Agriculture, Trade and the Environment

The Pig Sector

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THE PIG SECTOR

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

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– to contribute to sound economic expansion in member as well as non-member countries in the process of economic development; and
– to contribute to the expansion of world trade on a multilateral, non-discriminatory basis in accordance with international obligations.

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LE SECTEUR PORCIN

FOREWORD

The main purpose of this study is to improve the understanding of the linkages between agriculture, trade and the environment in OECD countries. There are two main issues of concern: the environmental impact of agricultural support measures and the consequences of further trade liberalisation; and the trade impact of policies measures introduced to address environmental issues in agriculture. After examining these issues it may also be possible to define the characteristics of policies that can best achieve environmental objectives in ways that are compatible with multilateral trade and environmental agreements.

This work continues the analysis of these linkages by the OECD Joint Working Party on Agriculture and the Environment (JWP). The JWP has already completed two general studies on these linkages. One examined the domestic and international environmental impacts of agricultural trade liberalisation (OECD, 2000*a*), while the other examined the production and trade effects of agri-environmental measures (OECD, 2000*b*). Both studies provided a conceptual overview of the specific linkages and the issues involved, reported the results from general quantitative studies that had been undertaken, and suggested issues for further analysis.

Livestock was highlighted as an area for further examination in both reports. The report on the impact of trade liberalisation on the environment concluded that "subsequent research could also cover in more depth the impact of trade liberalisation on issues like concentration of livestock herds that have been identified in this study as potential environmental 'problem hot-spots'" (OECD, 2000*a*). Similarly, the report on the production and trade effects of agri-environment measures concluded "that the impact of agri-environmental measures on farming costs is more pronounced in livestock production than in crop farming. This issue of potential distortions in international livestock trade could be more extensively explored by drawing on empirical work in OECD countries" (OECD, 2000*b*). Within livestock, the pig sector was chosen for the initial study before progressing on to the dairy sector. To provide a broader perspective, the JWP is also beginning work on examining these linkages in certain crop sectors.

The pig sector provides a good opportunity to consider these linkages. The environmental impacts of pig farming, particularly the issues of water and air pollution are of increasing concern for most OECD countries. Consequently, there have been a large number of different policy measures introduced to deal with the environmental impacts of pig production, providing a rich variety of material that can be examined. At the same time there is a wide variation in the level of support, including trade measures, provided to pig producers over time and between OECD countries. And finally, significant structural and technological changes have occurred in the pig sector, which may have implications for the environment and for policy. The study also provides an excellent opportunity to use and progress two tools being developed by the OECD: the agri-environmental indicators and the inventory of policy measures addressing environmental issues in agriculture. A third group of policies, those dealing with animal welfare, also have an impact on pig producers, but a review of these policies is beyond the scope of this study.

The principal author of this report is Darryl Jones. The report was developed from five papers originally prepared by Dimitris Diakosavvas, Darryl Jones and Kevin Parris, all of the OECD Directorate for Food, Agriculture and Fisheries; Trevor Young of Manchester University, United Kingdom; and Mikael Skou Andersen, National Environmental Research Institute, Denmark, who carried out the comparative analysis in Chapter 7. Statistical support was given by Véronique de Saint Martin, Laetitia Reille and Chen Yuong. Sarah Salmond provided valuable assistance in editing together the five papers. Françoise Benicourt and Theresa Poincet prepared the document for publication. Colleagues in the OECD Secretariat, notably Kevin Parris, and delegates from member countries provided useful comments on the five initial papers and drafts of the final report. This report is published under the responsibility of the Secretary-General of the OECD.

TABLE OF CONTENTS

Chapter 7.
THE EFFECT OF MANURE MANAGEMENT REGULATIONS ON INTERNATIONAL COMPETITIVENESS 129

Tables

Figures

Boxes

Annex Tables

Annex Figures

SUMMARY AND CONCLUSIONS

Overview

Pig production in OECD countries raises a number of policy challenges when viewed in terms of the economic, environmental and social dimensions of sustainable agriculture. Pigmeat accounts for nearly 40% of world meat consumption, and pigs are extremely efficient at converting feed to meat. Given the rapidly expanding global demand for meat and the projected need for a 20% increase in global food production by 2020, the pig sector will continue to play an important role in meeting this demand. At the same time, the environmental consequences of pig production are of increasing public concern, particularly regarding the management of pig manure in relation to water and air pollution. There are also human health issues, especially for those engaged in or living nearby large-scale pig operations.

Within this broader challenge, this study focuses primarily on the linkages between pig production, trade and the environment. In particular, two linkages have been explored: the impact of trade liberalisation on pig production and the environment; and the impact on competitiveness of policies introduced to reduce the negative environmental effects of pig production. Animal welfare requirements also have a significant impact on pig producers, but a review of these policies is beyond the scope of this study. Six main conclusions emerge from this study and are discussed in more detail in the following sections.

- In regions with a high concentration of pig production there is a larger risk of negative environmental effects such as water pollution *e.g.* in regions of Northern Europe, Japan and Korea, although the risk is increasing in North America, Spain and Ireland. There is evidence that some environmental pressures are becoming more “decoupled” from production in some countries.

- There has been a significant increase in the number of pigs per farm in all countries, even where total pig numbers have fallen, and evidence of greater regional concentration of production. This potentially raises the environmental risks associated with pig production. At the same time, technologies and management practices have been developed that reduce the risks, some of which are more easily adopted by large-scale operations or have been imposed by legislation.

- The level of support for pigmeat is low relative to other agricultural commodities but varies greatly between countries. Although high support levels are not a necessary condition for environmental pressure, those countries with the highest levels of pigmeat support are also those with the greatest risk of nitrogen water pollution from pig production. However, linking changes in support with changes in environmental risk is much more difficult to substantiate.

- Further trade liberalisation will strengthen the trends that are expected to occur in the market, with production growing at slower rates, if not falling, in Europe and Asia, but becoming more intensive in all countries unless legislation or consumer concerns put limits to it. Incentives for pig production are affected by changes in relative prices of meats and feeds, with trade flows also influenced by sanitary requirements.

- Environmental policies affecting pig production have focussed on water pollution and odour, and more recently on ammonia and greenhouse gas emissions. Policy measures are predominately regulatory, and are increasing in severity and complexity. Research and advisory services have also formed a crucial part of most governments' policy response. Apart from payments to reduce the cost of meeting new regulations, economic instruments have been rarely used.

- Manure management regulations vary between countries but they are not significantly different. Variations in the cost of manure management regulations only partially explain differences in trade competitiveness, and environmental regulations appear to be only a minor consideration for location decisions.

Linkages between pig production and the environment

The main environmental issues associated with pig production concern water and air pollution. Water pollution arises from the inappropriate disposal of pig manure. Nutrients in manure, principally nitrogen and phosphorus, are a significant component of pollution from agriculture to surface water, groundwater and marine waters, damaging ecosystems through eutrophication and degrading their recreational use. Water bodies can also be affected by organic effluents and pathogens contained in manure. Water pollution is more of a local or regional concern, although cross-border pollution can occur.

It is difficult to quantify the specific contribution of pig production to water pollution but an indirect measure — the OECD's soil nitrogen balance indicator — can reveal the potential risks. The OECD balance is only calculated at the national level so regional variations in nitrogen balances, which can be significant, are derived from other information sources. The actual level of pollution also depends on factors such as the soil type, climate and management practices.

Countries can be grouped into four distinct groups according to the *level* of risk as measured by the overall nitrogen balance and the importance of pig manure as a source of nitrogen. The risk is highest in certain regions of Belgium, the Czech Republic, Denmark, France, Germany, Japan, Korea, the Netherlands, Norway and Switzerland. In Australia, Italy, Mexico, Poland, Sweden and the United States the risk of nitrogen pollution from pig production is low at the national level, although studies indicate that the risk at the regional level, particularly in the United States, can be just as large as in the high-risk countries. In Ireland, other regions of France and the United Kingdom, the overall nutrient balance is high but the contribution of pigs is small. In Austria, Canada and Spain, the reverse is true.

Changes in the nitrogen balance indicator between 1985-87 and 1995-97 reveal a number of different *trends* in the potential risk of water pollution from pig production. The risk has increased in Canada, Korea, Ireland, Spain and the United States; decreased in Austria, Germany, Japan, Mexico and Switzerland; and stayed the same in Australia and Norway. For other countries the nitrogen balance has decreased but the contribution of pig to livestock nitrogen production has increased.

In some countries, the emission of ammonia from livestock housing facilities and from badly managed storage and spreading of manure are also of serious local concern. Livestock accounts for around 80% of total ammonia emissions in the OECD, with the importance of pigs as a source of emissions following a similar pattern to its contribution to livestock nitrogen manure production *i.e.* the issue is particularly serious in regions of high pig concentration in parts of northern Europe and Asia. Pig production can also be a source of greenhouse gas emissions, mainly methane and nitrous oxide, but its importance is small at less than 5% of agricultural related emissions for most

OECD countries. At the local level, odour can be a serious air pollution problem resulting from pig production in all OECD countries.

Other environmental issues relating to pig production include the genetic erosion of pig breeds; the effects of invasive wild pigs on agriculture and the environment; and in some areas, the beneficial impact of the use of free range pigs to maintain certain ecosystems. In terms of genetic diversity, there are globally 650 recorded breeds of pigs, of which 150 have become extinct. A further 164 are at risk of being lost, with OECD countries accounting for around 20% of those at risk.

Analysis of the OECD agri-environmental indicators also suggests that in some countries pig nitrogen manure and methane emissions are becoming more "decoupled" from production in the sense that the output of these environmental risk indicators per unit of pigmeat produced has fallen over time. While some care is required in interpreting these trends, improvements in productivity and the adoption of more environmentally friendly technologies and management techniques would suggest that such changes could be expected to occur.

Developments in the structure, technology and management practices of pig production

To meet growing consumer demand, world pigmeat production increased by almost 75% between 1980 and 2001. Growth has been the most rapid in China, the world's largest producer. Within the OECD, growth has been particularly significant in Korea, Poland and the United States, and to a lesser extent in the European Union, while production fell in Japan. Trade has grown at a faster rate than production, but less than 4% of pigmeat is traded internationally (8% if intra-EU trade is included).

Along with an expansion of production, there have been significant structural changes in the pig sector. In all OECD countries, production has become more intensive, with an increase in the average number of animals kept both per pig holding and per land area of pig holdings. This is the case even in countries like Japan where overall pig numbers have decreased. In many OECD countries pig production has historically been associated with other agricultural activities that provide livestock feed, for example with grain production in the midwest United States, but has now become more specialised relying on brought in feed. Over time, pig production has become more regionally concentrated, with growth in non-traditional pig producing regions.

A major factor driving these structural changes has been technology. Improvements in production, breeding and management techniques have enabled considerable productivity gains to be made, particularly for larger operations, thus creating an incentive to increase scale. Technologies and economies of scale have also made it possible to move the industry toward off-farm feed preparation. A major factor encouraging the development and uptake of productivity enhancing technologies has been the intense competition in the meat market and the long-term decline in real prices received by farmers, which in turn is driven by productivity improvements.

These structural changes potentially raise the environmental risks associated with pig production. A greater number of animals per farm leads to a larger volume of manure that must be disposed of. If there is less land available per pig, the quantity of nutrients supplied to the soil will increase, with potential harm to water quality. Greater regional concentration of production further exacerbates this problem. More intensive production along with deficient manure storage management also leads to an increase in air pollution, including odours and ammonia.

On the other hand, technological developments (*e.g.* in regard to housing (holding) facilities, manure storage and treatment systems, and alternative energy production units) and management practices (*e.g.* altering feed composition and manure spreading practices) are helping to ease the environmental pressures associated with pig production. Given that some of the technologies are not scale-neutral nor lead to increases in production, operations of a larger-scale have a greater potential to introduce such technologies because the cost can be spread over a larger volume of production. Other changes, such as in feed composition, can provide win-win situations for all farmers, lowering both production costs and the environmental risks. Regional changes in the location of production may also have positive environmental impacts by reducing pressure in current production areas and moving to areas where the environmental impact is not so large. For example, a move to less densely populated areas will reduce the nuisance of odour pollution or a move to areas with a greater carrying capacity due to more favourable geographic or climatic conditions will reduce the risk of water pollution.

Agricultural support policies for OECD pig producers

Like most other commodities, the level of support provided to pig producers varies across OECD countries. In countries where support is provided to pig producers, policy measures that are more output linked (*e.g.* measures such as tariffs and export subsidies) make up a significant proportion. There are clearly two main groups of OECD countries in terms of support levels for pigs. The first have very few trade intervention policies in terms of tariffs and export subsidies *e.g.* Australia, Canada, New Zealand and the United States, and consequently a very low overall level of support. The other group has relatively high tariffs *e.g.* Japan, Korea, the European Union, Norway and Switzerland, with export subsidies also important for the European Union, and consequently higher overall levels of support. While pig producers do not benefit from budgetary payments to the same extent as other agricultural producers, including beef and sheepmeat producers, the average level of tariff protection on pigmeat is higher than for other meats.

In comparison to other commodities, support levels for pigmeat are generally lower even in countries where pigmeat support is high. Consequently, changes in support levels for other commodities are likely to influence incentives for pigmeat production. In particular, pig producers are affected by changes in support policies for cereals that are used as feed inputs. Reforms that have reduced cereal prices, for example in the European Union and North America, also lower input costs for pigmeat producers in these countries.

This pattern of support for pigmeat, in terms of the level and composition, influences production patterns and contributes to greater pressure on the environment than if they were not in place. The countries where the potential risk of nitrogen water pollution is the highest are also those with the highest level of support to pig producers *i.e.* Europe, Japan and Korea. However, high support levels are not the only factor causing environmental pressure. Negative environmental impacts of pig production are also evident in countries with low levels of support. But where support policies have over the long-term consistently provided higher producer returns, encouraging greater volumes of production, this is likely to have exerted greater pressure on the environment than if producers were responding to market signals, all other things being equal.

Agricultural support policies have also influenced location decisions. For example, in the European Union, access to cheap imported feeds as compared to the price of feed-grains produced under the CAP played a significant role in encouraging the expansion of pig production in the Netherlands. Changes to cereal support policies have encouraged shifts in the location of production in North America.

It is more difficult to connect changes in support for pigmeat with changes in environmental pressure. A number of other variables can contribute including changes in support provided to other commodities, agri-environmental measures, and market induced changes. Changes in environmental pressure need to be analysed on a case-by-case basis. The 1992 CAP reform in the European Union illustrates the complexity of the link between changes in support policies and environmental impacts. By reducing prices for EU-produced feed grains, the reform led to an increase in support provided to pigmeat producers. But a reduction in EU cereal prices also changed the relative prices of feed inputs, leading to a lower protein content in compound feed. This in turn reduces the nutrient content of animal manure, lowering the overall potential environmental damage.

The impact of further trade liberalisation on pig production and the environment

Developments in the market alone, without further trade liberalisation, are expected to cause changes in pigmeat production, with higher than average growth in Australia, Poland and North America, slower than average growth in the European Union and Korea, and a fall in production in Japan. The competition induced pressure to lower production costs will encourage further intensification of production in all countries. Further trade liberalisation is expected to strengthen these trends in the pattern and scale of production.

The impact of further policy reform on the environment depends on the effects on production arising from changes in relative levels of support, not only between countries but also between commodities. Further reform in the pig sector alone, particularly that driven by trade liberalisation, without increases in other forms of support, would likely result in pig production increasing in countries with lower or virtually no support and decreasing in those with high levels of support. In general, the former group is more land rich than the latter group of countries. Given that many of the environmental issues involved with pig production are associated with pressure on land this would appear to be a positive development, relieving some of the pressure in high support countries if adequate spatial requirements are respected. But as a consequence of increased production, environmental pressures will increase in some areas of the countries that offer less support.

The impact of a wider reform programme affecting all commodities is much more complicated. As the level of support for pigs is generally lower than that provided to other commodities, more resources are currently transferred into the production of higher support commodities. Consequently, reductions in support for these commodities could increase the amount of resources going into pig production, even those with relatively high levels of pig support at present. In terms of relative returns from outputs, pigmeat could become a more attractive option for producers. On the input side, there will be some benefit for pig producers in countries with high price support for feed grains, as further liberalisation will lower the cost of feeds. Other pig producers purchasing on markets determined by international trade may find their feed costs increasing. Overall evidence suggests that further trade liberalisation, both a reduction in tariffs and export subsidies, will lead to a reduction in production in the more highly supported countries.

The study also showed that other factors could be as important in determining the future impact of pig production on the environment. Trade flows in pigs and pigmeat are significantly influenced by border sanitary measures and the health situation in the pig and substitute meat sectors (beef, sheep and poultry). Consequently, progress in meeting sanitary requirements, either through improved systems in the exporting countries or changes in the requirements set by importing countries, could have a large effect on patterns of trade and production, particularly for developing countries. Developments in China and the enlargement of the European Union are also likely to have an impact on trade flows and may induce changes in the location of production. Finally, consumer concerns, particularly regarding animal welfare may result in public and private sector responses that change production patterns and processes.

Policy measures addressing environmental issues in the pig sector

Agri-environmental policy measures affecting the pig sector are clearly focussed on reducing the harmful environmental impacts of pig production. The main objectives of such policy measures have been to reduce water pollution and odour. In recent years, measures have been introduced in some countries to deal with other concerns, particularly ammonia emissions. Most of the policy measures have been motivated by local or regional concerns, and are very often designed and implemented at that level. There are relatively few measures that specifically relate to pigs, with pig producers affected by wider policies aimed at the livestock sector or the agricultural sector as a whole. Some policy measures have been introduced in response to international environmental agreements and this trend is likely to continue.

In terms of policy measures, the initial response by most governments to address environmental issues in the pig sector was to impose regulations, develop research programmes and provide on-farm technical assistance and extension services to farmers. Such policy measures remain an integral part of the overall environmental strategy in most countries.

Pig producers face an array of regulations impacting on their production levels and practices. Regulations were first introduced to limit point source pollution, for example by prohibiting or limiting the direct discharge of pig manure into waters. Regulations have been steadily introduced to limit non-point source pollution, for example by regulating the quantity of manure that can be produced, the quantity that can be spread and the way in which it is spread. Overtime there has been a clear trend for the number of regulations to be increasing and to be imposing more stringent conditions on pig farmers. Environmental cross-compliance requirements have typically been imposed on the receipt of budgetary support payments in the few countries that provide such payments to pig producers.

Economic instruments have not been as widely used. Payments have often been made to assist farmers adopt technologies or change farm structures, and are generally provided for a limited period. Taxes have only been used in a few countries but have increased in their severity. Where used they are levied on the volume of nutrients above a certain level measured at the total farm level. Tradable rights are only used in the Netherlands, and related initially to the volume of manure produced and more recently to the number of pigs kept on-farm. Support has also been provided to encourage alternative uses for pig manure, such as an energy source, in both on-farm and off-farm operations. Payments to stimulate the exit of producers from the sector have been recently introduced in a few countries to more rapidly reduce the environmental pressure of pig production.

A greater number of measures and generally of a more restrictive nature have been applied to producers in northern European countries. This perhaps reflects the relative environmental risks associated with highly concentrated pig production systems. Undoubtedly the various policy measures that have been introduced for environmental reasons since the mid-1980s have reduced the impact of support policies on the environment. An obvious question is the extent to which agri-environmental policies are fixing problems created amongst other reasons by agricultural support policies.

The effect of manure management regulations on competitiveness

Concerns have been raised about the impact of agri-environmental measures on trade competitiveness, and the resulting impact on the pattern of trade and location of production. The important issue for the pig sector is the extent to which variations in environmental regulations between countries could be having an impact on trade patterns by imposing different production costs on producers. In this study, analysis was undertaken of one aspect *i.e.,* the differences in production costs imposed by regulations concerning the storage, disposal and application of manure in five countries.

The analysis shows that costs imposed by manure management regulations are up to 50% lower in New South Wales (Australia), Korea and Iowa (United States) than in Denmark and the Netherlands. However, the additional costs are not of a scale that explains differences in competitiveness. Differences in production costs imposed by regulations should be expected to the extent that these are associated with variations in the environmental cost of pig production and are in conformity with the polluter-pays-principle (PPP). This is particularly true for those environmental effects that are of a local nature. The environmental costs of pig production are likely to vary between countries just as labour, land and capital costs vary between countries.

Support has been provided in some countries to offset the increased costs imposed by regulations. In particular, support has often been given to reduce the level of capital expenditure required to bring production facilities into conformity with regulations. The 1974 OECD Council Act on the implementation of the PPP specifies the situations where subsidies could be offered to help polluters comply with environmental measures. One of the important specifications is that such support should not create significant distortions in international trade and investment. It is difficult to quantify whether such support in the pig sector has had a significant impact on trade. Nevertheless, the pattern of trade would be distorted to the extent that such support has kept more farmers in pig production than would have been the case had they born the full cost of the regulations (as a proxy for the cost of pollution).

Another result of the analysis was the relationship between farm size and the costs imposed by manure management regulations. The costs of manure management regulations, as measured in relation to total production costs per pig for slaughter, were greatest for the medium-sized and the very large-scale farm, with a lesser impact on the large-scale farm. Medium-scale farms have less production across which to spread the cost of standard regulations, and very large-scale farms are required to meet additional regulations and have a lower average production cost. In all situations, costs were greatest for the very large-scale farm.

The results indicate that differences in manure regulations are not likely to lead to shifts in the location of production at the international level or across countries. This confirms analysis carried out in the United States indicating that differences in environmental regulations appear to play only a minor role in location decisions inside the country, although this could change with more stringent regulations as evidenced in the Netherlands. These studies also suggested that environmental regulations fall more heavily on small producers, who will opt out of pig production rather than shift production to a different location, or on very large-scale producers who are often the focus of policy measures.

Policy implications

A number of policy implications can be drawn from this study.

- Flows of environmentally damaging materials into water (*e.g.* nutrients) and emissions into the air (*e.g.* ammonia) are a common consequence of pig production. Reducing the flows of these materials and emissions to an acceptable level of risk in terms of human and environmental health is a priority for policy.

- While support for pigmeat is lower than for other commodities, agricultural support policies are influencing the level and pattern of pigmeat production, with some negative environmental consequences.

- Policy makers need to be aware of the link between commodities when developing and implementing agricultural policy reform. Relative changes in output (*e.g.* beef) and input (*e.g.* cereals) prices that result from reforms will influence incentives for pigmeat production.

- Policy reform, including trade liberalisation, is likely to reduce or slow down growth in pigmeat production in those countries where the environmental risk and cost is currently the highest, and increase it in others.

- While most countries will have to face the pressures associated with increased pig production to meet growing consumer demand, all countries will have to respond to increases in pollution risks associated with the further intensification of production.

- Technologies and management techniques do offer the possibility of reducing the environmental risks, with evidence of some "decoupling" of environmental risk from pigmeat production taking place. Policy makers should examine such developments, and consider ways it can influence their uptake.

- Policy makers should recognise the cost impact of agri-environmental policies, especially regulations, on different sized producers and consider this in relation to the resulting environmental benefit. A one-size-fits-all approach or requirement, particularly when focused on a specific farming practice, may be neither environmentally effective nor economically efficient.

- Sometimes more drastic measures, including policies which lead to the exit of producers from the sector, may be needed in order to achieve the desired environmental outcome.

- Policy instruments that more directly target the localised nature of environmental concerns rather than establish blanket requirements on all producers need to be developed. In this regard, some of the economic instruments recently developed may provide examples to others.

- Differences in regulations do exist, but these appear to reflect differences in the environmental risk and are not large enough to impact on the trade competitiveness of producers. Payments to offset the cost of regulations should be carefully considered before being provided, particularly if the PPP is to be appropriately implemented.

Chapter 1

WORLD PIGMEAT MARKET

Pigmeat accounts for the largest share of world meat consumption. Production has increased to meet consumer demand, particularly in China and in most OECD countries, although it has fallen in a few, most significantly in Japan. Trade has increased at a faster rate, but only a small percentage of world production is traded. Exports are significant for some European countries and Canada, while Japan has developed into a major import market.

Pigmeat consumption

Over the last two decades, pigmeat has accounted for the largest share of world meat consumption (Figure 1.1). World pigmeat consumption increased over 70% from 1980 to 2000, when it reached 90 million tonnes. Poultry consumption has also increased significantly over this period and continues to show a higher rate of growth than pigmeat. Beef consumption has been declining steadily, while remaining largely stable for sheep and goat meat. **China**, the **European Union**, **Japan**, **Russia** and the **United States** accounted for over three-quarters of total world pigmeat consumption during the 1996-2000 period (Annex Table 1). In terms of per capita pigmeat consumption, **Poland** ranks first at 47 kg followed by the **European Union** (43 kg), **China**, the **United States** and **Canada** (29 kg). Within the European Union, per capita pigmeat consumption is very high in some countries such as **Denmark** (66 kg), **Spain** (61 kg), **Germany** (54 kg) and the **Netherlands** (51 kg). Pork consumption rates in some central and east European countries such as the **Czech Republic** are very similar to the Polish level.

Pigmeat production

World pigmeat production increased by 75% (annual rate of 2.7%) between 1980 and 2001 to 92 million tonnes (Figure 1.2). **China** is the largest producer, accounting for 46% of total world production in 1997-2001 period

(Figure 1.3). The **European Union** is second at 20% (**Germany** 5%, **France** and **Spain** 3%, the **Netherlands** 2%, **Denmark** 2%, **Belgium** and the **United Kingdom** just over 1%), followed by the **United States** at 10%.

