suppliers.

- Support for agriculture is, in principle, inefficient in regions where multifunctional services are provided in a satisfactory manner for society in general without agricultural support. There is no market failure.

The importance of multifunctional services provided by agriculture varies depending on the combination involved: in the vicinity of built-up areas or in regions with a tourist industry there is a public demand for well-maintained cultivated landscape as leisure and recreational areas. In the first instance, the utility of the landscape is associated with the local consumer value (Häfliger and Rieder, 1996). However, agriculture only plays a minor role in the rural development in this type of region. On the other hand, agriculture's contribution to rural development is relatively large in agrarian regions. Nevertheless, as discussed in the preceding, cultivation and settlement in this kind of region is beginning to be queried critically.

By way of contrast to the spatially differentiated multifunctional services, agriculture's contribution to providing the population with secure supplies relates to the production potential of the land area and processing capacities required in the event of a crisis for the whole of Switzerland. In this context, the crop rotation areas defined in the subject plan are of primary importance. Depending on the region, other multifunctional services provided by agriculture are assigned to the locations which are important for them, whereby the importance of the individual services in the service mix varies according to the location. While open land and structured landscapes are important characteristics of leisure and recreational areas, the workforce which is employed in the provision of multifunctional services contributes to rural development. At the same time, the production and capacities which are essential for food security are maintained by production which is linked to land-use. However, as mentioned above, these functions exhibit explicit spatial tie-ins.

The efficiency with which funds are used can be improved by an approach involving the specific alignment of instruments with agricultural policy targets and a regionally differentiated configuration of measures (Mann, 2005). In both cases, a more efficient use of funds is to be expected when the provision of multifunctional services is de-linked from support for the production of goods, regardless of whether the services are provided by agricultural or alternative suppliers. On the one hand, it must be stated that by concentrating on fund efficiency, regional measures can generate higher policy related transaction costs which lower efficiency. On the other hand, when making a comprehensive assessment of efficiency it must be borne in mind that agricultural activities simultaneously contribute to the achievement of various agricultural policy targets.

The aspect of efficiency assessment is of particular importance given the fact that up till now, projects on the evaluation of jointness have focused on individual multifunctional services and in most cases do not present a quantitative investigation of the costs of linked production or the costs of an alternative provision. A comprehensive evaluation of jointness must consider all the multifunctional services provided by agriculture simultaneously. In particular, the costs of alternative provision of all multifunctional services must be taken into account when assessing linked production and thus the efficiency of today's support, whereby the interrelationships between the multifunctional services must also be given due consideration (Figure 1). A definite statement regarding the existence or non-existence of jointness between the production of goods and multifunctional services can only be made on the basis of a comparison of today's agricultural costs with the sum of all the costs generated by alternative suppliers.

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Multifunctionality in Agriculture

EVALUATING THE DEGREE OF JOINTNESS, POLICY IMPLICATIONS

These proceedings are part of an OECD series that explores the nature of multifunctionality in agriculture. In November 2006 an OECD workshop was organised to examine the nature and strength of jointness between agricultural commodity production and non-commodity outputs from the perspective of three areas important to the agricultural sector: rural development, environmental externalities and food security. This workshop also examined whether the relationships among these non-commodity outputs were complementary or competing. Finally, the policy implications that could be derived from the findings of this workshop were also a key element in the discussions and are summarised in the Rapporteur's summary.

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