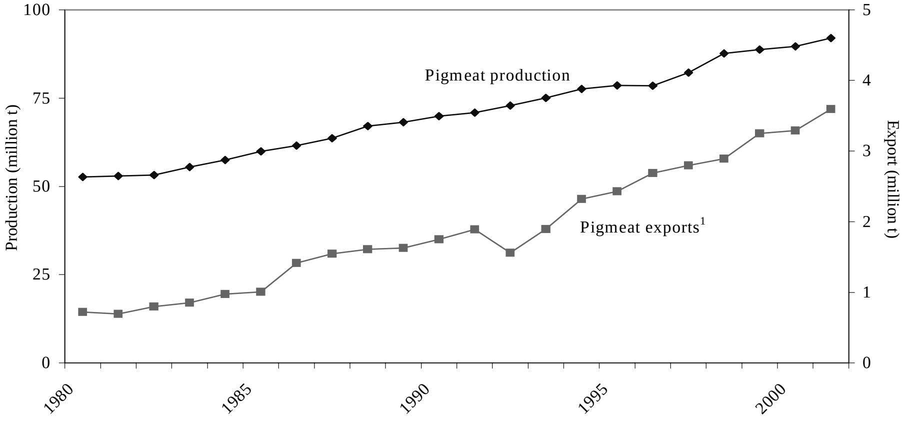
Figure 1.1. Share of world meat consumption, 1980-2000

% volume consumed

Source: FAO database, 2003.

Figure 1.2. World production and export of pigmeat, 1980-2001

Million tonnes



Note:

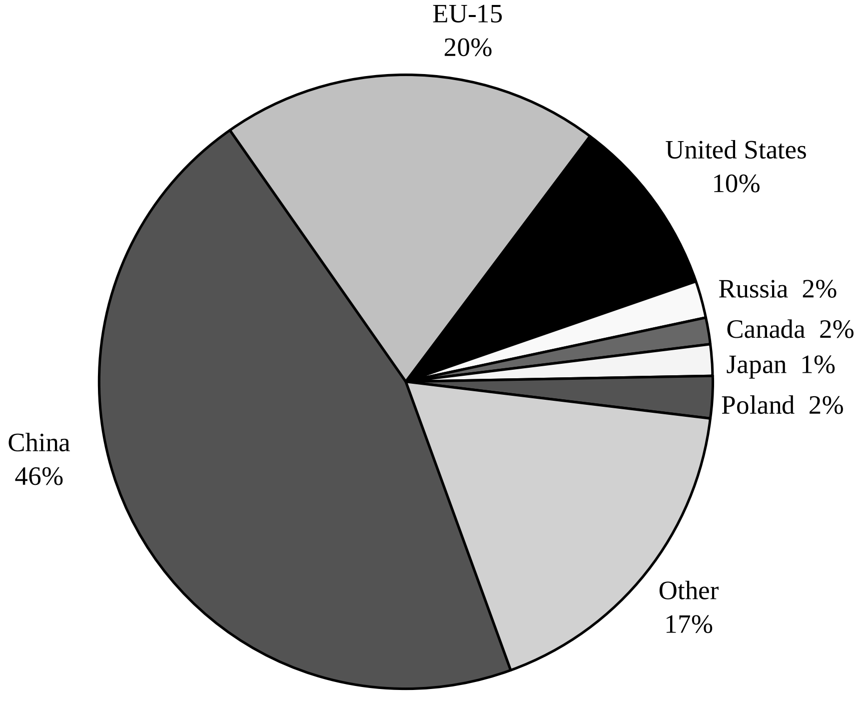
1. Export data exclude intra-EU trade, see Annex Tables 1 and 2.

Source: FAO database, 2003.

Pigmeat production in the **United States** increased by 2% per year during the 1990s and expanded to 8.7 million tonnes in 2001. Production in the **European Union** as a whole grew at a slower annual rate of 1.2% between 1990 and 2001 but there were variations between EU countries. For example, production declined in **Germany**, the **Netherlands** and the **United Kingdom**, but increased by 3% or more per year in **Belgium**, **Denmark** and **Spain**. Production has also increased significantly in **China** and **Korea**, at around 5% a year since 1990. Production in **Russia** has declined sharply since 1990 as a result of economic and political turmoil in the mid-1990s. Production in **Japan** increased slightly through the 1980s, but has since declined.

Figure 1.3. Share of world pigmeat production, 1997-2001 average

% volume produced



Source: FAO database, 2003.

Pigmeat trade

The volume of pigmeat exports (excluding intra-EU trade) increased by 7% per year between 1980 and 2001 (Figure 1.2), and by 5% per year if intra-EU trade is included. The **European Union** is the largest exporter accounting for 86% of pigmeat exports in the 1997-2001 period when intra-EU trade is included (Annex Table 2). **Denmark** is the single most important exporter (18% of total world exports), followed by the **Netherlands** (13%). **Canada** and the **United States** each accounted for around 7%. **Poland** became a net exporter in 1998. In terms of exports as a percent of production, the world's largest traders are **Canada** and the **European Union** (both 33%). Within the European Union, the largest traders are **Denmark** (75%), the **Netherlands** (55%) and **Belgium** (41%). While the largest producer of pigmeat, **China** exported only 1% of its production.

Although on an aggregate basis the European Union is a net exporter, **Germany**, **Italy** and the **United Kingdom** are very large net importers, mainly from other EU countries. In the **European Union**, pigmeat imports from non-EU countries are negligible, with about 80% of exports from EU countries going to other EU countries. **Japan** is the major market for non-EU exports, with over 90% of the exports of pigmeat from EU countries to Japan originating from **Denmark**.

Danish pigmeat exports have increased rapidly over the years, increasing from nearly 0.7 million tonnes in 1980 to almost 1.3 million tonnes in 2001. Danish export destinations have changed over time. Exports to EU countries represented 67% in 1995, with **Germany** as the main importing country followed by the **United Kingdom** and **France**. In 1990, the United Kingdom had been the biggest importer of Danish pigmeat with a share of 27%. **Japan** takes the single greatest part of Danish exports to non-EU countries, followed by the **United States**. A decrease in exports to the United States has been compensated for by an increase in exports to other non-EU countries, including **eastern Europe** and, in particular, **Russia** and **Poland**.

In the **United States**, pigmeat exports have increased five-fold in the 1990s and since 1995 the United States has become a net exporter of pigmeat. **Mexico** is the largest foreign market for US live pigs and the second-largest for US pigmeat products.

Chapter 2

LINKAGES BETWEEN PIG PRODUCTION AND THE ENVIRONMENT

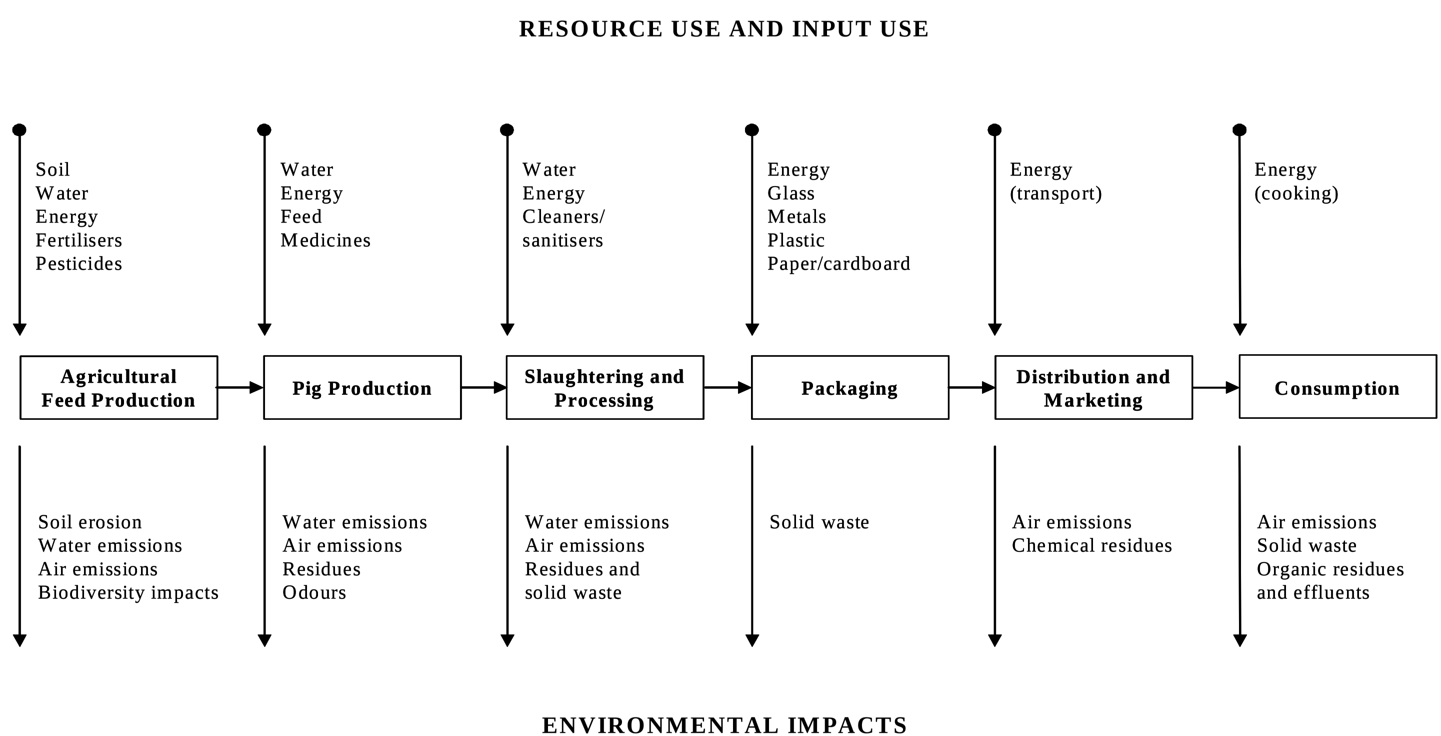
The key environmental issues associated with pig production concern water pollution (mainly nitrogen and phosphorus, but also pathogens in pig manure), air emissions (principally ammonia, methane and nitrous oxide), and the links between pig production and biodiversity, especially the genetic diversity of farm pig breeds. The distance or scale over which pig production impacts the environment varies greatly, from the local, regional, national, to the global scale. The environmental risks of pig manure disposal in certain regions have increased as pig production units have grown fewer, larger, and more specialised. Disposal of pig manure is usually driven by lowering disposal costs rather than optimising the nutrient needs of crops and pasture, leading to detrimental environmental costs. It is possible to identify different groups of OECD countries in terms of the level and trends in the risk to water pollution from nitrogen in pig manure. The level of risk is highest in Japan, Korea and several European countries, with the risk increasing in Ireland, Korea, Spain and North America. Methane emissions follow similar trends to those observed for nitrogen. A number of important social issues have developed with the emergence of large-scale pig production operations, including their impact on human health, animal welfare and property values. For a number of countries, pig production has grown more rapidly than the output of nitrogen in manure and methane emissions, due to improved productivity and the adoption of environmentally friendly technologies and management practices.

An overview of the linkages

A broad view of the pig industry can be taken by considering the entire agro-food chain, extending from feed production through to final consumption. The "life-cycle approach" illustrates the range and diversity of resource inputs and environmental outputs resulting from the actions of pig producers, processors, marketers and consumers along the food chain from pig to plate (Figure 2.1).

Figure 2.1. Resource and input use and environmental impacts through the pigmeat supply chain

“Life cycle approach”

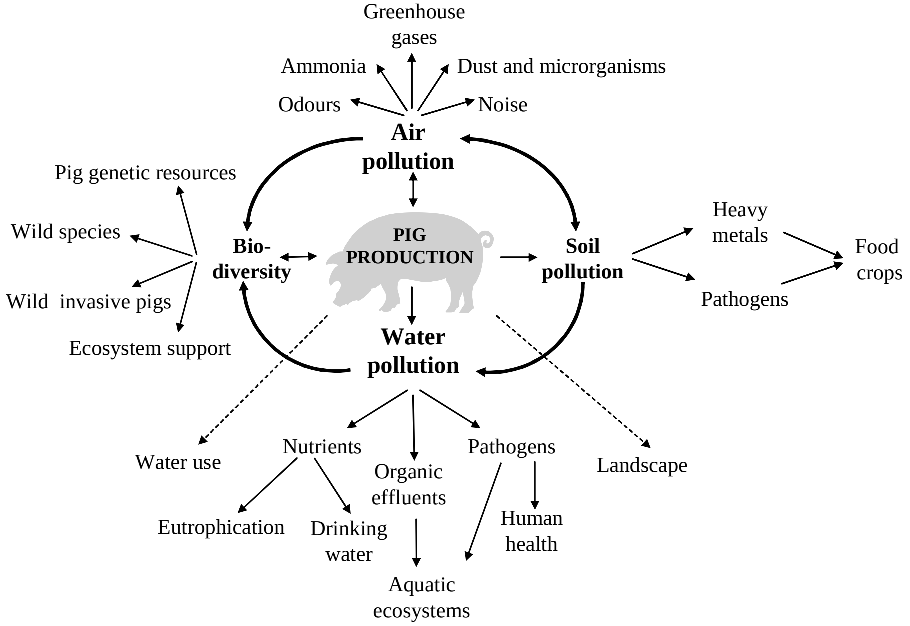


Source: OECD Secretariat, adapted from Pagan and Lake (1999).

A number of indirect positive benefits are attributed to intensive livestock production systems, including pigs, such as their efficiency in feed conversion, utilisation of food waste with few alternative uses, improvements in reducing the volume of waste per unit of output, reliability of meat supply, and reducing pressure on land which can be used for other uses, including as wildlife habitat (Avery *et al.*, 2001). It is not the objective of this study to examine the entire range of these impacts associated with the pig "life cycle", or potential indirect benefits of intensive pig production, instead the focus is on the direct impacts on the environment of the pig production stage of the chain.

The scope of the direct linkages between pig production and the environment cover a wide range of issues (Figure 2.2). The most important of these issues concern the water and air pollutions risk of pig production (Pellini and Morris, 2001), although other environmental issues need to be recognised, including soil quality, water use, biodiversity and landscape.

Figure 2.2. Linkages between pig production and the environment



Source: OECD Secretariat.

The environmental pollution risks associated with pig production mainly arise because 60-80% of their nitrogen and phosphate intake through feed is excreted in the form of solid, liquid and gaseous waste. A sow producing

22 pigs for slaughter at 90 kg liveweight can excrete around 100 kg of nitrogen (N) and 18-20 kg of phosphorus (P_2O_5) per year (Lara *et al.*, 2001).

On mixed farms with joint management of confined animal manure and plant nutrient needs, animal manure can provide a valuable nutrient source for crop and pasture growth and, in some cases, even eliminate the use of inorganic fertilisers (Gollehon *et al.*, 2001). The environmental risks of pig manure disposal have increased, however, in regions where pig production units have grown fewer, larger, and more specialised. Disposal of pig manure is usually driven by lowering disposal costs rather than optimising the nutrient needs of crops and pasture, leading to detrimental environmental costs. Because pig manure is a low density nutrient fertiliser source, and costly to transport over long distances compared to inorganic fertilisers, areas with high intensity pig production usually have a surplus of nutrient manure. This has led to an increase in residual pig manure in the environment in these areas, where they can degrade water and air quality and impose human health and environmental pollution costs on society.

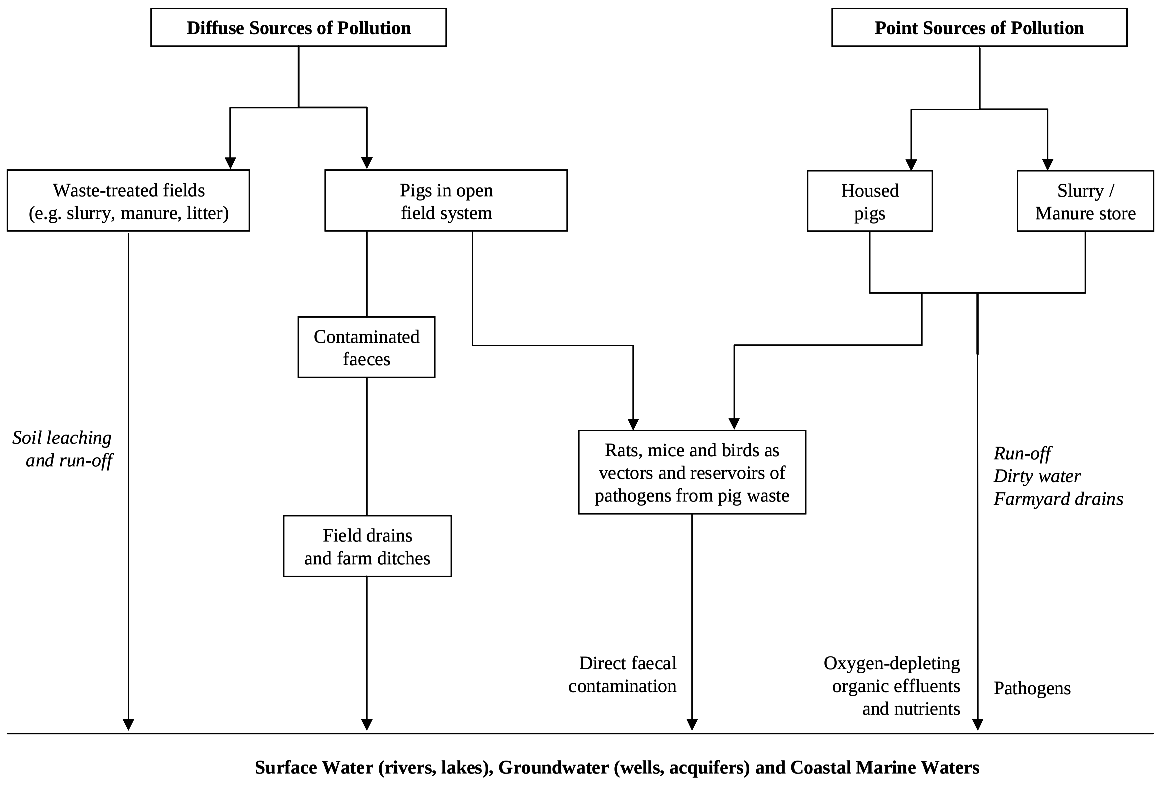
Water pollution

The contamination of water bodies with pollutants from pig production can occur through a variety of pathways, from both point or diffuse (non-point) sources of pollution, and transported as nutrient particles into soil and water or as organic effluents in the form of faecal waste direct into waterways (Figure 2.3).

In pig farming areas the disposal of excess ***nutrients***, principally nitrogen and phosphorus, from pig manure are among the principal causes of pollution of surface water (rivers and lakes), groundwater, and marine waters. Excess nutrients can damage aquatic ecosystems, including coastal marine ecosystems, through eutrophication (*i.e.* algae growth and depletion of oxygen in water) and degrade their use for recreational purposes, such as fishing (OECD, 2001*a*). Nutrients in surface water and groundwater can also impair drinking water quality and increase purification costs, and in high enough concentrations lead to human health problems.

Nutrient pollution from pigs mainly occurs because producers do not take into account the environmental costs resulting from point sources of pollution, slurry/manure storage and pig housing units, and non-point pollution sources from spreading manure in fields. Pigs reared in open fields, depending on the stocking density and local conditions (*e.g.* soil, weather), are also a non-point source of pollution resulting from surface run-off and leaching of manure excreted in the field.

Figure 2.3. Pathways of water pollution from pig slurry/manure



Source: OECD Secretariat, adapted from Hooda *et al.* (2000).

In addition to nutrients, ***organic effluents*** usually contain a high proportion of solids, and can be transported into waterways direct from pig slurry or manure storage. Organic pollution of water causes rapid growth in micro-organisms resulting in a high ***biochemical*** oxygen demand (BOD), and as a result reduces the available oxygen to support aquatic life. Direct discharge of organic effluents is capable of causing fish kills or severe disruptions to aquatic ecosystems by increasing BOD levels (Hooda *et al.*, 2000). Pig slurry, compared to other forms of waste, has a very high BOD concentration (Table 2.1).

Table 2.1. Ranges of biochemical oxygen demand concentrations from various wastes

Waste Source	BOD Value (mg/l)
Silage effluents	30 000 – 80 000
Pig slurry	**20 000 – 30 000**
Cattle slurry	10 000 – 20 000
Liquid effluents draining from slurry stores	1 000 – 12 000
Treated domestic sewage	20 – 60
Clean river water	< 5

Source: MAFF (1998).

A third source of water pollution concerns ***pathogens*** in pig manure (*e.g.* bacterial, parasites, and medicines) which can also be transmitted in waterways (and the air) directly from faecal discharges and leaking slurry/manure stores, and from field application of pig manure. These pathogens can damage fish and shellfish in aquatic ecosystems, and cause human health problems, including to the health of pigs, through impairing drinking water quality (USEPA, 1999*a*). Little is currently known about the fate, transport and overall potential human health and environmental effects that may occur from complex mixtures of pathogens released from pig and other livestock manure, although considerable research is now underway in this area (*e.g.* Kolpin *et al.*, 2002; ISU, 2002).

Given the many sources of nutrients from agriculture into water bodies (*e.g.* fertilisers from crop production and manure from livestock farming), there is little data available that identifies the specific contribution of pigs to water pollution. Given the prominence of the dairy, beef and poultry sectors in the livestock industry of many OECD countries, the pig sector is rarely the major source of pollution from the livestock sector. In the **United**

Kingdom, pig holdings contributed only 5% of total pollution incidents reported in 1998 (Williams and Bough, 2001).

As a first step, trends in the nitrogen content of pig manure production and the nitrogen soil surface balance can be used to reveal the "potential" risks to water quality from pig production. It is important to note that this is an indirect measure, as other factors, in particular soil types and precipitation levels, have an influence on the level of nitrogen leaching that actually occurs (Bechmann *et al.*, 1998).

The OECD nitrogen soil balance indicator measures the difference between the nitrogen available to an agricultural system (inputs, mainly from livestock manure and inorganic fertilisers) and the uptake of nitrogen by agriculture (outputs, largely crops and pasture), with a persistent surplus indicating potential environmental pollution of water (indicated by kilograms of nitrogen per hectare of agricultural land), as the volatilisation of ammonia from livestock is excluded from the balance (OECD, 2001*a*). While the baseline to assess the risk of nitrogen surplus can vary according to local conditions (*e.g.* soil types, climate), some studies suggest that above 50 kg nitrogen per hectare (kgN/ha) annually indicates a high risk of soil surface run-off or leaching of nitrate into water bodies (OECD, 2001*a*).

Using the information contained in the OECD nitrogen soil balance indicator, it is possible to identify four groups of countries in terms of the *level* of risk to water pollution from nitrogen in pig manure at the national level (Table 2.2 and Figure 2.4).

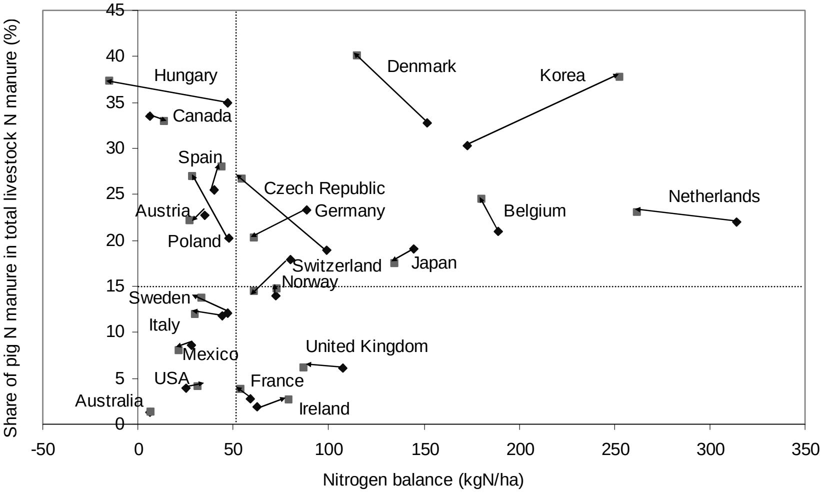
- First, there are countries where the risk is high as measured by the overall nitrogen balance (*i.e.* 50 kgN/ha or greater) and the importance of pig manure as a source of nitrogen (*i.e.* contributing 15% or more to the total livestock nitrogen manure production). These countries are in Europe (**Belgium**, **Czech Republic**, **Denmark**, **Germany**, the **Netherlands**, **Norway** and **Switzerland**) and Asia (**Japan** and **Korea**). These countries are located in the top right-hand quadrant of Figure 2.4.

- In **Ireland**, **France** and the **United Kingdom**, while the overall nitrogen balance is high, the contribution of nitrogen from pig manure is small.

- In **Austria**, **Canada**, **Hungary**, **Poland** and **Spain** the reverse is true, the overall nitrogen balance is low but the contribution of nitrogen from pig manure is high.

- In the final group, **Australia**, **Italy**, **Mexico**, **Sweden** and the **United States**, the risk of nitrogen pollution from pig production is low at the national level, with an overall nutrient balance below 50 kgN/ha and with pigs contributing less than 15% to total livestock nitrogen manure production. These countries are located in the bottom left-hand quadrant of Figure 2.4.

Figure 2.4. Risk to water pollution from nitrogen (N) in pig manure, 1985-87 and 1995-97[1]



Note:
1. Each point in the graph shows the combination of the overall nitrogen balance and the share of pig N manure in total livestock manure. The point at the tail of an arrow refers to 1985-87 and the point at the head of an arrow refers to 1995-97.
Source: OECD Nitrogen Soil Balance Indicator, www.oecd.org/agr/env/indicators.htm.

While this national level data can provide a good entry point for analysis and can be a reasonable indicator for small countries such as Denmark, Belgium and the Netherlands, it needs to be supplemented with regional information for larger countries because of the local nature of the problem. Using regional nitrogen balance information and data on the regional and distribution of pig production within countries (Chapter 3), it is evident that there are regions within some of the low-risk countries where the risk of water pollution from pig production is very high. In the EU, these include the regions of Brittany in **France**, Lower Saxony in **Germany**, Lombardia in **Italy** and Cataluña in **Spain** (Schleef and Kleinhanss, 1997). In the **United States**, a detailed study has shown that 68 counties (2.5% of total counties) have manure nitrogen production levels that exceed the assimilative capacity of all the county's crop and pasture land, with a number in the important pig producing state of North Carolina (Gollehon *et al.*, 2001).

Table 2.2. Pigmeat production and water pollution risk indicators, 1985-87 and 1995-97[1]

	Pigmeat production		Pig N manure		Nitrogen balance		Share of pig N manure in total livestock N manure	
	000 t		000 t		kgN/ha		%	
	1985-87	1995-97	1985-87	1995-97	1985-87	1995-97	1985-87	1995-97
Pigmeat production and pig N manure increasing								
Nitrogen balance increasing								
Share of pig N manure in total livestock N manure increasing								
Korea	446	867	62	118	173	253	30	38
Ireland	137	292	8	12	62	79	2	3
Norway	87	101	14	15	72	73	14	15
Spain	1 395	2 306	196	239	40	44	25	28
United States	6 487	7 743	364	432	25	32	4	4
Australia	277	347	33	33	7	7	1	1
Share of pig N manure in total livestock N manure decreasing								
Canada	1 154	1 413	351	416	6	14	34	33
Nitrogen balance decreasing								
Share of pig N manure in total livestock N manure increasing								
Denmark	1 125	1 503	91	108	152	115	33	40
Belgium	701	1 038	51	64	189	181	21	25
EU-15	14 358	16 173	1 228	1 229	68	59	15	15
France	1 603	2 180	45	57	59	54	3	4
Sweden	310	319	17	19	47	34	12	14
Pigmeat production increasing but pig N manure decreasing								
Nitrogen balance decreasing								
Share of pig N manure in total livestock N manure increasing								
Italy	1 095	1 323	84	74	44	30	12	12
Poland	1 648	1 965	177	162	48	29	20	27
Hungary	596	611	87	49	47	-15	35	37
Share of pig N manure in total livestock N manure decreasing								
United Kingdom	998	1 039	63	61	107	87	6	6
Germany	3 237	3 467	405	262	88	61	23	20
Austria	469	538	40	36	35	27	23	22
Pigmeat production and pig N manure decreasing								
Nitrogen balance decreasing								
Share of pig N manure in total livestock N manure increasing								
Netherlands	1 753	1 729	149	147	314	262	22	23
Czech Republic	579	471	49	45	99	54	19	27
Share of pig N manure in total livestock N manure decreasing								
Japan	1 555	1 290	153	134	145	135	19	18
Switzerland	283	234	24	17	80	61	18	14
Mexico	1 056	924	272	232	28	22	9	8

Note:
1. Countries are listed within each grouping according to their 1995-97 nitrogen balances.
Source: OECD Nitrogen Soil Balance Indicator, www.oecd.org/agr/env/indicators.htm.

Changes in the OECD nitrogen soil balance indicator between 1985-87 and 1995-97 reveal different *trends* in the potential risk to water pollution from nitrogen in pig manure. Again, four groupings of OECD countries can be identified.

- The risk has increased in **Ireland**, **Korea**, **Spain** and the **United States**, as measured by an increase in both the nitrogen balance and the contribution of pigs to total livestock nitrogen manure production between the two periods. In **Canada**, while the contribution of pigs to livestock nitrogen manure has fallen marginally, the overall nitrogen balance has increased. In all five countries there has been a significant increase in pigmeat production and in the quantity of pig nitrogen manure. These trends indicate that the expansion of pig production in these five countries is exerting a growing risk to the environment in terms of the potential release of nitrates from pig farming into water bodies.

- In **Austria**, **Germany**, **Japan**, **Mexico** and **Switzerland** the risk has decreased. Both the nitrogen balance and the contribution of pig nitrogen manure have decreased. In Japan, Mexico and Switzerland, a reduction in the level of pigmeat production and in the quantity of pig nitrogen manure have contributed to this decline in national risk. Austria and Germany have been able to expand production while reducing the quantity of nitrogen manure produced. Overall, it can be concluded that for this group of countries the risk of nitrogen water pollution from pig production has decreased, although it continues to remain a significant source in some.

- For another group of countries, **Belgium**, the **Czech Republic**, **Denmark**, **France**, **Hungary**, **Italy**, the **Netherlands**, **Poland**, **Sweden** and the **United Kingdom**, the nitrogen balance has fallen but the contribution of pigs to livestock nitrogen production has increased. It is difficult to conclude the net overall effect, but the importance of pigs as a potential source of nitrogen pollution may well have increased in some instances and remains a significant source in others.

- Finally, in **Australia** and **Norway**, there has not been a noticeable change in the level of risk between the two periods, although the level of risk varies greatly between these two countries. In both countries this has been achieved with an increase in pigmeat production.

With the shift toward fewer but larger pig farms the production of recoverable manure nutrients is exceeding the assimilative capacity of the cropland and pasture on these farms. Further, as pig production has become more spatially concentrated the quantity of manure from farms in these regions is exceeding the assimilative capacity of surrounding farmland to absorb pig manure nutrients at agronomic rates (Chapter 3).

This is an important issue in certain countries of the **European Union**, for example, the **Netherlands**, where many pig farms have insufficient land to meet the requirements of the EU Nitrates Directive (Gago da Câmara *et al.*, 1999). This is also becoming a problem in parts of **Canada** and the **United States** were the geographic concentration of pig production has occurred more rapidly than in most other OECD countries (Coote and Gregorich, 2000; Gollehon *et al.,* 2001; Kellogg *et al.*, 2000).

In view of the lack of economic and environmental incentives to dispose of the manure to internalise external environmental costs, large-scale pig operations are disposing of manure at above assimilative capacity and heightening the risks associated with nutrient water and air pollution. As the recoverable manure nutrients from these pig operations increases there is a growing challenge for producers, researchers and policy makers in terms of how to transport the manure off-farm at an economically feasible cost and/or use the manure for other purposes than as a fertiliser (*e.g.* biogas).

Changes in production practices (*e.g.* the use of open slurry/manure storage lagoons) are also raising the risks of environmental pollution. For concentrated pig operations with more and larger animal manure storage sites, especially lagoons, the environmental risks of a catastrophic leak, such as from flooding or hurricanes, have risen (Wing *et al.,* 2002). Over recent years the **United States** has experienced a number of major lagoon spills or leaks (USEPA, 1999*a*).

Air pollution

Pig production can lead to air pollution and cause harm to the environment and human health in several ways (Figure 2.2). The major airborne emissions from pig farming concern ammonia, which can lead to soil acidification, and greenhouse gases (methane and nitrous oxide), affecting climate change. Also important to those working in pig housing and living in the local vicinity of pig production units, are airborne dust and micro-organisms and unpleasant odours (ISU, 2002).

Ammonia (NH_3) is abundant in pig manure, and is released into the air from pig housing, stored manure and the land application of manure (Sommer and Hutchings, 2001). Pigs are potentially a significant source of ammonia pollution, although estimates of ammonia emission rates can vary according to livestock type, housing conditions, the season, and other factors (Table 2.3).

Usually ammonia tends to be deposited in the area surrounding the pig operation (up to several kilometres) and can be harmful to ecosystems through acidification (*i.e.* by acidifying soils and limiting plant growth) and eutrophication of the environment with prolonged exposure to ammonia. But the distance travelled by ammonia emissions will depend on the concentration of pigs and prevailing weather conditions (*e.g.* wind, rain) in a particular region. Within the confines of the pig housing unit, concentrations of ammonia can also reach levels that are toxic to those working in them and the pigs.

Table 2.3. Mean ammonia (NH_3) emission rates per type of animal

Animal	Emission rate of NH_3	
	mg/hour/ animal	mg/hour/ 500 kg liveweight
Poultry (laying hens, broilers)	2 – 39	602 – 10 892
Pigs (sow, weaner, finisher)	**22 –1 298**	**649 – 3 751**
Cattle (dairy cows, beef calves)	80 – 2 001	315 – 1 798

Source: OECD Secretariat, adapted from Hartung, 1999.

The main ***greenhouse gases*** (GHG), contributing to the process of climate change and global warming, from pigs mainly involve methane (CH_4) and nitrous oxide (N_2O). Methane emissions are derived from the digestive processes in pigs (although this is a more important process in ruminants) and decomposition of manure, while nitrous oxide is largely emitted from stored manure. Carbon dioxide, another GHG, also results from pig production through heating or mechanical ventilation of pig housing, but emissions are usually in small quantities compared to CH_4 and N_2O.

Pig housing units generate ***dust and micro-organisms***, of particular concern to those working in these units and people living in the vicinity of pig farms. However, as with pathogens released into water from pig manure little is known about the fate and transport of dust and micro-organisms into the environment from pig housing. ***Odours*** are an important environmental nuisance to those living close to pig production units, although hydrogen sulphide (an odour-causing compound) is known to lead to human health problems in high enough concentrations (USEPA, 1999*a*).

Concerning the emission of air pollutants from pig production, similar trends to those identified for nitrogen manure pollution can be observed for some OECD countries (Annex Figures 1-6). The data on air emissions from pig production, however, are incomplete (for methane) or missing (for ammonia) for many OECD countries. From the information that is available agricultural ***ammonia*** emissions contribute about 90% to total ammonia emissions from all sources. Livestock ammonia emissions account for over 80% of agricultural emissions. The share of pigs in total livestock ammonia emissions varies across OECD countries according to the relative importance of the pig sector in national livestock production, although the shares broadly reflect those of pigs in total livestock nitrogen manure. In the case of ***methane***, the pig sector's contribution to total agricultural greenhouse gas emissions is much lower compared with ammonia, less than 5% for most OECD countries.

Soil quality

Damage to ***soil quality*** from pig production can occur from heavy metals present in manure, in particular copper and zinc, which are added to concentrate feeds and cadmium, a pollutant resulting from the inclusion of phosphate in feed. Only 5-15% of metal additives are absorbed by pigs, the rest is excreted. Soils on which pig manure is applied can accumulate heavy metals impairing soil functions and contaminating crops, leading to possible human health impacts (Haan *et al.*, 1998). The uptake by crops of pathogens released from pig manure are also of concern to the environment and human health, but as observed above this is still an area requiring further research (USEPA, 1999*a*).

Water use

Vertically integrated pig production processing operations can impose a considerable demand on water resources, requiring in excess of 700 litres per pig to slaughter and process. In those cases where the water demand from large-scale pig operations can lower water table levels, this can affect aquifers and wells used for drinking water, and impact on aquatic ecosystems by reducing water supplies (Manitoba Commissioner, 1999). Even so, it is possible that water use for irrigation to grow the feed for confined pig operations has a greater impact on water levels than water for processing.

Biodiversity

The relationship between pig production and biodiversity can be summarised in terms of its links at the genetic, species and ecosystem levels (Figure 2.2). The utilisation of the ***genetic stock*** of pig breeds, domesticated (native and exotic breeds) and wild variants, is essential in maintaining pig production. The pig industry requires genetic variants and improvements in order to: upgrade the productivity of commercial lines of pigs; develop breeds less susceptible to disease and health problems; respond to changes in consumer demands for pigmeat products (*e.g.* leaner pigmeat cuts); and meet environmental demands, such as developing pig breeds that can lower pollutant emission levels per kilogram of pigmeat produced.

Table 2.4. Risk status for farm pig breeds in OECD countries

	Critical Breeds[1]			Endangered Breeds[2]		
	Total	Critical	Conservation[3]	Total	Endangered	Conservation[3]
Canada	1	1	..	2	2	..
Czech Republic	..	..	..	4	4	..
Denmark	2	..	2	1	1	..
France	6	4	2	18	14	4
Germany	6	6	..	4	4	..
Hungary	2	2	..	2	1	1
Ireland	1	1	..	1	1	..
Italy	3	3	..	4	3	1
Japan	1	1	..	..	..	..
Mexico	1	1	..	..	..	..
New Zealand	..	..	..	1	1	..
Norway	..	..	..	2	2	..
Poland	2	..	2	2	..	2
Portugal	1	1	..	..	..	..
Spain	5	2	3	5	3	2
Sweden	..	..	..	3	2	1
Switzerland	..	..	..	1	..	1
United Kingdom	1	1	..	10	4	6
United States	4	4	..	3	3	..
EU-15	25	18	7	46	32	14
World[4]	58	47	11	106	84	22

Notes:

1. A breed is categorized as critical if the total number of breeding females is less than or equal to 100 or the total number of breeding males is less than or equal to 5; or if the overall population size is less than or equal to 120 and decreasing and the percentage of females being bred to males of the same breed is below 80%.

2. A breed is categorized as endangered if the total number of breeding females is greater than 100 and less than or equal to 1 000 or the total number of breeding males is less than or equal to 20 and greater than 5; or if the overall population size is greater than 80 and less than 100 and decreasing and the percentage of females being bred to males of the same breed is above 80%; or if the overall population size is greater than 1 000 and less than or equal to 1200 and decreasing and the percentage of females being bred to males of the same breed is below 80%.

3. This category identifies populations for which active conservation programmes are in place or those that are maintained by commercial companies or research institutes.

4. In 1999, the total recorded number of farm pig breeds was 649, of which 151 are extinct, the risk status of 111 is unknown and 223 are not at risk, leaving 164 breeds either classified as critical or endangered.

Source: Scherf (2000).

Given the cost of maintaining rare and endangered pig breeds, a key challenge is to maintain the minimum number of genotypes for optimal future genetic improvement (Haan *et al.*, 1998). Techniques of genetic engineering and cloning hold the potential to meet this challenge, with the birth of the first cloned piglets in 2000. However, concerns have been raised about the implications for animal welfare and possible risks to the environment of genetically modified pigs escaping into the wild (Turner, 2002) and the potential risk to pig genetic diversity (Wetterich, 2001).

There are numerous domesticated and wild pig breeds (*Sus scrofa),* and recent trends reveal that many OECD countries are reducing their susceptibility to disease risks by diversifying the number of pig breeds used in production (OECD, 2001*a*). In **Poland**, for example, there has been an increase in the number of breeds that make up the national pig herd through importing landraces and national pig breeding programmes (Liro *et al.,* 2001).

Information on genetic erosion or loss is incomplete, but for some countries losses or endangerment of loss of farm pig breeds has been significant over recent decade. Globally there are 650 recorded farm pig breeds, of which 150 breeds have become extinct over the past 100 years (Scherf, 2000). Of the existing pig breeds, about one-third is at risk of being lost, with the risk status of over 20% unknown. Knowledge on the genetic erosion of wild pig breeds is incomplete.

OECD countries account for around 20% of the world total of farm pig breeds considered at risk of being lost. Nearly one-third of the OECD pig breeds under the risk status are part of active conservation programmes to maintain these breeds (Table 2.4). The **European Union** accounts for over 70% of the OECD pig breeds included within the risk of loss status, with nearly 30% of the EU pig breeds at risk included under national and EU conservation programmes (Ollivier *et al.,* 2001).

Linkages between pigs and ***wild species diversity*** concern a range of issues. Wild species, either terrestrial or aquatic, can be affected by water and air pollution from piggeries. Also, indirectly, wild species can be impacted through the production of feed for the pig industry, although the extent of this impact will depend on the farm management practices and systems used to produce feed crops. It is difficult to isolate the specific impacts on wild species from pig production relative to the overall impact of the crop and livestock sectors on ecosystems.

Populations of ***wild (feral) pigs*** have become established in some OECD countries, mainly as a result of pigs escaping from farms. Feral pigs have been of greatest concern in countries such as **Australia, New Zealand** and the **United States**, where the pig was introduced relatively recently as an exotic species. In sufficient numbers, feral pigs can cause damage to natural ecosystems by destroying habitats around watercourses and by feeding on ground nesting birds and small mammals (Choquenot *et al.,* 1996). In **Australia**, feral pigs have adversely affected a number of listed threatened species (Hill, 2001). Feral pigs can also become a serious agricultural pest by consuming and damaging crops and young livestock, and posing a health threat to animals by carrying diseases such as foot and mouth. Up to 40% of new-born lambs in some regions of **Australia** have been killed by feral pigs, costing the sheep industry millions of dollars annually (Environment Australia, 2001).

The association of pig production with the maintenance of ***ecosystem diversity***, has a long history in **Europe** (Gade, 1998). Pannage, the pasturing of pigs on mast (acorns and nuts) on the forest floor, still exists in a few places in Europe. In south-west **Spain** the natural cork oak ecosystem, la Dehesa, supports the black and red Iberian pig (*Cerdo Iberico*), source of dried Serrano ham. With the decline in this valued ecosystem (mainly because of the disappearance of transhumance, loss of importance as a source of firewood, etc), the present conservation of the remaining area of Dehesa is possible due to the maintenance of the Iberian pig for its dried cured ham and vice versa (Lopez-Bote, 1998). The pig's productive cycle has become adapted to the annual acorn harvest from cork oaks, although only 40% of the total Iberian pig population are exclusively fed on acorns, the remainder also receiving concentrate feed supplements to their diet. At present the Iberian pigs accounts for less than 10% of the total Spanish pig herd. Pigs are also used to harvest for black truffles (edible fungi) in the natural oak woods of Perigord, **France** (Hall, 1993).

Scale of environmental impacts

The distance or scale over which pig production impacts the environment varies greatly, from the local, regional, national, to the global scale (Table 2.5). For example, odour and dust emissions from pig operations are a public nuisance and health problem at the local level, while the greenhouse gases produced by pigs are a global concern related to climate change.

Health and social concerns associated with pig production

There is evidence of harm to human health from exposure to pig air emissions and odours, mainly for those working in housed pig units and the public living near these operations. For those working in housed pig production, research indicates they have a higher incidence of human health problems relative to other pig producers (Hurley *et al.*, 1996). At least 25% of workers in these pig units in the **United States** are reported to have current respiratory health problems, linked to increased cumulative exposure due to some workers spending as much as 70 hours per week in these buildings (ISU, 2002). There are also public health concerns for those living close to these pig operations (Marks, 2001). A US study concluded that air emissions from large-scale pig operations constitute a public health hazard and that precautions should be taken to minimise exposure to hydrogen sulphide, ammonia and odours (ISU, 2002).

Table 2.5. The scale of environment impacts resulting from pig production

Environmental issue	Human health impact	Pig health impact	Impact on environment	Scale of environmental impact :				
				Local	Sub-national	National	Cross-border	Global
Water pollution								
- Nitrate	Drinking water (Nitrate, Phosphate, Pathogens)	no	Eutrophication (Nitrate, Phosphate)	yes	yes	low	yes	no
- Phosphate		no		yes	yes	low	yes	no
- Pathogens		Infections	?	yes ?	yes ?	?	?	?
Air pollution								
- Ammonia	Irritant	Irritant	Acidification	high	moderate	low-moderate	low-moderate	low ?
- Methane	no	no	Climate change (Methane, Nitrous oxide)	yes	yes	yes	yes	yes
- Nitrous oxide	no	no		yes	yes	yes	yes	yes
- Odour	Nuisance	no	low	yes	no	no	no	no
- Dust	Allergy ?	Infections	low	yes	low	no	no	no
Soil pollution								
- Heavy metals	moderate	moderate	Crop growth	yes	yes	low	no	no
Water use	no	no	Water table levels	yes	yes	low	no	no
Biodiversity								
- Genetic erosion of rare pig breeds	no	Loss of genetic diversity	no	yes	yes	yes	yes	yes
- Invasive pigs	no	Infections	Ecosystem + agricultural damage	yes	yes	yes	no	no
- Ecosystem service from pasture pigs	no	no	Maintain certain ecosystems	yes	yes	low	no	no

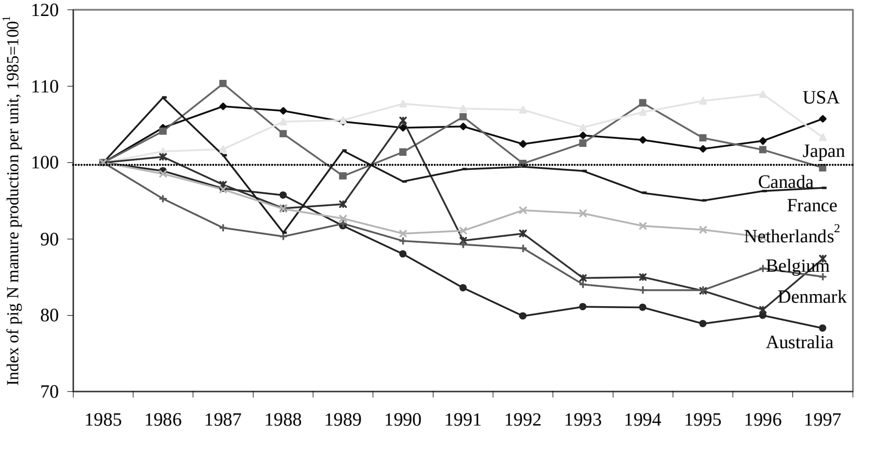
Source: OECD Secretariat, adapted from Wathes and Hurtung (2001).

A number of other important socio-economic issues have developed with the emergence of large-scale pig production operations, such as animal welfare concerns, the impact on residential property values for those in the vicinity of these operations, and declines in community social capital. Although the social impacts of pig production on society are not the focus of this paper, there are nevertheless important linkages between the environmental impacts of pig production and the social consequences. Among social issues considered of greatest importance include the impacts of pig operations on: property values in the vicinity of these plants; local tourism; and impacts on landscape quality (ISU, 2002).

Decoupling of environmental impacts from production

For a large number of countries, particularly in the **European Union**, increases in pig production have become more "decoupled" from the output of nitrogen manure, ammonia and methane emissions. The term "decoupling" refers to breaking the link between environmental pollution and economic growth. In the context of agriculture it can be measured in terms of the relative growth rates of an environmental pressure (*e.g.* pig nitrogen manure, ammonia and methane emissions) and an economically relevant variable (*e.g.* pigmeat production) to which it is causally linked (OECD, 2002*b*).

Figure 2.5. Pig nitrogen (N) manure production per unit of output in selected countries, 1985-1997



Notes:

1. Each point represents the level of pig N manure produced per tonne of pigmeat, with 1985=100.
2. Data for 1997 are not included for the Netherlands because a large drop in pigmeat production due to a pig cholera epidemic caused a significant increase in the indicator.

Source: OECD Nitrogen Soil Balance Indicator, www.oecd.org/agr/env/indicators.htm.

As discussed earlier, for some countries reductions in the volume of nitrogen manure production have been achieved while at the same time the volume of pigmeat production has increased. Reductions in the quantity of nitrogen manure produced per unit of pigmeat production are observed in a number of countries (Figure 2.5). Trends in pigmeat production relative to pig methane output (there are no time series data on ammonia emissions from pigs) also indicates that for some countries pig production is also becoming decoupled from methane emissions (Annex Figures 1-6). This would suggest that producers are improving their environmental efficiency by lowering pollutant emissions per unit volume of pigmeat produced. Some caution is required in interpreting these trends, especially because of data deficiencies and the relatively short time period over which these observations have been made.

The research literature does provide some evidence that many pig producers are improving their environmental performance through applying the technologies and husbandry practices and systems described in Chapter 3. Another factor that may be influencing "decoupling" is the improvements in productivity of pig production *i.e.* as the coefficient factors to calculate nitrogen manure production from pigs are based on live animals, with productivity improvements this implies less nitrogen emissions per unit volume of meat produced.

Chapter 3

DEVELOPMENTS IN THE STRUCTURE, TECHNOLOGY AND MANAGEMENT PRACTICES OF PIG PRODUCTION

Pig farming is becoming more intensive (fewer farms producing a larger number of pigs), more specialised (producing pigs with feed obtained from off-farm sources) and often associated with very little land. Developments in production technologies have allowed significant productivity gains, particularly for large-scale producers. Production is becoming more regionally concentrated, with growth in non-traditional regions of pig production. Technologies and management techniques have been developed to reduce the environmental impacts of production. Some of these are also economically beneficial to producers, while others require significant financial investment or increase variable costs. Pollution averting technologies in particular are not considered to be scale neutral. While different types and scales of production have potentially different effects on the environment, little evidence is available to judge between systems.

The principal public and policy concerns associated with pig production and the environment are largely attributable to the expanding scale and concentration of production. Over the past 20 years a predictable pattern of negative environmental externalities and public discontent has accompanied the concentration of the pig industry in OECD countries. This Chapter considers in more detail some of the key driving forces influencing the impact of pig production on the environment. It examines changes in the structure of pig production, and developments in technologies and management practices that reduce environmental impacts.

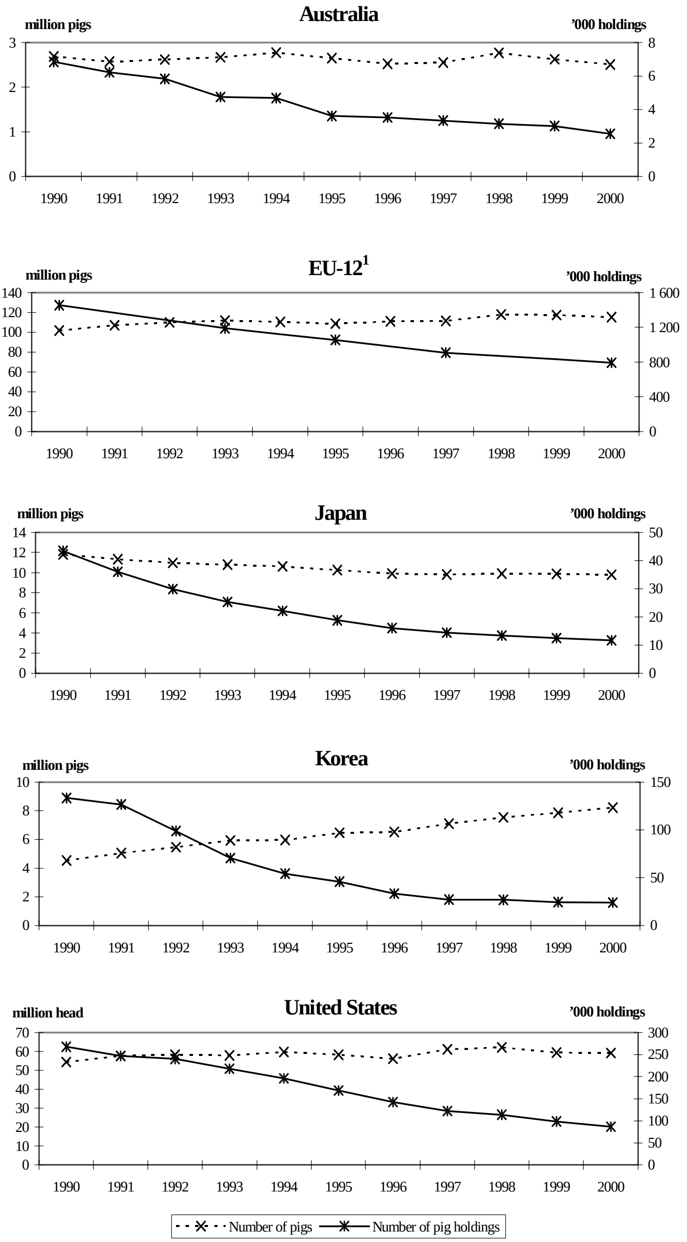
Intensification of pig production

Production intensity is reflected in the size of farms and the size distribution of farm holdings. The intensity of production and environmental concerns are closely related. Farm households in different farm size classes organise their production methods, financing and marketing arrangements in different ways. Consequently, predominance of small- to medium-sized farms would have different environmental implications than predominance of large farms, both of which might not be homogeneous across regions. For example, larger pig operations create larger local concentrations of pig manure, increasing the potential for adverse effects on local water quality. Some environmental accidents have pointed to the potential risks of intensive animal production. For example, the problem of leakage from large waste lagoons attracted public attention when millions of litres of manure overflowed in North Carolina, **United States**, in the aftermath of Hurricane Floyd in 1999. But larger pig operations can use technology more cost-effectively and may have a larger incentive and capacity to deal with environmental problems.

Similar trends in pig numbers, number of pig farms and pigs per farm can be found throughout the OECD (Figures 3.1 and 3.2.). In the **European Union**, the number of pigs in the EU-12 increased from 102 million in 1990 to 115 million in 2000, an annual increase of 1%. Over the same period, the number of pig farm holdings declined at an annual rate of 5%, leading to a doubling in the average number of pigs per holding. In the **United States**, the number of pig operations has steadily declined, with production shifting to a relatively small number of very large farms. During the period 1990-2000, the US pig herd grew by 1% per annum but the number of pig farms decreased by 7% per year. Consequently, the average number of pigs per farm was three times as large in 2000. In **Japan**, the number of pig-raising farms has declined at an average annual rate of 7% over the 1990-2000 period, from 43 400 in 1990 to less than 12 000 in 2000. While the number of pigs raised in Japan has also decreased, this decline has been at a much slower rate, leading to a 21% annual increase in the average numbers of pigs per farm. In **Korea**, pig numbers increased at an annual rate of 8% between 1990 and 2000. With an 8% annual decrease in the number of pig holdings, the average herd size was almost ten times higher in 2000. While pig numbers declined slightly in **Australia**, the number of pig holdings fell by 6% per year during the period 1990-2000, leading to a 16% annual increase in the average herd size.

In general, pig raising is less dependent on farm-produced fodder than cattle or sheep production, and is increasingly conducted using area independent methods and bought-in feedstuffs. This potentially increases the environmental risks of pig production by reducing farmers' options for manure disposal. This problem is most acute in the **Netherlands,** where over 50 pigs are kept per hectare of utilised agricultural land (UAA) in pig farming, followed by **Belgium** (Figure 3.3). In all cases, the number of pigs per hectare of UAA in pig farming has increased between 1990 and 1997.

Figure 3.1. Number of pigs and pig holdings in selected countries, 1990-2000

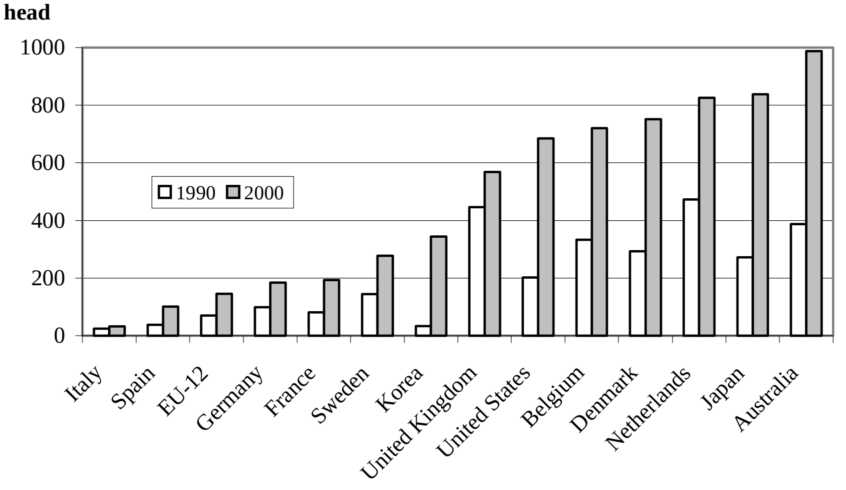


Note:

1. EU-12 is the EU-15 less Austria, Finland and Sweden.

Sources: ABARE (2003), APC (2002), EUROSTAT, MAFF (various), Arai (2001), NACF (2002), NASS (various).

Figure 3.2. Average number of pigs per holding in selected countries, 1990 and 2000[1,2]

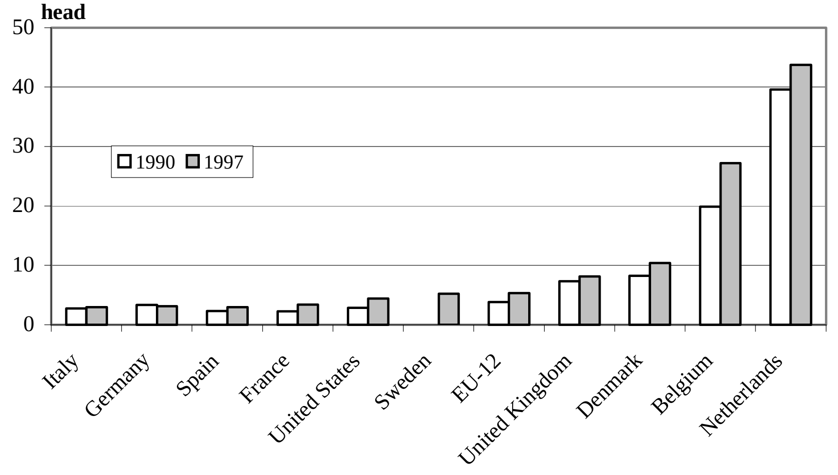


Notes:

1. For Italy, France, Spain, Sweden and the United Kingdom year 1997 data are used rather than 2000.
2. National averages can hide significant regional variations in the average number of pigs per holding, refer Table 3.4.

Sources: ABARE (2003), APC (2002), EUROSTAT, MAFF (various), Arai (2001), NACF (2002), NASS (various).

Figure 3.3. Average number of pigs per ha UAA in pig farming in selected countries, 1990 and 1997



Sources: EUROSTAT, NASS (various).

In the **United States**, from a side-line activity on corn and soybean farms, pig farming has moved to become a larger, more capital-intensive and specialised operation. In 1990, 4% of pig holdings had more than 1 000 pigs and by the year 2000 this share had increased to 16% (Table 3.1). In 1990, 60% of all pigs were raised on farms with less than 1 000 animals (Table 3.2). By 2000, 85% of all pigs are produced on farms with more than 1 000 head, with over 50% of pigs raised on very large farms (farms with more than 5 000 animals). In **Mexico**, in the mid-1990s, 99% of pig farms had fewer than 20 animals. But these small operations accounted for only 52% of the country's swine inventory. Larger operations, accounting for only 1% of pig farms, held the remaining 48% of Mexico's pigs (Southard, 1999).

In 2000, the proportion of pig holdings in the **European Union** with more than 1 000 pigs was 4% but these accounted for almost 60% of the pig population (Tables 3.1 and 3.2). In general, the development within the different herd size classes shows an increase in the number of holdings and animals in the larger herd classes, and a significant decrease in the farms with less than 100 pigs (Annex Tables 3 and 4). In **Denmark**, for example, in 1990 there were just over 2 000 farms with more then 1 000 pigs, accounting for 6% of pig farms and 37% of the total pig herd. By 2000, there were over 4 000 farms with more than 1 000 pigs, accounting for one-quarter of pig farms and almost three-quarters of the total herd. In **Greece**, **Italy** and **Portugal**, less than 1% of holdings have more than 1 000 pigs but these few farms account for over half the total pig population.

Similar increases have occurred in the scale of pig production in **Japan** and **Korea.** In Japan, in the late 1990s, the number of pig farms increased only in the very large farms category (those with more than 2 000 head of pigs). Although the share of this class in the total number of pig-fattening farms was 7%, its share in the number of pigs is 46% (Arai, 2001). In Korea, the rise in the number of large holdings has been most significant during the last half of the 1990s.

Developments in production, breeding and management techniques have resulted in scale economies and have enabled considerable increases in productivity, particularly for larger operations which serves as a motive for increasing the scale of production. Production technologies have led to a mechanised method of pig production, involving sheltering the animals in buildings where feeding, watering, climate control and waste disposal are largely carried out by automated equipment. Improved farming techniques, improvements in management practices and advances in genetics have resulted in significant productivity gains in terms of increased weight, decreasing feed requirements and the number of pigs farrowed per sow per year. Improvements in production technology have also made it possible to move the industry toward off-farm feed preparation, with feed produced at large centralised mills replacing feed from small, on-farm feed mills.

Table 3.1. Share of pig holdings with more than 1 000 pigs in selected countries[1]

% of pig holdings

Country	1990	1993	1995	1997	2000
EU12	1	2	2	3	4
Belgium	8	14	18	21	26
Denmark	6	12	16	20	26
France	2	4	5	6	8
Germany	1	1	1	2	3
Greece	0.5	0.2	0.4	0.5	0.6
Ireland	11	15	15	18	18
Italy	1	1	1	1	1
Netherlands	13	17	21	24	28
Portugal	0.1	0.3	0.3	0.3	0.4
Spain	1	1	1	3	3
United Kingdom	13	14	18	16	17
Japan	5	12	13	19	24
Korea	0.3	1	2	6	10
United States	4	6	7	11	16

Note:
1. Annex Table 3 contains a more detailed breakdown of the share of pig holdings by farm size.
Sources: EUROSTAT, MAFF (various), NASS (various).

Table 3.2. Share of pig population on holdings with more than 1 000 pigs in selected countries[1]

% of pig population

Country	1990	1993	1995	1997	2000
EU12	41	48	51	56	59
Belgium	42	51	56	60	66
Denmark	37	54	61	66	74
France	35	48	55	61	65
Germany	25	22	23	26	34
Greece	54	34	56	55	59
Ireland	85	87	86	89	94
Italy	66	69	65	71	79
Netherlands	48	54	61	66	70
Portugal	35	46	48	49	57
Spain	41	50	52	59	68
United Kingdom	70	74	51	78	81
Korea	23	26	26	49	60
United States	41	51	62	75	85

Note:
1. Annex Table 4 contains a more detailed breakdown of the share of pig population by farm size.
Sources: EUROSTAT, MAFF (various) NACF (2002), NASS (various).

The interaction of technological advances, production efficiency and farm size is reflected in an increase in the quantity of pigmeat produced per sow per year (*i.e.* litters per sow and pigs weaned per litter) measured on a carcass weight basis.[1] Over the 1980-98 period, **Denmark** and the **United States**, and to a lesser extent **Canada**, achieved tremendous productivity growth in pigmeat produced per sow (Table 3.3). The **Netherlands**' productivity declined in 1997 due to the pig cholera epidemic.

Table 3.3. Pigmeat produced per sow per year in selected countries, 1980-98

Kilograms, carcass weight

Year	United States	Canada	Mexico	Denmark	Netherlands
1980	781	979	910	1 006	1 163
1985	967	1 114	920	1 070	1 011
1990	1 017	1 141	978	1 318	1 114
1995	1 147	1 224	1 097	1 554	1 082
1996	1 134	1 263	1 065	1 540	1 104
1997	1 162	1 270	1 074	1 570	920
1998	1 197	1 329	1 056	1 619	1 013
Change 1980-1998	53%	36%	16%	61%	-13%

Source: OECD Secretariat, adapted from Buhr (1999).

Innovations in production have lowered average costs for firms operating at higher levels of output. In the **United States**, large specialized farms have total costs of production per unit that are much lower than smaller farms. It is estimated that in 1992 average production costs per pig varied from USD 0.80 kg on very large farms to USD 2 kg on very small farms (Onal *et al.*, 2000). In 1999, larger pig operations (those having 5 000 head or more) averaged 9 pigs per litter farrowed, while operations with an inventory of 500 to 999 head averaged 8.3 pigs per litter and operations with fewer than 100 head averaged only 7.6 pigs per litter (Plain, 2000).

Regional concentration of pig production

Together with the change in farm size, structural changes in the pig sector have also a regional dimension. Regional changes in production, followed by complementary processing investments, are driven by the ability of the emergent region to capture economies of scale in farm production. The transition toward specialisation and vertical co-ordination in the pig production industry has led to conditions that favour increases in the size and geographic concentration of pig feeding operations. But the proliferation of large operations, particularly those concentrated in certain geographic areas has raised public concerns about the environmental effects of pig production.

In the **European Union**, pig production is largely concentrated in the northern countries, which account for almost two-thirds of the total EU pig production. For example, in the **Netherlands**, pig production has developed as an increasingly more specialised activity. The development is attributable to a number of factors, including low cost feed supply through the port of Rotterdam, an adequate infrastructure with large-scale compound feed producers and modern slaughterhouses. Producers also have easy access to expert health care, professional extension advice and specialised education.

But regional concentration also occurs within EU countries (Table 3.4). For example, certain regions account for more than 20% of the respective country's total pig population in parts of **France** (Bretagne), **Italy** (Lombardia, Emilia Romagna), **Germany** (Niedersachsen, Nordrhein-Westfalen), **Spain** (Cataluña). The relatively small size of utilised agricultural area by pig farms as compared to other livestock farms together with the high density of livestock population are a major determinant of the high levels of nitrogen surpluses at such holdings (Brouwer, *et al.,* 1999). Again, proximity to feed sources has been a factor in this regional development. For example, in Italy, the historical concentration of pigs in the northern regions of Lombardia and Emilia Romagna is due to the relatively low cost of feed inputs derived from the dairy processing sector, in particular cheese production.

In the **United States**, the pig industry has grown most rapidly in areas that had not earlier produced many pigs, particularly the Southeast and to a lesser extent the West and Southwest. As feed is the main cost factor in raising pigs, the industry was traditionally concentrated in areas that were major feed grain producing regions. For example, the historical dominance of the Midwest region in the United States was based on the availability of relatively cheap feedstuffs produced on farm. The growth in pig production in grain deficit regions, however, indicates that close proximity to feed sources might no longer be a necessity as efficiency gains can be realised through improved managerial and production techniques (Plain, 2000). Large, environmentally controlled facilities, which spread costs over a larger number of animals and improve production efficiency, give producers in emerging areas distinct cost advantages (Key and McBride, 2001; Martinez, 1999).

Table 3.4. Regional pig farm structural characteristics in selected countries, 1990, 1995 and 1997

	1990			1995			1997		
	Share of pigs	Share of holdings	Pigs per holding	Share of pigs	Share of holdings	Pigs per holding	Share of pigs	Share of holdings	Pigs per holding
	%	%	head	%	%	head	%	%	head
France	**100**	**100**	**82**	**100**	**100**	**157**	**100**	**100**	**193**
Bretagne	54	15	304	57	14	635	58	14	786
Pays-de-la-Loire	8	7	95	10	7	215	10	7	271
Midi-Pyrénées	5	15	28	4	16	43	4	15	50
Nord-Pas-de-Calais	6	4	130	4	3	213	4	3	261
Aquitaine	4	13	25	4	13	46	4	14	49
Germany	**100**	**100**	**98**	**100**	**100**	**118**	**100**	**100**	**131**
Niedersachsen	26	17	151	28	16	204	29	16	233
Nordrhein-Westfalen	21	13	159	23	13	207	24	14	227
Bayern	13	31	42	15	32	55	15	31	61
Baden-Württemberg	8	18	45	9	17	63	9	17	71
Schleswig-Holstein	5	2	241	5	2	318	5	2	346
Italy	**100**	**100**	**24**	**100**	**100**	**29**	**100**	**100**	**33**
Lombardia	34	4	187	37	3	316	37	4	334
Emilia Romagna	23	3	171	21	3	214	21	2	306
Piemonte	9	3	86	9	2	168	10	1	232
Veneto	7	6	26	7	6	35	7	6	37
Friuli-Venezia Giulia	2	2	29	3	2	41	4	1	103
Spain	**100**	**100**	**38**	**100**	**100**	**61**	**100**	**100**	**102**
Cataluña	32	4	275	35	5	416	36	6	575
Aragón	13	3	141	14	2	369	15	3	494
Castilla y León	15	19	31	14	18	47	14	16	93
Andalucía	9	7	45	8	7	71	9	7	122
Murcia	6	1	187	5	1	375	6	1	548
United States	**100**	**100**	**203**	**100**	**100**	**346**	**100**	**100**	**501**
Iowa	25	13	394	23	15	540	24	15	811
North Carolina	5	4	280	14	4	1367	16	4	2133
Illinois	10	6	373	8	6	500	8	6	627
Indiana	8	5	338	7	5	444	6	5	608
Missouri	5	6	175	6	5	418	6	5	645
Ohio	3	5	132	3	5	212	3	6	250

Sources: EUROSTAT, NASS (various).

The increase in pig production in the Southeast is due in part to the decline in the tobacco industry (Martinez, 1999). Growth in some other non-traditional producing regions is due to the fact that these regions have a lower population density and less rainfall and are therefore less sensitive to some of the problems related to pig production such as odour control and manure handling. The shift in production to western states, primarily Colorado, Oklahoma and Texas, resulted in part from savings in transportation costs as production is closer to the economically important Asian export markets. In addition, western states offer a relatively disease-free environment for raising animals (Sullivan *et al.*, 2000). Tax incentives, more flexible labour laws and improvements in transportation infrastructure have been other factors stimulating industry relocation. Box 7.1 in Chapter 7 examines the influence of environmental regulations on producer location decisions.

Evidence in the **United States** also shows that growth in the emergent regions occurs mainly in the very large farms category, providing them with cost advantage over most producers in the traditional region who still operate on a relatively small scale (Onal *et al.*, 2000). The percentage of pigs raised on operations with inventories greater than 1 000 head increased from 41% of the US pig population in 1990 to 76% in 1997. In North Carolina, nearly 98% of pigs resided on these large farms in 1997, compared with 63% in Iowa, the leading pig-producing State.

Regional shifts towards non-traditional areas are also occurring in **Mexico**. Pig production is increasingly moving to Tampaulipas, Nuevo Leon, Quintaro Roo and Hidalgo, primarily because disease control has been improved enough in these areas to allow exportable pigmeat production (Southard, 1999). But it has also increased in some more traditional areas, particularly those with close access to the **United States**, such as Sonara and Yucatan. Concentration and intensification in these states has brought about significant environmental challenges, including huge increases in the levels of localised air, water and soil pollution. In Yucatan, there are estimated to be more than 490 000 pigs, which generate about 29 000 cubic metres of waste water and 166 tonnes of organic waste per day. Yucatan's water table has been absorbing much of these wastes as a direct consequence of the Peninsula's inadequate treatment systems and a lack of knowledge concerning the linkages between production and environment degradation.

Technologies to reduce the environmental impacts

There are many technological options which can contribute to the mitigation of pollution from pig production. Indirectly, this might be achieved through improvements in the productivity of pig production, leading to more efficient use of inputs by lowering feed usage, energy and water needs, and reducing water and air pollutants per unit of product (Bos and de Wit, 1996). Other technologies have the potential to directly reduce environmental pollution from pig farming, and principally concern pig housing and odour, manure storage facilities and manure treatment, with some recent attempts to develop genetically modified pigs capable of reducing pollutant loadings.

Pollutant emissions from *pig housing*, mainly gas emissions (ammonia, methane, nitrous oxide and hydrogen sulphide associated with odours) can be reduced through changes in the building's ventilation and hygiene, and manure management. There are numerous different systems to lower gas emissions from pig housing, but these essentially involve changes to the: design of the floor areas (*e.g.* fully slatted, reduce pit areas); different floor covering methods (*e.g.* straw, deep litter); and temperature and ventilation control in the housing. Improved ventilation systems can also provide benefits in reducing dust and odours important to workers in piggeries and local people living close to these operations. Results from the **Netherlands** show considerable variation in gas emissions from different housing systems, although calculation of these emission factors remains difficult and can vary for the same housing system (Table 3.5).

Table 3.5. Air emission levels for fattening pigs in various housing systems in the Netherlands

Kilograms per pig place per year

Housing System	Ammonia (NH_3)	Methane (CH_4)	Nitrous Oxide (N_2O)
"Traditional" fully slatted floors	3.0	2.8-4.5	0.02-0.15
"Traditional" 50% slatted floors	2.3-2.7	4.2	0.02
"Traditional" fully or partly slatted floors without straw	2.2-2.4	1.5-3.0	0.15-0.31
Various low emission systems[1]	1.6-2.1	0.9-1.1	0.05-3.73

Note:
1. Low emission systems include a variety of methods, for example, manure flushing, scraping and cooling.
Source: OECD Secretariat, adapted from Hartung (2001) and Monteny (2001).

While there are a range of different *manure storage systems*, for most OECD countries manure is separated from pigs by slatted floors or open channels, and the slurry stored as a liquid in storage tanks (Bos and de Wit, 1996). Lagoon storage systems are commonly used in **Canada** and the **United States**, involving the use of water to transport manure to treatment lagoons, with the water often recycled as flush water or used for irrigation on fields. While lagoons are cheaper as storage systems than storage tanks they require larger areas and are less efficient in reducing air pollution. Covering tanks or lagoons can also lead to a large reduction in air pollutants but are costly to install (Table 3.6). The Intergovernmental Panel on Climate Change (IPCC) currently has guidelines on methane and nitrous oxide emission factors for nine different types of manure management systems (IPPC, 2000).

Developments have also been made to improve the *treatment of manure*, including the use of aeration, anaerobic biodigestors, and solid separation and composting, with new methods such as thermal treatments, use of chemical additives and membrane processes. However, while promising technologies generate solids only limited viable markets have been identified and established for the end products due to the economic feasibility of the technology (Williams, 2001).

Table 3.6. Air emission efficiency and cost of different pig slurry/manure storage systems

Pig Slurry/ Manure Storage System	Ammonia Emission in % of Nitrogen Excretion	Cost (€ per m^3)
Open lagoons	25	0
Open storage tank	15	0
Straw cover	3	0.2
Swimming vinyl cover	2.3	0.6
Closed cover (*e.g.* concrete, plastic)	1.5	0.8-1.3

Source: OECD Secretariat, adapted from Gronauer and Schattner (2001).

Of growing interest as a technological solution to reduce pollution from pig waste is to store liquid pig manure in an anaerobic digester with the objective of producing methane for energy (biogas) and converting waste to chemicals and raw materials for manufacturing (Gronauer and Schattner, 2001). Extraction of methane gas for energy can also be achieved from covered lagoons. These technologies are already used in some larger scale pig units as a source of energy for heating and ventilation (Haan *et al.*, 1998). Converting pig waste to biogas and other recoverable materials brings a number of environmental benefits through reducing water and air pollution loadings and odour problems, and replacing non-renewable energy sources.

At present the widespread adoption of technologies to recycle pig waste for energy and other materials is relatively low, mainly because the price of petroleum based energy and raw material products remain more competitive (Bos and de Wit, 1996). Even so, with concerns related to climate change and fossil fuel consumption, governments and researchers are increasingly focusing on the possibilities to develop the use of technologies that can provide renewable energy and bio-based raw materials.

A more recent solution to reducing pig pollution is through the *genetic modification* of pigs to lower their emission of nutrients. Research in **Canada**, has revealed the possibility of developing a genetically modified pig, through altering bacterial genes, capable of producing 75% less phosphate in their manure than non-transgenic pigs (Golovan *et al.*, 2001). Nevertheless, there are concerns that manipulation of bacterial genes in animals destined for human consumption raises concerns over food safety (Turner, 2002).

The optimum combination of technologies to reduce the environmental impacts from pig production have complex relations with other producer and societal objectives, including pig health and economic performance, farm worker and public health, and animal welfare. Also a specific technological approach is unlikely to solve all pollution problems, and instead a combination of approaches, each selected for a particular application, is likely to be more effective (Phillips *et al.*, 1999). Further, while these technologies offer the potential to reduce the environmental impacts of pig production, the additional costs of installing some of these systems usually brings little gain in improving pig performance (van t'Klooster, 2001).

Management practices to reduce the environmental impacts

The feeding practices, manure spreading management and farming systems used in rearing pigs have important implications for the environmental outcomes from pig production. Use and uptake of these farm management practices and systems in pig farming are closely linked to the adoption of the various technologies outlined in the previous Chapter.

Changes in *pig feed composition* or increased *feed conversion efficiency* can lead to a reduction in nutrient excretions per unit of production. Fattening pigs use only about 30-35% of ingested dietary nitrogen and phosphate but there are various ways in which changing the dietary intake of pigs can lower nutrient output, such as using feeds with high nutrient digestibility, feeding low protein diets (to reduce ammonia emissions), and using enzymes to increase digestibility of nutrients. In the **Netherlands**, the excretion of phosphorus per fattening pig has been reduced by more than 50% over the last 20 years as a result of changing pig feeding practices (Jongbloed *et al.*, 1997).

While changing dietary composition and improving feed conversion efficiency can reduce the nutrient output per unit of production, it may not lead to the total output of nutrients being reduced. This is because improving the productivity of pigs also involves increasing the number of pigs produced per sow, and increasing the feeding requirements of the parent stock to raise productivity (Dourmad *et al.*, 1999). Moreover, these dietary manipulations aimed at reducing nutrient excretions from pigs can be costly, although technical improvements are lowering the costs of these feeding strategies (van der Peet-Scwering *et al.,* 1999; and Yap *et al.*, 2001).

The choice of management practice to *spread pig slurry/manure* on fields can considerably alter ammonia emission levels and nutrient soil surface run-off and leaching. Depending on the timing, methods, climate, soil conditions, crop uptake and other factors, ammonia emissions as a percent of the nitrogen applied in manure can vary on arable land from 0-40% for the more efficient soil injection method, to 20-100% for broadcast spreading, although timing is critical in minimising ammonia emissions (Monteney, 2001; and Sommer and Hutchings, 2001). As with many other technologies and practices to reduce environmental pollution from pigs, the more efficient (soil injection) method of manure application in fields is the most costly practice. Experiments on the use of territorial information systems to minimise the excess application on manure are also being trialled.

Comparing the efficiency of different *pig farming systems* in controlling environmental pollution is complex**.** This is because of the large array of pig production systems across OECD countries, ranging from indoor to outdoor systems, small to large fully integrated production/processing operations, extensive to intensive units, through to organic rearing of pigs. Also while one particular system might be highly efficient in producing pigmeat in terms of economic cost it might be poorer in attaining high standards in terms of human health, animal welfare and environmental objectives or vice versa.

There is little information on this issue, especially for pigs reared in large operations. The performance of nutrient emissions can also vary considerably between farms using the same pig husbandry practices (Backus *et al.*, 1998). Research in the **Netherlands**, shows considerable differences in nutrient emissions between the best and worst 25% of pig farms (Table 3.7), with similar variation reported in **Denmark** (Fernandez *et al.*, 1999) and **France** (Dourmad *et al.,* 1999).

As the pig sector becomes more industrialised, reliance on farm stewardship and voluntary/business led approaches is considered by some researchers unlikely to yield a sufficient level of investment in technologies and farming practices/systems aimed at lowering the environmental costs associated with pig production. A large share of the costs associated with the adoption of these technologies, practices and systems is the capital investment cost, with no immediate reward to offset these costs, except avoidance of fines/charges if regulations are enforced. The distribution of costs and benefits of environmental technology adoption can also vary, for example, a feed manufacturer may have little incentive to reduce phosphorus in pig feeds as they bear no responsibility for manure management (Norris and Thurow, 1999).

Table 3.7. Nutrient excretion per finishing pig on Dutch farms, 1995

Kg Nutrient Excretion/Pig/Annum	25% Best	25% Worst	Average
Phosphorus (P_2O_5)	3.9	6.4	5.0
Nitrogen (N)	11.7	14.4	13.1

Source: Backus *et al.,* 1998.

Pollution-averting technologies in the livestock sector are not considered to be scale neutral. Economies of scale imply per unit production costs decline as animal numbers increase, until external environmental costs begin to rise and per unit costs rise accordingly. In this situation, some researchers consider that if large-scale land-intensive pig operations were regulated so as to take into account (internalise) their environmental costs, then land-extensive mixed farms integrating crop and pig production would have significant cost advantages. Others argue that these large operations can take advantage of "state of the art" technologies in controlling pollution, which smaller producers are unable to afford or manage (Norris and Thurow, 1999).

At present there is little empirical work to validate the competing claims between the relative efficiency, in economic and environmental terms, of different pig rearing systems and scales of production. The policy issue which arises from this debate is how the polluter-pays-principle can be implemented, so that all pig producers, regardless of their scale or system of production, are encouraged to account for the full external costs resulting from environmental pollution, and what are the cost and benefit implications for the various alternative policies that could be implemented.

NOTE

1. The amount of pigmeat produced per sow per year is an important indicator of efficiency as it is a relatively consistent measure in contrast to cost values which can be skewed greatly by definitions and types of operations which vary across regions. It concisely incorporates litter sizes, conception rates and yields of live animals since production is measured on a carcass weight basis.

Chapter 4

AGRICULTURAL SUPPORT POLICIES FOR OECD PIG PRODUCERS

Support levels for pigmeat are low compared to other commodities but there are significant differences between countries. Policies providing Market Price Support (e.g. tariffs and export subsidies) are the main form of support provided to pig producers, which explains the large annual variations in the level of support. Pig producers have benefited from reforms in the cereal sector, particularly in the European Union but also in the United States and Canada. Those countries with the highest levels of support for pigmeat are also the countries with the highest risk to water pollution from pig production. The link between changes in support levels and environment risk is much more difficult to discern.

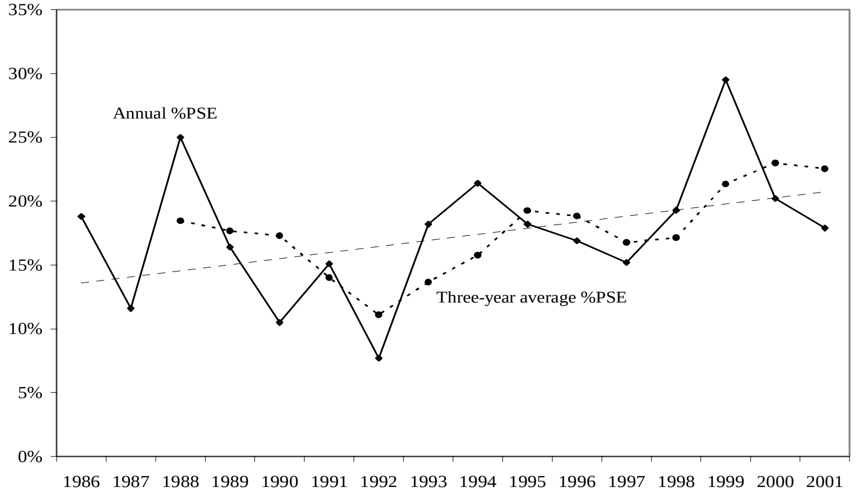
Over recent years there have been considerable developments in both agricultural support and environmental policies. Multilateral, regional and bilateral trade agreements, and unilateral decisions to reform support policies have impacted on the level and composition of support provided to producers. At the same time, the number and strength of policies to address environmental issues in agricultural has increased in response to growing public concern. The purpose of this Chapter is to review developments in agricultural support to pig producers. Environmental policy measures that affect pig producers in OECD countries will be discussed in Chapter 6.

The level of support at the OECD level

Every year the OECD calculates the level of support provided to producers through agricultural policy measures: the Producer Support Estimate (PSE).[1] The %PSE expresses the monetary value of support as a share of gross farm receipts.[2] A notable feature of the %PSE for pigmeat, calculated at the total OECD level, is the large annual variation from a low of 8% in 1992 and a high of 30% in 1999 (Figure 4.1). Around these annual variations there has been an upward trend in support since 1992.

Figure 4.1. OECD average Producer Support Estimate for pigmeat, 1986-2001

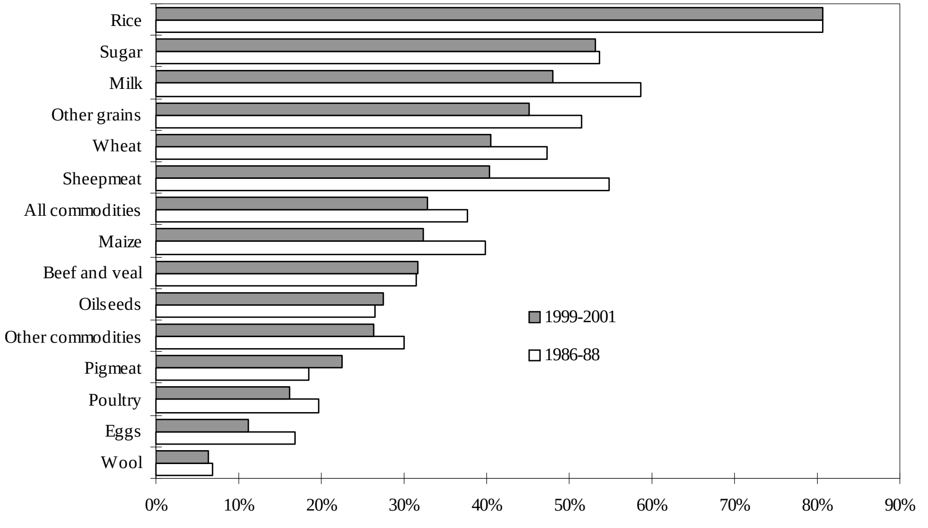
% of value of gross farm receipts



Source: OECD, PSE/CSE database, 2003, see Annex Table 5 for more details.

Figure 4.2. Producer Support Estimate by commodity, 1986-88 and 1999-2001

OECD average as % of value of gross farm receipts



Source: OECD, PSE/CSE database, 2003.

Expressing support as a share of gross farm receipts allows comparison to be made between the level of support provided to pigmeat relative to other commodities (Figure 4.2). The increase in the %PSE for pigmeat between 1986-88 and 1999-2001 is against the trend in support levels observed for almost all other agricultural commodities. While support for pigmeat is lower than that provided to most other agricultural commodities, the average %PSE has decreased between these periods for all commodities except oilseeds, beef and veal, and pigmeat. Moreover, of these commodities the increase in the %PSE for pigmeat has been the most significant, both in absolute and percentage terms.

Comparison of support levels between OECD countries

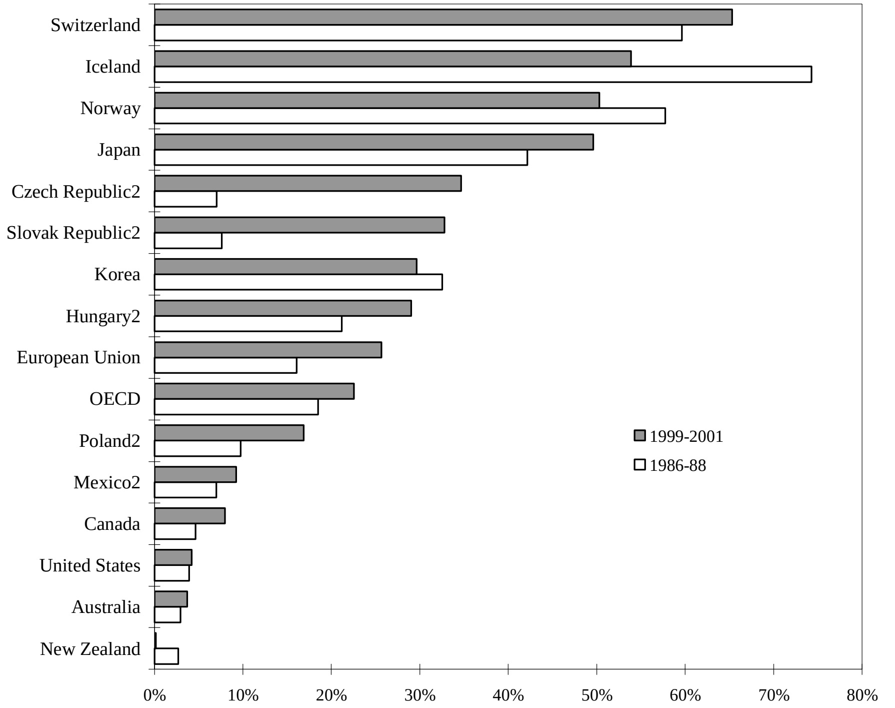
Within the total OECD PSE there are significant variations between countries in the level of support provided to pig producers (Figure 4.3). Support levels in 1999-2001 were highest in western Europe and Asia, particularly in **Iceland**, **Japan**, **Norway** and **Switzerland** where over 40% of gross farm receipts to pig producers are generated by support policies. On the other hand, support has been very low throughout the whole period in **Australia**, **Canada**, **Mexico, New Zealand** and the **United States**.

Between 1986-88 and 1999-2001 there has been a reduction in the level of support provided to pig producers in **Iceland, Korea, New Zealand** and **Norway**. In all other OECD countries, support to pigmeat has increased between the two periods, with some significant increases in European countries. The %PSE for pigmeat is generally lower than for most other commodities in all countries.

The level of support can also be expressed on a product weight basis (Annex Table 6).[3] On average, transfers from consumers and taxpayer to pig producers in **Iceland**, **Japan**, **Norway** and **Switzerland** amounted to over USD 1.40 kg in the period 1999-2001, while producers in **Australia** and the **United States** received less than USD 0.05 kg and these in New Zealand virtually nothing. Pig producers in the **European Union** received on average USD 0.32 kg during the same period. Converting these prices into a "pig equivalent", assuming that a market ready pig weighs 100 kg, support to pig farmers in **Japan**, the **European Union** and the **United States** was equivalent to USD 160, USD 32 and USD 5 per pig respectively.

Figure 4.3. Pigmeat Producer Support Estimate by country, 1986-88 and 1999-2001[1]

% of value of gross farm receipts



Notes:
1. Countries are ranked according to 1999-2001 levels.
2. For the Czech Republic, Hungary, Mexico, Poland and the Slovak Republic, 1991-93 replaces 1986-88.
Source: OECD, PSE/CSE database, 2003, see Annex Table 6 for more details.

Composition of support policies

In addition to the level of support, the way in which support is provided is also important, particularly when understanding the effects of support policies on factors such as production, trade, farm income and the environment.[4] A study in the crop sector found that *Market Price Support* (*e.g.* tariffs, administered prices, export subsidies etc.), *payments based on output* (*e.g.* deficiency payments etc.) and *payments based on input use* (*e.g.* fertiliser subsidies, interest concessions etc.) are more production- and trade-distorting, and less efficient at increasing farm household income than payments based on area (OECD, 2001*b*).

The impacts of agricultural support measures on the environment are more complicated to evaluate and largely depend on the distortions they introduce into farm-level decision-making. In general, the more a measure is linked to an output or an input (*i.e.* those classified as *Market Price Support*, *payments based on output* and *payments based on input use* in the PSE), the higher is the pressure on the environment through effects on the scale and location of production, input usage and structure. For example, output-linked support creates a greater incentive to increase production of specific agricultural commodities. Adverse environmental impacts occur in so far as farmers make more intensive use of environmentally harmful inputs or the use of environmentally sensitive land. Agricultural policies that increase livestock production also imply an increase in the volume of manure. Constraints on providing support (*e.g.* through production quotas or environmental cross-compliance) and restrictions imposed by regulations may help to reduce the environmental impacts of support measures. By lowering those forms of support most closely linked to outputs or inputs, and shifting to direct payments and other less production linked ways of providing support, policy reforms have in many cases generated a double benefit. They have resulted in a more efficient allocation of resources, and have reduced environmental damage and enhanced the provision of certain positive environmental services.[5]

While there is some variation between countries in terms of the composition of support provided to pig producers, the most distortive categories of support dominate (Table 4.1).[6] *Market Price Support* is the most dominant support category in all OECD countries except **Australia**, **Canada**, **New Zealand** and the **United States**, where it is not provided. *Payments based on input use* is the next most important category of support, with every OECD country calculated to be providing support measures to pig farmers that are classified in this category. *Payments based on output* are relatively important in **Canada** and **Hungary**; *payments based on animal numbers* in **Norway** and the **Slovak Republic**; *and payments based on historical entitlements* in **Switzerland**.

Since 1986-88, there have been changes in the composition of support in most countries. On the positive side, there has been a reduction in some of the most distorting categories of support. *Market Price Support* measures have been removed in **Australia** and **New Zealand**, and have lowered in importance in **Iceland**, **Korea**, **Norway** and **Switzerland**, in some cases by a significant extent. There has been a decrease in the importance in gross farm receipts of *payments based on output* in **Canada**, **Iceland** and **Norway**. There has also been a decrease in the importance of measures classified under *payments based on input use* in **Canada**, the **European Union**, **Japan**, **Mexico**, **New Zealand**, **Poland**, **Switzerland** and the **United States**, although the extent of the reduction has varied considerably.

Table 4.1. Composition of pigmeat PSE by country, 1986-88 and 1999-2001

Share of producer support categories of gross farm receipts

Share of gross farm receipts[2]		Australia	Canada	Czech Republic[1]	EU15	Hungary[1]	Iceland	Japan	Korea	Mexico[1]	New Zealand	Norway	Poland[1]	Slovak Republic[1]	Switzerland	United States	OECD
Producer Support Estimate	1986-88	2.9%	4.5%	6.3%	16.3%	21.2%	74.9%	41.9%	33.0%	7.0%	2.8%	57.9%	9.5%	7.7%	59.7%	3.9%	18.5%
	1999-01	3.7%	7.6%	34.9%	24.8%	28.6%	54.1%	49.6%	30.5%	8.8%	0.2%	50.6%	17.9%	32.5%	65.2%	4.2%	22.1%
Market Price Support[3]	1986-88	0.1%	-4.8%	5.0%	13.6%	17.5%	65.8%	40.3%	32.6%	0.6%	1.6%	47.0%	6.8%	-6.0%	50.1%	-0.6%	14.2%
	1999-01	-	-	30.7%	21.9%	19.7%	50.9%	48.2%	27.9%	5.5%	-	37.9%	15.9%	20.8%	41.2%	-	18.3%
Payments based on output	1986-88	-	3.5%	-	-	-	7.1%	-	-	-	-	3.1%	-	-	-	-	0.5%
	1999-01	-	3.2%	-	-	2.3%	0.4%	-	-	-	-	2.1%	-	0.3%	-	-	0.2%
Payments based on input use	1986-88	2.3%	5.8%	1.6%	2.4%	3.3%	2.0%	1.6%	0.4%	6.4%	1.1%	4.3%	2.7%	2.9%	7.1%	4.0%	0.2%
	1999-01	3.1%	1.5%	2.4%	2.2%	5.5%	2.8%	1.3%	1.2%	2.9%	0.2%	6.6%	1.9%	5.9%	3.4%	3.2%	0.4%
Payments based on animal numbers	1986-88	-	0.04%	-	0.3%	0.4%	-	-	-	0.02%	-	5.9%	-	7.3%	0.5%	-	0.1%
	1999-01	-	-	-	0.5%	1.1%	-	-	0.1%	0.1%	-	2.9%	-	5.4%	3.4%	-	0.4%
Payments based on historical entitlements[4]	1986-88	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.0%
	1999-01	-	0.02%	1.8%	0.2%	-	-	-	-	-	-	-	-	-	14.8%	-	2.4%
Payments based on input constraints	1986-88	-	-	0.1%	0.1%	-	-	-		-	-	0.7%	0.01%	-	-	-	0.04%
	1999-01	-	-	-	0.4%	0.1%	-	-	0.6%	-	-	0.6%	0.01%	-	-	0.1%	0.2%
Payments based on overall farm income	1986-88	0.5%		-0.4%	-	-	-	-	0.03%	-	0.1%	-	-	3.1%	-	0.6%	0.5%
	1999-01	0.5%	2.7%	0.1%	-	-	-	-	0.7%	0.3%	-	0.4%	-	0.2%	-	1.0%	0.4%
Miscellaneous payments	1986-88	-	0.1%	-	-	-	-	-	-	-	-	-	0.1%	0.3%	2.0%	-	0.1%
	1999-01	-	0.2%	-	-0.3%	-	-	-	-	0.01%	-	-	0.1%	-	2.5%	-	-0.1%

(For Notes, see following page)

Notes to Table 4.1:

1. For the Czech Republic, Hungary, Mexico, Poland and the Slovak Republic, 1986-88 is replaced by 1991-93.
2. A percentage figure indicates that support policies classified under that PSE category were in place. A percentage figure in 1986-88 but not in 1999-01 indicates that there are no longer support policies classified in that PSE category. A percentage figure in 1999-2001 but not in 1986-88 indicates that there is now support policies classified in that PSE category whereas none existed in 1986-88.
3. A negative percentage figure indicates that producers were being "taxed" by the policy measures within that PSE category. It should be noted that moving from a negative percentage to no support, for example in the case of Market Price Support in Canada and the United States, leads to an increase in the Producer Support Estimate.
4. Payments based on historical entitlements existed in Poland in the period 1986-88, which explains why there is a number at the OECD level but none at the individual country level.

Source: OECD PSE/CSE database, 2003, see Annex Tables 7 and 8 for more details.

At the same time there have been some attempts to introduce or increase support provided through less production-distorting measures and those more directly targeted at environmental or farm income objectives. For example, it is calculated that support measures classified under *payments based on historical entitlements* have been introduced to the benefit of pig producers in **Canada**, the **Czech Republic**, the **European Union** and **Switzerland**. Measures classified under p*ayments based on input constraints* have been introduced in **Hungary**, **Korea** and the **United States**, and have increased in importance in the **European Union**.

On the negative side, there have been increases in the most distorting forms of support in some OECD countries. While both the level and percentage change has been small in some instances, the importance of *payments based on inputs* in gross farm receipts has increased in **Australia**, the **Czech Republic**, **Hungary**, **Iceland**, **Korea**, **Norway** and the **Slovak Republic** between 1986-88 and 1999-2001. More importantly, the importance of *Market Price Support* measures in gross farm receipts has increased for pig producers in the **Czech Republic**, the **European Union**, **Hungary**, **Japan**, **Mexico, Poland** and the **Slovak Republic**. There has also been a move from a negative to a zero calculation of Market Price Support in **Canada** and the **United States**. The negative number in the base period represents the calculation of an excess feed cost for pig producers because of Market Price Support provided to cereal producers.

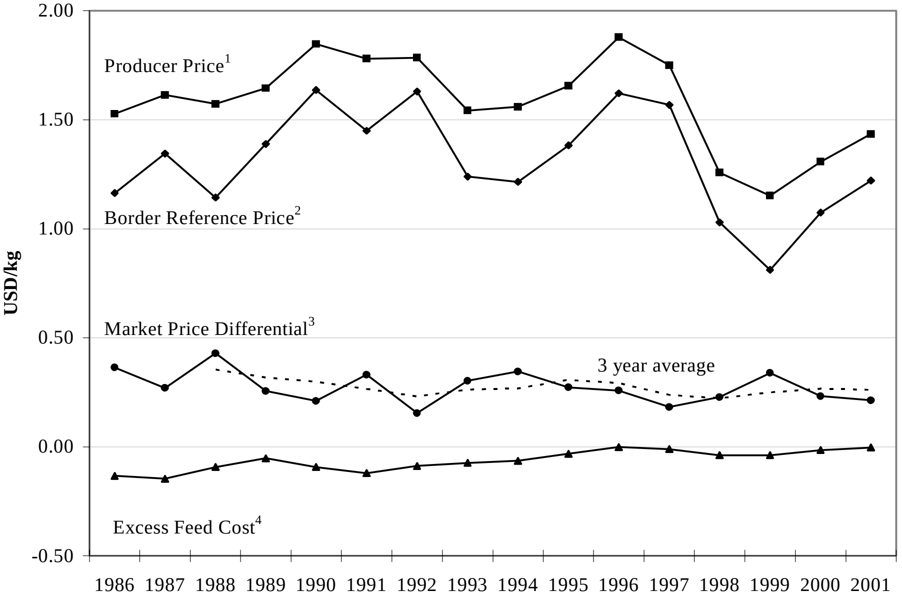
Developments in Market Price Support

Examining in closer detail the movement in *Market Price Support* highlights some interesting trends and provides the main explanation for changes in producer support, at both the OECD and individual country levels.[7] It is calculated by multiplying the level of production by the difference between the farm-gate price the producer receives and a border reference price (the market price differential). For livestock producers, including pig farmers, any extra costs that they pay because of Market Price Support provided to feed-grain producers (termed the "excess feed cost") is subtracted.

In nominal terms, the average OECD farm-gate producer price for pigmeat has followed a pattern very similar to that observed for most other commodities, *i.e.* increasing during the period 1986-1990 and generally decreasing since 1991, with significant fluctuations around this long term decline (Figure 4.4). Within this OECD average, there has been a notable decrease in producer prices in those countries with the highest level of support indicating a greater integration between pigmeat producer prices and world prices in OECD countries.[8] The average border reference price shows more variation than the average producer price but a similar downward trend.

Figure 4.4. Market Price Support for pigmeat, 1986-2001

Average OECD producer price, border reference price and excess feed cost per kilogram of pigmeat, USD kg



Notes:
1. Producer Market Price is the average price received by pig producers, measured at the farm gate.
2. Border Reference Price is the average reference price for pigmeat, calculated at the farm-gate level.
3. Market Price Differential is the Producer Market Price minus the Border Reference Price.
4. Excess Feed Cost is the extra money that pig producers pay for feed-grains because of Market Price Support to feed-grain producers, measured at the farm gate. It is subtracted when calculating the level of Market Price Support (hence a negative number in the figure).
Source: OECD, PSE/CSE database, 2003, see Annex Table 9 for more details.

Changes in the market price differential explain to a large extent the annual variations in the average OECD %PSE for pigmeat (Figure 4.1). Market Price Support policies are designed to protect producers from lower prices, insulating them from market changes and they have been effective in doing this. For example, in 1997, the average price received by OECD pig farmers was only 12% above the border price but by 1999 the difference had increased to 43% when the reduction in border prices was not matched by a similar reduction in producer prices.[9] The significant fall in prices in 1998 and 1999 was the result of a series of supply and demand shocks, including the Bovine Spongiform Encephalopathy (BSE) crisis and the outbreak of Classical Swine Fever (CSF) in parts of Europe (OECD, 1999). In 2000 and 2001, the average OECD producer price for pigmeat was around 20% above border reference price.

The downward trend in the market price differential has been mirrored by a reduction in the excess feed cost that pig farmers had to pay for their feed-grain inputs. At the OECD average level, this extra cost has decreased from USD 0.13 kg in 1986 to USD 0.01 kg in 2001. The reduction in the excess feed cost reflects the reforms that have occurred in the feed-grain markets in the **European Union**, **Canada** and the **United States** which have reduced the amount of Market Price Support provided to these commodities.

Summary of agricultural policy reform

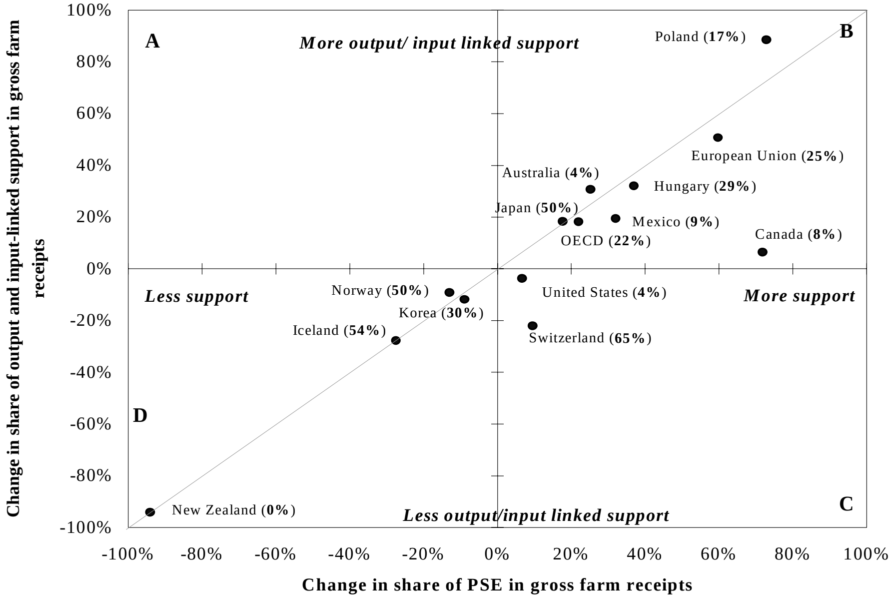
On the basis of the above analysis, a number of conclusions about agricultural support policy reform in the pig sector can be drawn (Figure 4.5). The reform progress has varied considerably between countries. Both the level of support and the importance of the most distorting forms of support in gross farm receipts have increased for pig producers in nine countries. The most dramatic increase has affected pig producers in the **Czech Republic**, the **European Union**, **Hungary**, **Poland**, and the **Slovak Republic**. Both variables also increased in **Australia**, **Canada**, **Japan** and **Mexico**. However, the increase in support provided to pig producers in Canada was less output- and input-linked than in the other three. More importantly, the level of support provided in Australia, Canada and Mexico is significantly lower than in Japan.

While support as measured by the %PSE has increased in **Switzerland**, the share of output- and input-linked support in gross farm receipts has fallen. This indicates that the increase in other PSE categories of support has been greater than the decrease in output- and input-linked support. A similar, but less dramatic change has occurred in the **United States**.

There has been a reduction in both the level of support and in the share of the output- and input-linked support in four countries. The percentage change in support has been most dramatic in **New Zealand** but the initial level of support was very low. The high support countries of **Iceland, Korea** and **Norway** have also made some progress.

Figure 4.5. Policy reform in the pigmeat sector by country, 1986-88 to 1999-2001[1,2]

Changes in %PSE and in the share of output- and input-linked support in gross farm receipts



Notes:
1. For the Czech Republic, Hungary, Mexico, Poland and the Slovak Republic, 1986-88 is replaced by 1991-93.
2. The Czech Republic and the Slovak Republic could not be included on the scale used for the graph but would appear in Quadrant B.

Source: OECD PSE/CSE database, 2003.

Impact of agricultural policy changes on the environment

The trend and pattern of support, in terms of both the level and composition, has influenced production patterns, including location, and charged the pressure on the environment. The countries which were identified in Chapter 2 as having the highest risk of nitrogen water pollution from pig production are also those with the highest level of support to pig producers *i.e.* a number of countries within the European **Union**, **Japan**, **Korea**, **Norway** and **Switzerland**. However, high support levels are not a necessary condition for environmental pressure. Negative environmental impacts of pig production at the local or regional level are also evident in countries with low levels of support, for example **Canada** and the **United States**. The significant regional differences in the intensity of production within the European Union, and hence in environmental pressure, also suggests that other factors play an important role.

It is more difficult to connect changes in support levels with changes in environmental pressure. First, support levels for pigmeat, as measured by the PSE, show large annual variations even though policy measures have not changed rapidly. This is because of the predominance of Market Price Support-based measures in the PSE and the volatility of world prices. Consequently, support increases when world prices decrease, and decreases when world prices increase, without any change in policy measure. Secondly, there may also be cases where the PSE for pigmeat does not fully take into account those incentives provided to producers through local tax concessions and other sub-national support measures. In **Canada** and the **United States**, for example, tax concessions and subsidies have been provided to pig producers in certain provinces/states that are not currently included in the OECD PSE estimates (Sierra Club, 1999). Finally, a number of other factors also influence production decisions including changes in support provided to other commodities, agri-environmental measures, and market induced changes. Changes in environmental pressure therefore need to be analysed on a case-by-case basis.

Since the early 1990s there has been a general decrease in producer prices for pigmeat, particularly in those countries with the highest level of support in response to increased import competition as tariffs fall or because of limits placed on export subsidies. Over the same time there has been a reduction in the risk to water pollution from pig production in some **European Union** countries (particularly in northern Europe), **Switzerland** and **Japan** as a result of a fall in production. At the same time, the risk of nitrogen water pollution has increased in the low support countries **United States** and **Canada** where production has increased dramatically. Such changes would be expected to result from trade liberalisation but other factors have influenced changes in the environmental risk, including the development of agri-environmental policies, particularly in northern Europe.

While tariffs have fallen in **Korea**, the risk to water pollution from pig production has increased dramatically. The large income growth in Korea during this period, fuelling domestic demand for meats, the increase in other payments to support pig farmers and the rapid expansion in exports, particularly to Japan, appear to have had a greater impact than the tariff reductions required under the World Trade Organization (WTO) Uruguay Round Agreement on

Agriculture (URAA). The increase in environmental risk in some EU member states such as **Spain** and **Ireland** may reflect a weaker implementation of environmental regulations, with production also encouraged by the lowering of cereal prices in the 1992 CAP reform increasing the competitiveness of producers located further away from large-scale port facilities.

The 1992 CAP reform in the **European Union** indicates the complexity of the link between changes in support policies and environmental impacts. The 1992 CAP reform reduced prices for feed grains, leading to an increase in support provided to pigmeat producers as calculated by the PSE methodology. Lower cereal prices changed the relative prices of inputs, which led to a lower protein content in compound feed. A lower protein content in turn reduces the nutrient content of animal manure, reducing the potential environmental damage (Brouwer *et al.*, 1999).

Agricultural support policies have also had an influence on production location decisions. For example, in the **European Union**, access to cheap imported feeds as compared to the price of feed-grains produced under the CAP played a significant role in encouraging the expansion of pig production in the Netherlands.

Changes to cereal support policies have also encouraged shifts in the location of production in North America. In the **United States**, the policy to lower prices for feed-grains contributed to the move in production away from the traditional grain producing states. In **Canada**, the removal of the Crow Rate grain transport subsidy in 1995 had two important effects. First, it created on incentive to shift pig production to the grain producing regions in the Prairies (Langley, 2001). Secondly, the reduction in support to Canadian pig producers caused a reduction in existing **United States** countervailing duties on imported Canadian pigs, making them more price competitive. These policy changes have contributed to the recent expansion in the Canadian pigmeat industry.

NOTES

1. The PSE is an indicator of the annual monetary value of gross transfers from consumers and taxpayers to agricultural producers (in this case specifically pig producers), measured at the farm-gate level, arising from policy measures that support agriculture, regardless of their nature, objectives or impacts on farm production or income.

2. Gross farm receipts is the sum of the gross value of transfers arising from support policies *i.e.* the PSE, plus the returns obtained from the market. A %PSE of 25% for example, means that the value of support is equivalent to 25% of the value of gross farm receipts; in other words, a quarter of gross farm receipts come from support policies.

3. Derived by dividing the PSE (in monetary terms) by the quantity of pigmeat produced.

4. For a detailed description of the various PSE categories and the methodology for classifying support measures consult *Methodology for the measurement of support and use in policy evaluation* at www.oecd.org/pdf/M00031000/M00031750.pdf.

5. See OECD (1995) and OECD (1998) for some examples of these relationships and benefits.

6. It should be noted that with the exception of *Market Price Support* and *payments based on output*, all the other payments in the PSE for pigmeat generally come from sector wide agricultural support policies (*i.e.* measures supporting all agricultural or livestock producers). If the actual level of support provided to specific commodities through these sector-wide measures is not available, the level of support is usually allocated between commodities on the basis of the value of production.

7. *Market Price Support* is defined as an indicator of the annual monetary value of gross transfers from consumers and taxpayers to agricultural producers arising from policy measures that create a gap between domestic market prices and border (reference) prices of a specific agricultural commodity, measured at the farm-gate level. Transfers from taxpayers occur, for example, when subsidies are used to finance exports.

8. The variation between producer prices across OECD countries, as measured by the coefficient of variation, has decreased from a high of 0.63 in 1991 to 0.42 in 2001. The coefficient of variation is derived by dividing the standard deviation in producer prices by the mean producer price.

9. As measured by the Producer Nominal Protection Coefficient (NPC*p*), an indicator of the nominal rate of assistance to producers measuring the ratio between the average price received by producers (at the farm-gate), including payments per tonne of output, and the border price (measured at the farm-gate level) (Annex Table 9).

Chapter 5

FUTURE TRENDS AND THE IMPACT OF FURTHER TRADE LIBERALISATION

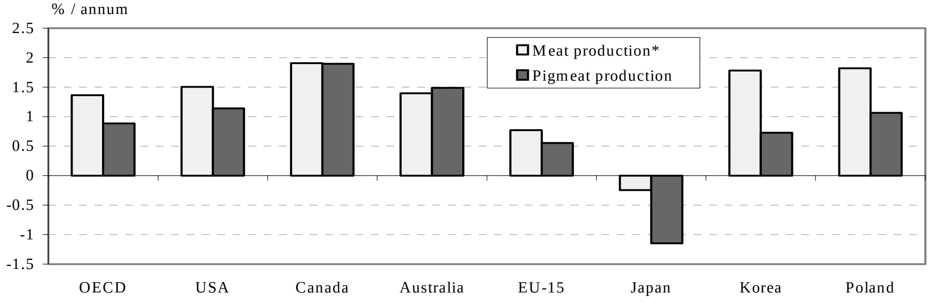
Between now and 2020, pigmeat production and consumption is expected to increase in both developed and developing countries. Pig production systems are anticipated to become more intensive, with more pigs on fewer farms. The sector is also likely to become more specialised, competitive, vertically integrated, and regionally concentrated. There are many distortions in the international pigmeat market. These include high tariffs and tariff quotas, the use of export subsidies, and the provision of support to producers of production inputs and substitute meat products. Trade is also influenced by sanitary regulations. Agricultural trade liberalisation through the World Trade Organization (WTO) may remove some of the policy incentives for production in Europe and high-income Asia. It may also stimulate developing country pig production and lead to some changes in the pattern of global trade. Domestic reform in China and the enlargement of the European Union will also have an important impact upon global patterns of pig production and trade. There may be a gradual shift of pig farming out of the more densely populated, environmentally sensitive areas in Europe and high-income Asia, and into areas with a greater advantage in pig production. Unless appropriate environmental policies or technologies are adapted in certain countries, future growth in pig production may exert more pressure on the environment.

Future developments in demand and supply

There are a number of key projected developments in the demand and supply of OECD agricultural goods and services out to 2020 which could be important in terms of their potential impacts on the pig sector and the environment. The projections that follow in the first part of this Chapter use current policy settings, and do not make any assumptions regarding possible changes in the structure of the agro-food chain, future domestic agricultural policy reforms, including developments in agri-environmental policy, or changes under any future WTO negotiations.[1]

Growth in incomes, population and urbanisation are fuelling a rapid increase in the demand for animal products, particularly in developing countries. The FAO projects that if the demand for pigmeat continues along the current trend, worldwide consumption will reach 107-131 million tonnes by 2010. This represents an increase of between 20% and 45% on current levels. It projects that aggregate world pigmeat consumption will grow at an annual rate of 2%; this figure is based on an estimated increase of 1% in the developed world and 2.6% per annum in developing countries. China is forecast to account for almost 80% of this growth in the developing world. By 2010, the FAO expects per capita pigmeat consumption to reach 35 kg in developed countries and 12.5 kg in developing countries (FAO, 2000).

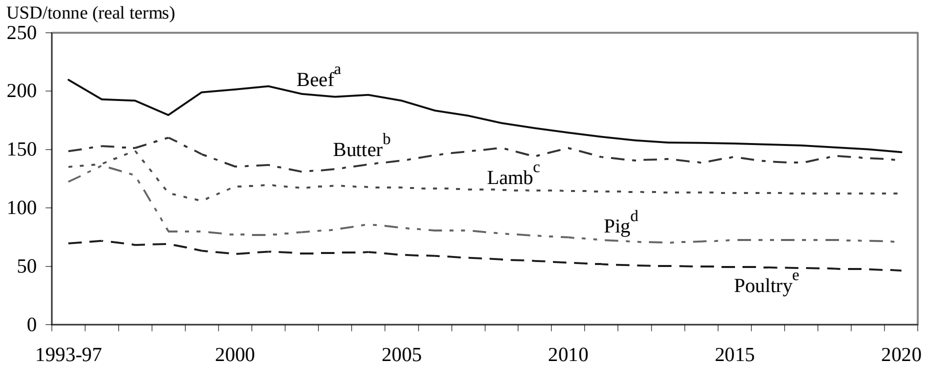
Figure 5.1. Livestock production projections, 1993-97 to 2020



Note:
* Meat production includes: beef and veal, poultry, pigmeat, and sheep meat.
Source: OECD Secretariat.

OECD pigmeat production is projected to expand up to 2020, in response to lower feed prices and increased demand in Asian markets as a result of economic recovery and disease-related supply disruptions from other Asian suppliers (Figure 5.1). Long-term growth rates are expected to be above OECD average in the **United States**, **Canada**, **Australia**, and **Poland**, below OECD average in the **European Union** and **Korea**, and declining in **Japan**. Much of the growth in OECD output is likely to be derived from improvements in productivity, rather than from increasing livestock numbers. While OECD pigmeat production is expected to expand at a rate of almost 1% per annum over the next 18 years, this is below the growth rate for total meat production. The poultry sector will experience the highest rate of growth.

Figure 5.2. World market meat and butter price projections, 1993-97 to 2020



Notes:
a) Choice steers, 1 100-1 300 lb lw, United States.
b) F.o.b. export price, 40 lb blocks, Northern Europe.
c) New Zealand lamb schedule price, all grade average.
d) Barrows and gilts, No. 1-3, 230-250 lb lw, Iowa/South Minnesota, United States.
e) Wholesale weighted average broiler price, 12 cities, United States.

Source: OECD Secretariat.

The FAO projects that pigmeat production in developing countries will grow at a faster rate of 2.2% per annum out to 2015, mainly due to an increase in the number of pigs. By 2015, total developing country production is projected to be 66 million tonnes, or 62% of total world production. China will account for 49 million tonnes, or 46% of total world production (FAO, 2000).

Inflation adjusted world market prices for livestock products, including pigmeat, are expected to continue their long-term downward trend to 2020, but at slower rates than in the previous two decades (Figure 5.2). The projected decrease in real pigmeat prices, and strong competition in the export market, can be expected to bring pressure on farm incomes and contribute towards further structural changes in the pigmeat sectors of all OECD countries regardless of any changes in trade policy measures.

There are many economic uncertainties surrounding these projections. On the supply side, these include weather-related changes in production conditions. While not directly impacting on pig production, which mainly occurs indoors, such changes can affect the supply and cost of feed inputs. On the demand side, there are variations in macroeconomic developments such as GDP growth rates or changes in exchange rates which could have unforeseen impacts on domestic and import demand and hence on trade.

There are also uncertainties on the policy side. While many of these are of a general nature, affecting the entire agricultural sector, they will nevertheless have a significant impact on the outlook for the pigmeat sector, and subsequently, the impact of the sector on the environment. Some key uncertainties include the outcome of the next round of WTO trade negotiations; the consequences of China's implementation of its WTO accession commitments; and the extent of future reform in the enlarged European Union. These issues are discussed in more detail below.

The impact of further trade liberalisation on pig production

At present, even if intra-EU trade is included, only 8% of global pigmeat production is traded internationally (Annex Table 2). This is largely due to the relatively high transaction costs associated with the export of meat products, including refrigeration and sanitary certification. Regardless of this, the volume of pigmeat traded internationally increased by about 8% per year between 1980 and 2000. Over that period there were also some major changes in trading patterns, with trade between OECD and non-OECD countries gaining in importance. OECD pigmeat exports to non-OECD countries rose from 0% in 1970 to 35% of all exports in 1999, with the biggest import markets emerging in Asia.

While the pigmeat trade is increasingly global, the market remains very segmented. Three distinct blocks exist: the North Pacific market (Canada, Japan, Korea, Mexico, the United States, and Chinese Taipei), the Oceania market (Australia and New Zealand), and the European Union, from which some product is exported to eastern Europe and the North Pacific market. This market segmentation has been caused by high transportation costs and trade barriers, as well as differences in sanitary standards and consumer preferences.

The WTO Uruguay Round Agreement on Agriculture (URAA) went some way towards liberalising trade in agricultural products. A significant development has been that pigmeat prices in the **European Union** and **United States** are now moving on the same trend whereas before the late 1990s they were often moving in opposite directions.[2] However, significant policy distortions still remain in the pigmeat sector, as discussed in Chapter 4.

The WTO Doha Ministerial Declaration 2001 set out the broad areas for negotiations in the current WTO round. The stated aims regarding agriculture were very much a continuation of the work of the Uruguay Round, aiming for substantial improvements in market access, reductions of, with a view to phasing out, all forms of export subsidies, and substantial reductions in trade distorting domestic support. There is clearly considerable scope for further trade liberalisation in the pigmeat sector under the new round of WTO negotiations.

Improvements in market access

Pigmeat imports are still restricted by tariffs and tariff quotas in many countries (Table 5.1). The average WTO scheduled in-quota, non-quota and out-of-quota pigmeat tariffs across OECD countries in 2000 were 27%, 42% and 60% respectively. Average tariffs were comparatively low in **Australia**, **Canada**, **New Zealand** and the **United States**, and significantly higher in **European** and **Asian** OECD countries. These tariffs, in addition to being very high, also contain substantial tariff peaks. For example, **Japan** can impose a tariff of 394% on certain types of pigmeat. The average OECD applied tariff rate for pigmeat was the highest of all the meats at 44% in 1997 (Liapis, 2001).

Table 5.1. Average bound tariffs for pigmeat in selected OECD countries, 1995-2000

%, including *ad valorem* equivalents

Country	Average tariff[1]	1995	1996	1997	1998	1999	2000
Australia	Non-quota	0	0	0	0	0	0
Canada	Non-quota	0	0	0	0	0	0
European Union	In-quota	30	22	21	32	37	28
	Out-of-quota	106	73	64	91	95	67
Hungary	In-quota	15	15	15	15	15	15
	Out-of-quota	60	58	57	55	53	52
Iceland	In-quota	313	228	225	346	378	311
	Out-of-quota	973	735	709	976	1033	842
Japan	Non-quota	140	91	82	114	137	122
Korea	In-quota	25	25	25	25	25	25
	Out-of-quota	33	29	25	25	25	25
Mexico	Non-quota	50	49	49	48	48	47
Norway	In-quota	455	357	342	470	489	385
	Out-of-quota	656	528	498	621	623	501
	Non-quota	706	539	504	673	681	521
New Zealand	Non-quota	18	16	14	12	10	9
Poland	In-quota	30	30	30	30	30	30
	Out-of-quota	74	58	51	57	52	48
Switzerland	In-quota	30	23	19	31	33	30
	Out-of-quota	149	110	89	141	144	128
United States	Non-quota	0.6	0.4	0.4	0.6	0.6	0.5

Note:

1. The average tariff is calculated as the unweighted average of each tariff line. Specific tariffs have been converted into *ad valorem* equivalents for comparative purposes. This explains some of the large annual variations and increases in tariffs during a period of tariff reduction.

Source: OECD (2001*d*) and OECD Secretariat.

These tariffs may overstate the extent of protection as they do not take into account preferential agreements countries may have, such as the North American Free Trade Agreement (NAFTA), the European agreements, or the Generalised System of Preferences some developed countries have for developing countries, nor unilateral decisions to apply tariffs lower than the bound rate. However, analysis by the OECD suggests that the difference between the scheduled and actual applied tariffs for pigmeat in 1997 was not significant, nor as large as the differences for other commodities (OECD, 2001*d*).

Within the OECD, the **European Union**, **Hungary**, **Poland**, **Switzerland**, **Norway** and **Korea** all maintain tariff quotas for pigmeat imports. Across the implementation period, average fill rates for pigmeat tariff quotas were the lowest of all the meats at around 70% *(i.e.* the quantity of product imported through the pigmeat tariff quotas amounted to 70% of the permitted quantity). These low rates of fill may be due to problems with tariff quota administration, or reflect market conditions in quota countries.

There appears to be significant room for improvement in market access by lowering tariffs and/or increasing tariff quota volumes. An expansion of quotas combined with a reduction in tariffs would field the broadest results. Expanding tariff quota volumes alone would be unlikely to induce any significant improvement in access as analysis suggests that it is the out-of-quota tariffs and not the quota volumes that are binding in the majority of cases (Liapis, 2001). Estimates suggest that a reduction of out-of-quota and non-quota rates by 36% over a six year period would lead to an increase in pigmeat imports of 8% in **Japan** and 13% in **Korea**, two major world pigmeat importers. At the same time domestic prices in these countries would fall by 4% and 5% respectively. Other estimates suggest that multilateral removal of border protection would result in a 26% decline in pig production and a 50% decline in producer revenues in Japan (Meilke *et al*., 2001).

In the **European Union**, studies indicate that the trade effect of a further 36% reduction in tariffs depends to a large extent on the exchange rate (Huan-Niemi *et al.*, 2000). If the euro is weak against the **United States** dollar, (0.90 USD/EUR), EU pigmeat production will remain highly protected from external competition. However, if the euro is strong (1.30 USD/EUR), the level of protection for pigmeat will reduce quite substantially by 2005 and import competition within the EU market could ensue.

Reduction in export subsidies

On the export side, certain OECD countries are entitled to subsidise large volumes of pigs and pigmeat under the URAA (Table 5.2). Many countries have not used this right but the **European Union** remains an exception, accounting for 95% or more of the total quantity of pigmeat exported with the aid of subsidies during the period 1995-2000. The European Union retains the right to subsidise 443 000 tonnes of pigmeat annually. High world prices between 1995 and 1997 allowed the export of large volumes of pigmeat without subsidy. For the marketing years 1997 and 1998, the actual export subsidy expenditures were between 26 and 30% of the budgetary commitments, and the actual subsidised export quantities were between 42 and 55% of the quantity commitments. However, the collapse in world prices for pigmeat in the late 1990s caused a sharp increase in the export subsidy rate for pigmeat. In the marketing years 1998 and 1999, the European Union resorted to the rollover of unused export subsidy quantity and budget outlay entitlements. In 2000, pigmeat export subsidies were well below commitment levels. Consequently, WTO negotiations that lead to a reduction or elimination of export subsidies are expected to have the largest impact on pigmeat production from the European Union.

Table 5.2. Pigmeat export subsidy volume and value commitment and actual levels, 1995-2000

Calendar years, except for the European Union and the United States

Country	Export Subsidy	Unit	1995	1996	1997	1998	1999	2000
Bulgaria	Volume Commitment	tonnes	670	640	620	590	570	550
	Volume Actual	tonnes	n.n	n.n	0	n.n	n.n	n.n
	Budget Commitment	ECU million	0.65	0.60	0.56	0.52	0.48	0.45
	Budget Actual	ECU million	n.n	n.n	0	n.n	n.n	n.n
Cyprus	Volume Commitment	tonnes	986	972	958	944	930	916
	Volume Actual	tonnes	0	20	1 785	0	n.n	n.n
	Budget Commitment	C £ million	0.586	0.571	0.557	0.542	0.528	0.514
	Budget Actual	C £ million	0.000	0.020	0.145	0	n.n	n.n
Czech Republic	Volume Commitment	tonnes	12 400	11 900	11 500	11 000	10 600	10 100
	Volume Actual	tonnes	0	0	0	0	0	660
	Budget Commitment	Kc million	105.2	98.5	91.8	85.1	78.4	71.7
	Budget Actual	Kc million	0.0	0.0	0.0	0.0	0.0	32.8
EU[1]	Volume Commitment	tonnes	541 800	522 100	502 500	482 800	463 200	443 000
	Volume Actual	tonnes	378 200	285 900	212 700	742 700	694 000	128 600
	Budget Commitment	ECU million	288.8	269.3	249.8	230.3	210.8	191.3
	Budget Actual	ECU million	100.5	71.1	74.4	356.1	243.0	33.8
Hungary	Volume Commitment	tonnes	111 000	107 000	103 000	99 000	95 000	91 000
	Volume Actual	tonnes	1 457	9 181	5 051	3 880	9 181	6 000
	Budget Commitment	HUF million	4 451	4 167	3 883	3 599	3 315	3 031
	Budget Actual	HUF million	61	325	101	2 366	517	408
Norway	Volume Commitment	tonnes	4 631	4 463	4 295	4 127	3 959	3 791
	Volume Actual	tonnes	508	429	4 547	818	11 724	1 418
	Budget Commitment	NOK million	127.4	119.3	111.1	103.0	94.9	86.7
	Budget Actual	NOK million	8.4	6.4	84.9	17.3	265.0	26
Slovak Republic	Volume Commitment	tonnes	5 800	5 600	5 400	5 200	5 000	4 700
	Volume Actual	tonnes	0	400	0	0	0	0
	Budget Commitment	Sk million	47	44	41	38	35	32
	Budget Actual	Sk million	0	17	0	0	0	0
South Africa	Volume Commitment	tonnes	1 930	1 860	1 790	13 759	1 650	1 850
	Volume Actual	tonnes	345	0	0	0	0	0
	Budget Commitment	Rand	1 175 486	1 100 455	1 025 424	950 393	875 362	800 331
	Budget Actual	Rand	106 686	0	0	0	0	0
United States[2]	Volume Commitment	tonnes	483	465	448	430	413	395
	Volume Actual	tonnes	0	0	0	0	0	0
	Budget Commitment	USD	730 050	683 451	636 852	590 253	543 654	497 055
	Budget Actual	USD	0	0	0	0	0	0

Notes:
1. The period for the EU is the year beginning 1 July.
2. The period for the US volume commitments is the year beginning 1 July, for budget commitments the period is the year beginning 1 October.
n.n. Not yet notified to the WTO.
Source: OECD Secretariat based on country notifications to the WTO.

However, the reduction or elimination of **European Union** export subsidies on other products, including substitute meats and cereals, would have flow on effects for the pig sector by influencing production incentives. For example, a reduction in the use of export subsidies for other meats could raise the relative competitiveness of European Union pigmeat exports. A reduction in the use of export subsidies for cereals could increase the domestic cereals supply, therefore driving down European Union pig producers' input costs. At the same time it could lead to an increase in the world price for cereals. This would increase input costs for non-EU producers raising pigs on imported cereals or who purchase feed on markets determined by international prices. A toughening of disciplines on export credits, while not impacting on the meat sectors directly, would have flow on effects via the impact on the cereals sector.

Modelling work on the impacts of eliminating export subsidies finds that the removal of all export subsidies leads to an average 10% decrease in pigmeat prices in the **European Union** (OECD, 2001*d*). Although pig producers in the European Union benefit from an average 15% fall in coarse grain prices, pigmeat production is estimated to fall by 5.4%. The impact on world pigmeat prices is minimal, with prices rising for example in the **United States** by just 1%. World cereal prices are expected to increase slightly more, by 3% on average in the case of coarse grains.

Reductions in domestic support

The effects on the pigmeat sector of further reductions in domestic support are harder to quantify as there are very few pigmeat producer support policies which fall under the WTO blue or amber boxes. As a result, the most important impact of domestic support reform for the pigmeat sector will be the flow-on effects that are brought about by reductions in support for cereals' producers and producers of substitute meat products, particularly beef and sheepmeat. Further liberalisation of the cereals sector would result in a reduction of pig producer production costs, and a reduction of support for beef and sheepmeat producers could improve pig producer competitiveness and encourage a subsequent shift in production in favour of pig farming.

In the **European Union**, pigmeat producers have become more competitive in recent years as a result of the lower feed costs that were brought about with the 1992 CAP reforms. The 15% reduction in price support for cereals had a marked impact on European Union production incentives as feed costs can account for up to two-thirds of the total cost of pigmeat production. If reform of the cereals sector continues as a result of subsequent reviews of the CAP or the current WTO negotiations, European Union producers are expected to respond by marginally increasing pigmeat production.

It would appear that further multilateral trade liberalisation will induce a change in global production patterns and an increase in the volume of pigmeat traded internationally. It could be anticipated that further trade liberalisation will strengthen the trends projected for world pigmeat production, with production reducing further in **Japan** and growing slower in the **European Union** and **Korea**. However, there will also be other developments that will have a significant impact on the pig production and trade as discussed below.

Other influences impacting on future pig production and trade

Sanitary measures

World pigmeat trade is significantly influenced by sanitary restrictions (Box 5.1).[3] One of the factors currently limiting developing countries' capacity to develop export oriented pigmeat sectors is the sanitary standards that importing countries are requiring meat exporters to meet. Some of the most pressing problems experienced by exporters appear to be insufficient access to scientific and/or technical expertise, incompatibility of sanitary standard requirements with domestic production and marketing methods, and a lack of information and administrative awareness of sanitary standard requirements. Developing country producers subsequently have fewer incentives to expand their operations or to invest in productivity enhancing technologies as there is no certainty that there will be a market for their surplus production.

The Uruguay Round Agreement on Sanitary and Phytosanitary Measures (SPS) includes a number of provisions to facilitate trade. In particular, Article 4 provides that countries may negotiate bilateral or multilateral agreements to recognise the mutual equivalence of each other's specific SPS measures. However, as yet, very few agreements have been concluded to develop the pigmeat trade significantly.

Similarly, Article 6 sets out a regional principle for animal health. That means that the signatory countries of the SPS Agreement must recognise areas that are disease-free or with low prevalence of parasites or diseases – even when countries in their entirety do not meet these criteria. To date, very few countries have embodied such concepts within their national legislation, or implemented them – though these would clearly help develop trade. For example, the **United States** does not accept pigmeat imports from areas within countries that are free from Classical Swine Fever (CSF), and various countries will not accept pigmeat from Chinese Taipei as a result of its recent outbreak of Foot and Mouth Disease (FMD).

Box 5.1. The impact of sanitary restrictions on pig and pigmeat trade in North America

The North American Free Trade Agreement (NAFTA) took effect on 1 January 1994. It provides for the progressive elimination of most trade and investment barriers between Canada, Mexico and the United States, over the 14-year period ending 1 January 1998. The direct impact of NAFTA on pig and pigmeat trade in North American has been fairly limited. Neither **Canada** nor the **United States** levied tariffs or maintained quantitative restrictions on pig or pigmeat imports at the time NAFTA was implemented. **Mexico** still maintains some protection through a tariff, which has been reduced on an annual basis from 20% in 1994, and a special safeguard quota on non-pure bred pigs and certain cuts of pigmeat. From 1 January 2003 both the tariff and the special safeguards were eliminated. While Mexico's tariff reductions have been an important contributing factor to the growth of US pork exports to Mexico, the far more significant drivers of export growth have been the rapid recovery of the Mexican economy following its recession in 1995 and continuing economic growth since then.

The North American trade in pigs and pigmeat has also been influenced by sanitary restrictions. With the exception of certain regions, Mexico is considered to be hog-cholera endemic, and any pigs exported to the US are subject to 90 days in quarantine. This effectively precludes pig exports to the US. In addition, US pig exports to Canada are restricted by a disease problem – pseudorabies. Consequently, the North American pig trade consists almost exclusively of Canadian exports to the US and US exports to Mexico.

Regionalisation of Hog-Cholera Restrictions – In 1994, Mexico officially requested that the US recognise the states of Sonora, Sinaloa, Chihauhua, Baja California Sur, and Baja California Norte as low risk regions for hog-cholera to enable those states to ship pigmeat to US markets. In 1995, Mexico added Yucatan to this list. In July 1997, a final rule recognising Sonora to be free of hog-cholera was published in the Federal Register. In October 1997, the US published final rules that establish procedures for recognising hog-cholera free regions and the levels of risk among regions with regard to US importation of live animal products.

The volume of Mexican pigmeat exports to the US continues to be extremely small due to these disease problems. Any imports from Mexican states deemed to be hog-cholera endemic must be cooked and then sealed in air-tight containers. As in the case of live pigs, US health restrictions regarding hog-cholera have led Mexican pigmeat producers to complain that they are being unjustly prevented from exporting pigmeat to the US.

Regulation of Pseudorabies – On 3 December 1998, Canada amended its Health of Animal Regulation to permit the importation of pigs from certain US states. This amendment exempts imported slaughter pigs from states with Stage IV or Stage V status under the US Psuedorabies Eradication Program from undergoing disease testing and quarantine requirements.

Although the new regulations allowed imports where they were prohibited in the past, they still strongly discouraged Canadian processors from importing US pigs. Requirements that were later deemed excessively onerous included disposal of manure in the trucks, washing of trucks, reconfiguration of plant grounds to segregate US pigs, and special bangle ear tags on US pigs. Canadian processors also contested requirements to slaughter US pigs within 4 hours after arriving at the plant and within 24 hours after arriving in Canada. In addition, these animals were to have travelled to Canadian slaughter plants along defined routes and within defined time frames.

On 30 March 1999, the Canadian Food Inspection Agency (CFIA) met with various Canadian stakeholders to explore various strategies to address their concerns. The challenge facing CFIA was to open the channels of trade without weakening the risk-protection aspect of the regulation. New regulations were published on 27 October 1999. The regulations amended previous requirements for animals imported from US states with Stage IV or Stage V classification with regard to truck washing, manure handling and disposal, veterinary supervision, and animal identification.

The new regulations have done little to induce US pig exports to Canada. The minimal flow of this trade is more a consequence of price rather than sanitary requirements, as US packers typically offer higher prices for pigs than Canadian slaughter operations.

Greater time and attention has been focused on resolving conflicts related to sanitary measures since the implementation of NAFTA. In addition, producers in each NAFTA country have demonstrated a greater degree of co-operation in developing and working to meet higher quality standards. Regardless of these improvements in sanitary co-operation, and the relative absence of trade barriers, the North American pig and pigmeat trade is still constrained by sanitary restrictions.

Source: Zahniser and Links (eds), 2002.

As long as there continues to be a divergence in, or a lack of equivalence of, the sanitary standards of potential trading countries, the international pigmeat trade will remain segmented, irrespective of any further trade liberalisation resulting from a reduction in tariffs or the elimination of export subsidies. Therefore, while trade liberalisation may encourage a gradual shift in the location production from developed to developing countries, this effect will be constrained if developing countries are not able to meet the standards required by developed countries, or to have their domestic standards recognised as equivalent. Further technical and financial assistance for developing country producers and exporters could go some way to resolving these difficulties.

Domestic reform in China

Accession to the WTO is expected to have a significant impact upon China's patterns of production, processing and trade. In terms of the livestock sector, much will depend on the growth of Chinese incomes, productivity gains enhanced by investment in infrastructure, and the adjustment of domestic prices to world levels. As China is the world's largest pigmeat producer and consumer, these changes may have a significant impact upon the international pigmeat market.

At present pigmeat represents 70% of China's total meat production. About 80% of pigmeat is produced by small family units fattening one to three pigs a year, mainly on crop residues and food waste. However, China's animal production sector is modernising, with larger family farms and large specialised breeding units that are more dependent on feed grains and concentrates. This trend is likely to accelerate in the future.

As part of its accession agreement China agreed to reduce tariffs on pigmeat from 20% to 12% by 2004. It also agreed to establish tariff quotas for cereals. It is difficult to estimate what affect these changes will have on the level of China's pigmeat and animal feed imports. An increase in imports may be limited by inadequate or insufficient infrastructure to manage the trade, or the behaviour of China's state trading enterprises which will be to some degree responsible for overseeing meat and grain imports. Differences in preferences and tastes may also make imported meat products imperfect substitutes for domestic produce.

China could play a major role in determining the distribution amongst countries of the potential gains and losses from trade liberalisation (Meilke *et al.*, 2000). If China were to liberalise its pigmeat market world prices would increase significantly, and a number of additional opportunities would open up for competitive exporters from all over the world.

Enlargement of the European Union

Ten countries are currently preparing to accede to the **European Union**, where they will be required to adhere to stricter rules and regulations. It is likely that all ten applicants will be challenged to meet these standards. Large production units may manage the transition swiftly, especially with European Union structural assistance. But smaller units may find it harder to generate the investment needed to meet more stringent hygiene and veterinary criteria, animal welfare and sanitary requirements. It is difficult to estimate the degree to which changes in the applicant countries will impact upon the international market given Europe's traditional isolation in the segmented pigmeat market, but these changes will certainly have significant consequences for the intra-European market.

Consumer concerns

Future pigmeat production and trade patterns will also be affected by the policies and regulations put in place to address a variety of consumer concerns. These concerns, which are most often expressed by developed country consumers, are generally in the areas of food safety and quality, environment, animal welfare and the viability of rural areas. These policies and regulations may significantly modify or counteract the trends that would have otherwise occurred.

Governments are increasingly developing policies in these areas, many of which result in the more stringent regulation of livestock production and marketing, and a subsequent reconfiguration of existing production patterns. Even in the absence of standards and regulations, changes in consumer preferences for meat products due to lifestyle changes, food safety concerns, health perceptions, and other reasons, will increasingly affect production decisions in the future.

A recent study concluded that the **European Union** Agenda 2000 agreements will have little or no impact on the future of intensive livestock farming in Europe (Massink and Meester, 2002). While they find there will be a modest impact on the pigmeat sector as a result of further drops in the prices of cereals and beef, they estimate that other factors, such as compliance with animal welfare and environmental requirements, will have a much greater impact.

Conclusions regarding the future of pig production and trade

Predicting the future of pig production and trade is a difficult task given the large number of uncertainties surrounding most of the variables that will impact upon production and trade incentives. On the economic side, there is uncertainty surrounding future developments in population growth, GDP growth rates, exchange rate movements, and other demand and supply impacts. On the policy side, there is uncertainty regarding the outcome of the current round of WTO trade negotiations, the extent of future agricultural reforms in China and the consequences of **European Union** enlargement, and the extent to which developed countries' consumer concerns will result in restrictions on pig production practices.

Despite these uncertainties, there are a number of underlying trends in the nature of pigmeat production and trade that should continue regardless of many of the factors mentioned above. The trend towards fewer and larger pig farms in the OECD is expected to continue as producers intensify production and increase productivity, although the pace of this change may decelerate. This should encourage further rationalisation, consolidation, regional concentration, and vertical integration of the industry. Competitiveness pressures, when combined with an increase in access to capital and technology, will lead to increased levels of investment in on-farm technologies machinery aimed at increasing productivity and reducing environmental harm. In the long term there may be a gradual shift in the location of production to less densely populated areas, especially if policymakers in developed countries continue to force pig producers to internalise the environmental costs of production through policy or regulatory constraints.

Similarly, pigmeat production in developing countries will increasingly rely on intensive livestock systems, located predominantly in peri-urban areas. The rate of this shift will depend primarily on the ease with which developing country producers can access modern technologies and capital investment. This continued shift towards intensive pigmeat production will result in a growing reliance on imported basic inputs including genetic material, veterinary products and feed stuffs in many developing countries. By 2030, the FAO projects that the bulk of world pigmeat production will be largely landless (FAO, 2001).

The FAO projects that the world meat trade will remain buoyant in the medium- to long-term, particularly with continued trade liberalisation and ongoing economic reforms for economies in transition and elsewhere. It projects that developing countries will increasingly become net meat importers with South Asia, East Asia and Near-East/North Africa being the most significant importers to 2030. New countries will emerge as significant exporters, including Mexico, Brazil, and Korea (FAO, 2001).

Projected effects of pig production on the environment

Concerns about the impacts of livestock production on the environment are likely to increase in the future as production intensifies and incomes grow. Some believe that further trade liberalisation will exacerbate environmental damage, including resource depletion and pollution, given that trade increases economic growth, production and consumption. Others argue that trade benefits the environment by allowing greater specialisation of production in countries where inputs are used more efficiently, and that the resultant increases in income lead to greater concern for, and spending on the environment.

A reduction of trade barriers will influence the overall scale of agricultural activities in different countries, as well as the structure of agricultural production, the mix of inputs and outputs, the production related externalities, the production and transfer of technologies, the scale and pattern of transportation, and the regulatory framework. These adjustments will in turn impact upon the environment by increasing or reducing environmental harm and creating or destroying environmental amenities. The following Chapter will examine the possible environmental impacts of pigmeat production in the future.

Environmental effects of intensification

From all indications it appears that further trade liberalisation will encourage the continued intensification of livestock production systems in developed countries, and an acceleration of this process in developing countries. This prospect is a concern to many environmentalists who associate larger pig operations with increased livestock density and thus, potentially, an increase in localised environmental problems. If this relationship were to hold one would expect an increase in pollution in a large number of OECD countries given the production forecasts and structural changes discussed earlier.

Rae and Strutt (2001) found that further intensification of livestock production systems, in the absence of appropriate intervention, would further exacerbate the negative environmental impacts of livestock production in countries such as **Canada**, **New Zealand** and the **United States**, and in South America. However, due to their relatively low population densities, the human consequences of such damage were expected to be relatively lower. In the case of **Japan** and the **European Union** they found that future economic developments would probably lead to a decline in the size of their overall livestock sector and a subsequent reduction in effluent output and fertiliser use.

In some countries however, trends show that increases in pig production can become “decoupled” from the output of nitrogen and methane emissions (Chapter 2 and Figure 2.5). This suggests that producers are improving their environmental efficiency by lowering pollutant emissions per unit volume of pigmeat produced. While intensification may increase pollution in a situation where all other variables remain constant, advances in pollution reducing technologies and production systems may be able to mitigate, if not reverse much of this damage in the future.

Environmental effects of a shift in the location of production

It would also appear that trade liberalisation will further the changes in the location of production that are expected to occur. Rae and Strutt (2001) examined this hypothesis in relation to the livestock sector as a whole. They predict that some portion of farm production will likely shift to regions of the world with lower population densities and more extensive production systems. As extensive systems use less grain-feeding than intensive systems, and tend to rely on nitrogen-fixing pasture plants, there would appear to be net environmental gains to be made from the relocation. It is important to remember however, that Rae and Strutt's analysis does not take all impediments to a shift in the location of production into account. For example, developed country producers will not shift their production to developing countries if those countries do not have the infrastructure or sanitary clearance necessary to export meat to other countries for consumption.

Given the projected expansion of the pig sectors, especially in **Australia, Canada, Korea, Poland** and the **United States**, pressure on the environment from excess manure nutrients and air emissions is likely to increase, but at a rate of growth below that of the 1990s. Regions within these countries can expect to have to continue to address problems of eutrophication of water bodies and impairment of drinking water close to large scale pig operations, and perhaps over longer distances as nutrients are transported to marine waters. Ammonia emissions are also likely to pose an increase burden on the environment through the acidification of ecosystems, in the absence of remedial action.

Pigmeat production is also projected to expand in the **European Union**, which may be a continued source of pressure on the environment in some areas of the EU, especially given the faster rates of growth for pig production expected in **Belgium**, **Denmark**, **France**, **Greece**, **Ireland**, and **Spain** (Cofala *et al.,* 2000). But as the EU's agricultural sector is likely to expand at a much slower rate than during the 1990s, the rate of increase in the pressure on the environment from farming could also slow. The area across the EU subject to eutrophication and acidification, for example, is likely to diminish significantly (Cofala *et al.*, 2000).

Japan's pig sector is projected to continue its long term contraction up to 2020. In view of the overall contraction of the Japanese agricultural sector anticipated over the next two decades, the risks of environmental pollution from pig production at the national level is expected to diminish. This does not however preclude the possibility of risks increasing in certain areas given the similar patterns of intensification that have occurred over the 1990s.

Concerns have been expressed that a shift in the location of production from developed to developing countries could have serious environmental consequences as developing countries traditionally maintain lower standards of environmental conservation and pollution control. Others dispute this assertion and argue that this fear of the development of "pollution havens" has been exaggerated as the evidence of their existence is marginal (FAO, 2001). Many of the conditions and production practices that have led to environmental problems and subsequent regulations in developed countries, such as limited land space and intensive farming methods, are not present or are not as prevalent in developing countries. In this case, the environmental conditions in developing countries should be seen as contributing to their overall comparative advantage.

Environmental effects of an increase in transportation

All of the modelling work suggests that further trade liberalisation and reform in the meat sector will lead to an expansion in trade, not only in animals, meat and livestock products but also in feed. The FAO estimates that almost 600 million tonnes of cereals was traded annually between 1995 and 1997. By 2015, it expects the annual figure to be around 735 million tonnes, expanding to 840 million tonnes by 2030 (FAO, 2000).

An OECD study on the effect of two different Uruguay Round implementation scenarios on trade flows concluded that trade liberalisation would lead to a greater quantity of goods travelling longer distances (OECD, 1997). For agriculture as a whole the projected effects of the Uruguay Round were an increase in seaborne transport of between 9% and 14%. Over time, agricultural goods appear to be travelling larger distances domestically as well.

Any future increase in transportation may have implications for the environment, including an increase consumption of non-renewable energy sources and an increase in air and water pollution. However, the costs associated with this damage are expected to be minimal when compared to the other economic, social, and environmental gains to be made from trade liberalisation. The focus therefore should be on promoting the development of more efficient transportation methods that utilise more renewable energy sources. Increase trade also raises the risk of imported pests and diseases. This is particularly relevant for pigs which are prone to a number of highly communicable diseases such as Foot and Mouth Disease (FMD) and Classical Swine Fever (CSF). This requires the implementation of effective sanitary precautions.

Minimising the negative environmental impacts

Further trade liberalisation will have both positive and negative impacts upon the environment. The direction and magnitude of these effects will depend on the trade liberalisation-induced changes in agricultural production patterns, the state of the environment, and the environmental regulations and policies in place to preserve and improve environmental quality.

Given the considerable diversity of agricultural production systems, natural conditions, and regulatory approaches in OECD countries, the environmental impacts will vary between countries, regions and locations.

Further trade liberalisation will probably lead to the further intensification of pigmeat production systems, shifts in the location of production, and increases in market competition, sectoral integration and transportation. All of these changes may have some negative consequences for the environment if appropriate pollution limiting technologies and regulations are not implemented to combat them.

An increase in the mobility of capital, as part of the broader programme of trade liberalisation, may have a number of positive consequences for the environment. A reduction of barriers to investment may allow for the establishment of production plants in regions with environmental conditions more suitable for pigmeat production than those in which much of the world's production is located today.

Trade liberalisation could also encourage innovation and the development of new environmentally friendly production technologies as a result of increased investment and market competition. Furthermore, it may encourage the spread of these technologies as a reduction in trade barriers should gradually reduce the real costs of their adoption.

A number of new technologies have already been developed to mitigate the negative environmental impacts of pig production (Chapter 3). These include systems that: guard against manure spills; reduce or alter the chemical make-up of manure; reduce odour and gas emissions; and recycle manure into other products. Trade liberalisation may facilitate the uptake of these sorts of systems given its promotion of large-scale production facilities that invariably have more resources to invest in new technologies.

One of the most common measures used to mitigate the negative environmental impacts of pig production in OECD countries has been for governments to impose regulations on producers which require them to modify their production systems in order to prevent the creation or exacerbation of localised environmental problems (Chapter 6). Regulations have been introduced to control the scale, location and methods of production, as well as the disposal of environmentally harmful production by-products. If designed appropriately regulations can prevent unnecessary production externalities or internalise the cost of the less preventable environmental externalities into producers' overall production costs. In this way regulations can ensure that the environment is considered alongside all other factors when determining the relative comparative advantage of various production sites.

By co-ordinating trade and environmental policy instruments, countries can preserve the economic gains from expanded trade while mitigating adverse environmental impacts and promoting a more sustainable pattern of resource use. Economic growth and higher incomes engendered by free trade may also lead to a greater social preference for the resources available to achieve environmental improvement.

Countries should implement policies that target the specific needs of their environments and societies in a way that does not unduly mitigate the positive effects of trade liberalisation. These policies should require both producers and processors to internalise the environmental costs of their production. Without such policies, the products of pig farms will continue to be artificially cheap, in that prices will not reflect their impact on the environment, human health, animal welfare or the economic and social stability of rural communities.

NOTES

1. The agricultural demand and supply projections outlined in this first part draw on the results of the chapter on Agriculture in OECD (2001*c*) which, in turn, was based on FAO (2000). Commodity coverage includes cereals, oilseeds, and livestock products (including pigmeat), but not fruits and vegetables, permanent crops, harvested fodder crops or pasture

2. See, for example, the report on the "Future of the European Meat Industry" conference in *Agra Europe*, 28 September 2001, where Karsten Fleming of the Danish meat group Danske Slagterier explained that the US and EU pig production cycles were now moving in tandem instead of working against each other as they had in the early 1990s.

3. As another example of the influence of sanitary measures, the outbreak of Foot and Mouth Disease in Taiwan in March 1997 dramatically changed world trade flows. Prior to the outbreak, Taiwan held a 38% share of Japan's pigmeat import market. Those exports are now effectively zero as Japan has a ban on pigmeat sales from countries which are not categorised as FMD-free.

Chapter 6

POLICY MEASURES ADDRESSING ENVIRONMENTAL ISSUES IN THE PIG SECTOR

Environmental policies have focused on reducing water and odour pollution from pig production, with some policies recently introduced to deal with ammonia emissions. The most frequently adopted policy measures have been regulations, research, and technical assistance and extension. Regulations have been introduced to limit point source pollution (e.g. prohibit direct discharge into waterways) and reduce non-point source pollution through controlling the quantity of manure produced, the quantity spread and how the manure is spread. Payments are mainly provided to offset the capital costs of regulations particularly relating to manure storage requirements. Other economic instruments, e.g. taxes and tradeable rights, have only been used to a limited extent. Over time, policy measures are becoming more stringent, with regulations increasing in severity and complexity, and tax rates increasing. An increasing number of policy measures are being used in all countries, with the number and severity of policy measures perhaps greatest in north European countries.

This Chapter discusses the policies used to address environmental issues in the pig sector and how these have changed over time. Policy measures are grouped into three general categories: economic instruments; regulatory and legal measures; and advisory and institutional measures. Within each category there is a further breakdown into the type of policy instrument according to the classification system established for the OECD's *Inventory of Policy Measures Addressing Environmental Issues in Agriculture*. Policy measures are also discussed according to their environmental objective.[1]

Overview of developments in environmental policy measures

A notable feature of agri-environmental policies across OECD countries is for objectives and/or the broad policy framework to be set at the national level, and actual policy measures established at the state or regional level (or at the country level in the case of **European Union** members). For example, the **European Union** addresses issues of water management through the more broadly focussed EU Water Framework Directive, and specific issues of water pollution from agriculture through the Nitrates Directive (EU Council Directive 676/91) and the Drinking Water Directive.[2] Each **European Union** country is responsible for meeting the targets set by the Nitrates Directive, so differences emerge at the country level. Then within **European Union** members, regulations can vary from region to region, particularly where the country has designated certain areas as nitrate vulnerable zones (NVZ) *e.g.* **France**, **Italy** and **Sweden**.

The 1972 Clean Water Act (CWA) is the major **United States** federal legislation that addresses water quality. It provides for the development of federal, state and local government programmes for reducing and preventing the contamination of surface and groundwater. In **Canada**, the primary responsibility for the environment regulation of agriculture rests with the provincial and municipal levels of government. The federal government has set standards for nutrients, bacteria and pesticides. In most provinces, with the exception of Quebec, enforcement is devolving to the municipal level (Fox and Kidon, 2002). This policy framework is typical of all OECD countries and reflects the rather localised nature of environmental concerns.

The localised nature of policies also makes it very difficult to summarise the environmental policy measures impacting on pig producers in any one country. Furthermore, the policy measures for addressing environmental issues that affect pig producers are also intended to affect other agricultural producers, in particular other livestock producers. There are only a limited number of measures that solely affect pig producers. This reflects the fact that environmental issues associated with pig production are also issues of concern in other sectors.

Nevertheless, some general conclusions can be made about developments in policies to address environmental issues in the pig sector during the 1990s (Table 6.1 and Figure 6.1).

- All countries have had environmental regulations in place over the past decade affecting pig producers. Although changes in regulations are not shown, evidence indicates that these have got more stringent. Other forms of regulatory and legal measure (*i.e.* cross compliance) have been only recently introduced in a few OECD countries.

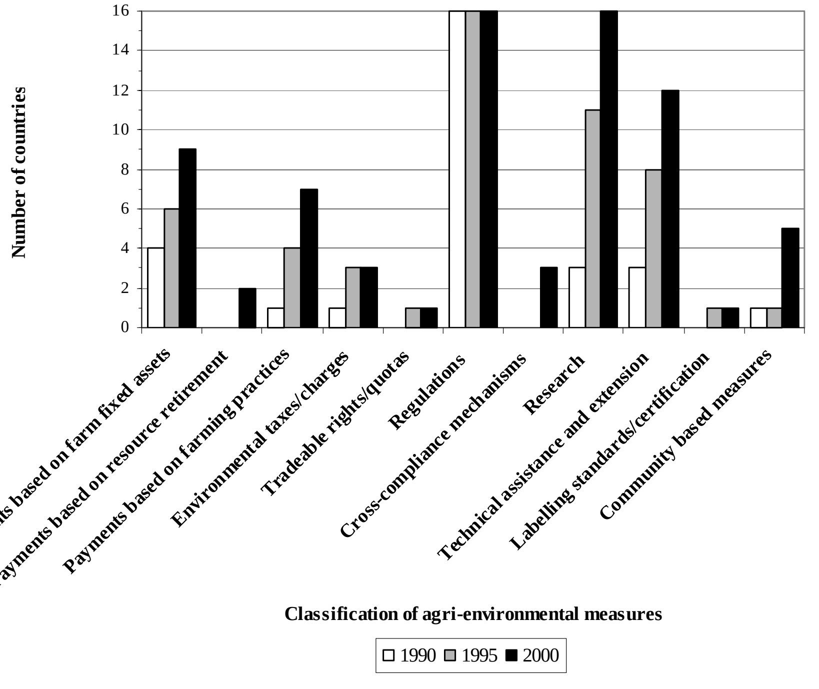
Table 6.1. Agri-environmental policies affecting pig producers in selected countries, 1990, 1995 and 2000

Country	Payments based on farm fixed assets	Payments based on resource retirement	Payments based on farming practices	Environmental taxes/charges[2]	Tradeable rights/quotas	Regulations	Cross-compliance mechanisms	Research[3]	Technical assistance and extension	Labelling standards/certification	Community based measures	Total
1990												
Denmark	X					X		X	X		X	5
Netherlands	X			X		X		X	X			5
Sweden	X					X		X	X			4
Norway	X					X						2
UK			X			X						2
Australia						X						1
Belgium						X						1
Canada						X						1
France						X						1
Germany						X						1
Ireland						X						1
Italy						X						1
Japan						X						1
Korea						X						1
Switzerland						X						1
United States						X						1
T0TAL	4		1	1		16		3	3		1	29
1995												
Denmark			X	X		X		X	X		X	6
Netherlands				X	X	X		X	X	X		6
UK	X		X			X		X	X			5
France	X					X		X	X			4
Sweden			X			X		X	X			4
Canada						X		X	X			3
Germany	X					X		X				3
Japan	X					X		X				3
Korea	X					X		X				3
United States						X		X	X			3
Belgium				X		X						2
Ireland			X			X						2
Italy						X			X			2
Norway	X					X						2
Switzerland						X		X				2
Australia						X						1
TOTAL	6		4	3	1	16		11	8	1	1	51
2000												
Netherlands		X		X	X	X		X	X	X	X	8
Denmark			X	X		X	X	X	X		X	7
Belgium		X	X	X		X		X	X			6
Germany	X		X			X		X	X		X	6
Ireland	X		X			X		X	X			5
Sweden	X		X			X		X	X			5
UK	X		X			X		X	X			5
United States	X		X			X		X	X			5
Canada						X		X	X		X	4
France	X					X		X	X			4
Italy	X					X		X	X			4
Korea	X					X		X			X	4
Australia						X		X	X			3
Japan	X					X		X				3
Norway						X	X	X				3
Switzerland						X	X	X				3
TOTAL	9	2	7	3	1	16	3	16	12	1	5	75

For Notes, see following page.

Notes to Table 6.1:
1. An "x" indicates that a policy measure(s) exists. The table mainly captures measures at the national level and so not all sub-national measures may be identified.
2. In a few OECD countries, such as Sweden, commercial fertilisers and pesticides are taxed. Although pig farmers in these countries who use these products are taxed they are not included in this table.
3. An "x" identifies specific research, and technical assistance and extension provided for environmental purposes. Pig producers benefit from other forms of research, and technical assistance and extension.
Source: OECD Secretariat.

Figure 6.1. Frequency of agri-environmental policies affecting pig producers in selected countries, 1990, 1995 and 2000



Source: OECD Secretariat, see Table 6.1 for further details.

- Measures broadly classified as advisory or institutional have also been more widely used in recent years. All countries are now undertaking some form of research relating to the impact of pigs on the environment. This research has often been translated into technical assistance and advice to farms, which is often used to try and persuade farmers to voluntarily change their management practices or adopt suitable technologies. Some attempts have been made in the last few years to develop community-based measures.

- Economic instruments have not been as widely used. In particular, environmental taxes and charges, and tradeable rights/quotas have only been implemented in a few countries. Payments, particularly those relating to farm fixed assets, such as assistance in the construction of manure storage facilities, have been increasingly used as a policy instrument.

- In all countries, the number of policy measures in place has increased over the period, although the use of policy instruments has been most extensive in northern European countries. It is likely that this trend will continue over the coming years. For example, it is estimated that pig producers in **France** will require substantial investment in manure-processing units costing EUR 180 to 210 million over the next few years to meet the costs of proposed regulations (Bondt *et al.*, 2000).

The major environmental objective of policy instruments affecting the pig sector has been to reduce the level of water pollution. Other environmental concerns addressed by policy measures on pig producers include odour, ammonia emissions, greenhouse gas (GHG) emissions, landscape and biodiversity. It is important to note that a particular policy measure introduced to deal with one environmental objective may have an effect on other environmental objectives.[3] And this link is not always positive. For example, the trend for pig producers to use liquid systems for manure storage, such as lagoons, ponds, lakes or pits, to reduce ammonia emissions have the highest methane emission rates because they promote anaerobic conditions. Furthermore, a policy measure may be introduced with the specific purpose of meeting more than one objective.

As discussed in Chapter 2, the certainty of the link between pig production and the environmental impact varies. For example, the link between pig production and air pollution (odour, ammonia and GHGs) are much more certain and direct than the impact of the land application of pig manure on water pollution. Consequently, the extent to which policy makers are able to introduce policies to limit these harmful effects varies. In particular, it is generally considered that fewer policy options exist for controlling the impact of diffuse, non-point source pollution from agricultural production. Non-point discharges are difficult to monitor because they occur over wide areas and vary from day to day depending on weather conditions and the frequency and timing of application of potential pollutants, such as fertilisers and pesticides. Research also indicates that that links between improved farm management practices and observed changes in the environment outcomes usually involve long time lags. For example, it may take many years to see aquatic habitats restored (*i.e.* increased fish stocks and aquatic plants, *etc*.), after farm practices to manage livestock nutrients have been improved.

Policy measures have focused on means (*e.g.* a ban on manure application during certain time periods) rather than ends. The advantage is that such measures are relatively simple to develop, that the worst excess can be dealt with, and a great deal can be seen to happen. However, there are a number of problems with a focus on means. To reach the intended environmental goal requires starting from a worst case scenario. Further, the efficacy of means specifications is often difficult to demonstrate (*e.g.* what is the environmental gain from a manure fertiliser ban lasting another month?). Means specifications for individual farms can be very expensive while contributing very little to reducing environmental damage at the farm level. Finally, it focuses on some specific aspect of farm management and is not conducive to an integrated approach.

The move to a more targeted policy approach (*e.g.* where farmers are obliged to achieve certain targets) has a number of benefits, particularly the freedom it gives to farmers to decide which ways they consider most cost effective to achieve the target on their farms. However, the major disadvantage is the difficulty in measuring the target. If a target cannot be measured practicably (*e.g.* emissions to groundwater) a target derived from the original aim can be selected (*e.g.* mineral surplus). But this is still only a proxy for the environmental damage that actually occurs.

There can also be spill-over environmental effects arising from agri-environmental policy measures. For example, policies that place a limit on the amount of manure that can be spread can increase the quantity and distance over which manure is transported. Manure is transported over long distances (100-200 km) in the Netherlands and from the most intensively farmed area in Lower Saxony, and is also beginning to happen in Brittany and Catalonia. In less intensive areas, manure is sometimes transported over distances of 10-15 km using tractors (Bondt *et al.*, 2000).

One important issue relating to the effectiveness of regulations is the extent to which compliance with regulations is measured and assessed. It is one thing to have regulations in place; it is another to know that they are implemented correctly. Evidence suggests that the monitoring of regulations may be lacking in some OECD countries. A recent report by the World Wildlife Fund concluded that most **European** countries have inadequate environmental monitoring systems to properly safeguard their water resources including a lack of reliable data on diffuse pollution (WWF, 2001). In the **United States**, a survey of livestock waste control programmes in ten mid-west and western states indicated that few states actively inspect facilities for problems, including the integrity of storage structures (Ribaudo *et al.*, 1999).

While many of the environmental policy measures affecting pig production have been introduced in response to local or domestic environmental problems, measures have also been implemented in response to obligations arising from international agreements to deal with transboundary pollution. There are a number of agreements that concern the prevention, control and reduction of transboundary impacts of ***water pollution*** from agricultural and other sources. For example, the 1992 Helsinki Convention on the Protection and Use of Transboundary Watercourses and International Lakes (HELCOM) commits signatories to reduce nutrient discharges into the Baltic Seas by 50%.[4]

Other international agreements to which some OECD countries are committed to improve water quality include, for example, the Oslo and Paris Conventions for the Prevention of Marine Pollution (OSPAR Convention) covering the north-east Atlantic and the North Sea, and the International Joint Commission Agreement on Great Lakes Water Quality in North America.[5] Under the Convention on Long–Range Transboundary Air Pollution, the Protocol to Abate Acidification, Eutrophication and Ground–level Ozone (the Gothenburg Protocol 1999) requires signatory countries to take measures to control ***ammonia emissions*** from agriculture.[6] Finally, most OECD countries, under the 1994 United Nations Framework Convention on Climate Change (UNFCCC), have committed themselves to stabilise ***greenhouse gas emissions*** at 1990 levels by 2000. They also agreed to implement the 1997 Kyoto Protocol, which specified the levels of emissions for the target period 2008 to 2012 (these targets cover total national emissions, including the agriculture sector).

Economic instruments

Economic instruments affect costs and benefits of alternative actions open to economic agents, with the effect of influencing behaviour in a way that is favourable to the environment. These instruments typically involve either a monetary transfer *e.g.* payments from governments to farmers or charges/taxes paid by farmers — or the creation of new markets *e.g.* tradeable pollution rights. The actual level of support to or tax paid by pig producers within the various programmes is not calculated. However, it appears that the level of payments provided to pig producers is small and often these are provided for a limited time period. Taxes/charges and tradeable quotas/rights are very rarely used in the pig sector.

Payments based on farm fixed assets

Payments based on farm fixed assets are policy measures granting a monetary transfer (including implicit transfers such as tax and credit concessions) to farmers to offset the investment cost of adjusting farm structure or equipment to adopt more environmentally friendly farming practices. Support has often been provided to livestock farmers, including pig farmers, to assist them meet the requirements of regulations, particularly in response to manure storage requirements which can be quite high.

Table 6.2. Support for manure storage construction in selected countries

Country	Support for manure storage construction
Denmark	The government offered a subsidy covering about 30% of the costs of upgrading the manure storage facilities to the required capacity (Dubgaard, 1991).
France	Under the Agricultural Pollution Management Programme (PMPOA)[1] established in 1993, farmers have been subsidised 65% of the costs of bringing buildings and manure storage facilities into line with environmental regulations (OECD, 2001*e*).
Germany	Support is provided at the regional government level. For example, in Bavaria farmers can get up to EUR 20 per m^3 of storage capacity up to a maximum of EUR 6 000 (Knickel, 1999).[2]
Japan	Grants have been traditionally provided to assist farmer, and have been supplemented since 1999 with low interest loans, and income and property tax concessions (FAPRC, 2001).
Norway	Support was provided between 1989 and 1998 in the form of grants of between 30-50% of construction costs to assist farmers in upgrading their manure storage facilities.
Sweden	Between 1988 and 1991, farmers in Nitrate Vulnerable Zones (NVZs) with more than 100 animal units could apply for support to cover 20% (maximum SEK 25 000) of the cost of upgrading manure storage capacity to 8-10 months. Under the Swedish Environmental and Rural Development Plan 2000-2006, any farmer can apply for 25% of the cost of enlarging capacity from 6, 8 or 10 months.
United Kingdom	Support is provided for capital investments in manure storage facilities within Nitrate Sensitive Areas through a targeted Farm Waste Management Grant Scheme, up to 25% of the total cost, with this figure set to increase to 40% in the future (OECD, 2001*f*).
United States	The Environmental Quality Incentives Program (EQIP), established by the 1996 Farm Bill, grants payments to farmers covering up to 75% of the investment cost of structural changes including building waste management facilities.[3]

Notes:

1. *Programme de Maîtrise des Pollutions d'Origine Agricole* (PMPOA).
2. A study of the Bavarian programme calculated that it would only be economically worthwhile to make the investment without the support of the subsidy if the cost of commercial nitrogen fertiliser was EUR 1.40 kg, compared to EUR 0.55 kg in the existing situation (Knickel, 1999).
3. The objective of EQIP is to encourage farmers to adopt practices that reduce environmental problems. By statute, 60% of funding is designated specifically to natural resource concerns associated with livestock production. Under the 1996 Farm Bill, large confined livestock operations were generally ineligible for cost sharing to construct animal waste management facilities. However, the 2002 Farm Act eliminated the 1 000 animal unit limit on eligibility for those cost-share funds, making larger operations eligible for assistance.

Source: OECD Secretariat.

For example, in **Denmark** it was estimated that the total investment by farmers in manure storage facilities to comply with the first Action Plan for the Aquatic Environment (APAE I) was over USD 470 million, averaging about USD 22 500 per farm (Dubgaard, 1991).[7] A number of OECD governments have therefore provided investment support for the expansion of manure storage capacity (Table 6.2). These often take the form of grants, interest concessions or special tax allowances. Moreover, the provision of this support varies over time depending on when the regulations were introduced and is often provided only for a limited period of time. For example, most of the support has already been provided in countries such as **Denmark**, **Norway** and **Sweden**, which have had more stringent storage requirements for a number of years.

In addition to support for manure storage, some governments have provided financial assistance for on-farm capital investment in manure processing facilities. The use of biogas recovery systems have been encouraged by the government in **Italy** through incentives for on-farm production of electricity (Knickel, 1999). In **Korea** support is provided through grants to assist the development of on-farm animal waste purification and processing facilities (Han, 1995). Support is also provided in **Japan** to assist farmers with manure processing facilities (FAPRC, 2001). The provision of support for such activities in these countries reflects the fact that they do not have large areas of land on which to recycle the animal manure as fertiliser in an environmentally sustainable manner. For example, in Korea only 20% of pig manure is spread onto agricultural fields.

Payments based on resource retirement

Payments based on resource retirement are policy measures granting monetary transfers (including implicit transfers such as tax and credit concessions) to farmers for retiring or removing resources from commodity production, including environmentally fragile land. Measures to reduce the negative environment impact of pigs by financing the exit of pig farmers have been recently implemented in **Belgium** and the **Netherlands**. In 2000, the **Netherlands** introduced a package of measures involving the purchase by the government of manure production rights and pig quotas, farm audit arrangements, assistance to individual farmers and demolition of farm buildings. The total cost of these measures was estimated at about EUR 900 million. It is anticipated that this buy-out scheme will reduce the Dutch national manure surplus by around one-third by 2003. By 2002, the scheme had been instrumental in reducing the amount of phosphate in manure by 7% and methane emissions by 6% (RIVM, 2002).

In Flanders, **Belgium,** a scheme was introduced in 2001 with the aim of reducing pig numbers by 10%.[8] Farmers received a premium of almost EUR 400 for every sow and EUR 118 for every fattening pig they sold to the state; with the government budgeting a total of EUR 75 million for the scheme. Farmers who participate in these buy-out schemes must stop pig farming completely, with the opportunity to receive the exit money available for a limited time period only.

Payments based on farming practices

Payments based on farming practices are policy measures granting annual monetary transfers (including implicit transfers such as tax and credit concessions) to farmers to encourage or constrain the use of farm inputs (farming practices) and/or offset the costs of implementing more environmentally friendly farming practices. Such payments are used to support pig producers to achieve environmental objectives in a number of **European Union** countries and the **United States**.

In the **European Union**, a large number of support programmes that fall under this classification have been established under the 1992 Agri-Environmental Regulation 2078/82, later brought under the 1999 Rural Development Regulation 1257/99.[9] This policy imposes a general obligation on EU member states to develop programmes for the promotion of the environment and the maintenance of the countryside, which go beyond mandatory requirements and normal "good farming practices". Farmers are reimbursed their costs on the principle of profit forgone, sometimes with the addition of an incentive element. But only a relatively small number of these programmes potentially provide payments to pig producers, and most of these concern programmes to compensate for lower rates of manure application made on a voluntary basis. Further, participation by pig producers in such programmes, including those examples mentioned below, is limited because of their high stocking densities.

Payments have been provided in **Denmark** since 1994 to support farmers who reduce their input of nitrogen to a level 60% below a certain standard. The premiums are in the range of EUR 80-120 ha per year, with the payment level determined by the yield achieved before taking part in the scheme. Beneficiaries are required to prepare crop rotation and manure and fertilisation plans and to keep balance sheets (Knickel, 1999). In the **United Kingdom**, all farmers in Nitrate Sensitive Areas (NSA) can agree to restrictions on their farm practices in return for standard payments per hectare. Pig farmers who own land and join the NSA scheme are able to receive annual support ranging from approximately EUR 90-900 ha depending on the area of the country and the extent of restrictions agreed to (Hanley, 2001).[10] In **Ireland**, pig farmers are currently eligible to receive annual support under the Rural Environmental Protection Scheme (REPS) (basic payment of EUR 25 ha) when they voluntarily reduce the level of manure they spread on land. Irish pig farmers are concerned about the introduction of by-laws which will make a reduction in the quantity of manure that can be spread compulsory and therefore make them ineligible for REPS support (Lara *et al.*, 2001). Similar programmes operate in **Germany** and **Finland**. In the **United States**, the Environmental Quality Incentives Programme (EQIP) also provides payments to implement land management practices including the application of manure.

Payments to assist in the conversion to organic agriculture have been an important objective of measures introduced under Regulation 2078/82. Again, the participation of pig producers in organic support programmes has been very limited due to the high livestock density and the large investment required to alter conventional housing systems to organic requirements. Under the Regulation, some member states have established programmes to promote ***biodiversity*** by supporting farmers who own local breeds threatened with extinction. In some cases, pigs are included but these are rare. For example, in **Sweden** farmers who have the Linderödssvin breed of pigs are compensated at a rate of SEK 1 500 per pig.

In some **European Union** countries, pig farmers are also potential beneficiaries of compensatory support measures other than those covered by Regulation 2078/82. In **Germany**, farmers who are subject to more stringent restrictions in water conservation areas are able to receive reasonable compensation for the economic disadvantages caused by the more stringent regional requirements on fertiliser use. The nature and the amount of compensation varies from region to region (Nies and Hackeschmidt, 1999). For example, in the state of Baden-Wuertteemberg, farmers who are restricted to applying 45 kgN/ha are provided financial assistance of EUR 159 ha, financed by a levy on consumers (van der Bijl *et al.*, 1999).

Environmental taxes/charges

Environmental taxes and charges are policy measures imposing a tax or charge relating to pollution or environmental degradation, including taxes and charges on farm inputs or outputs that are a potential source of environmental damage.[11] Such economic instruments have only been used on pig farmers in **Belgium**, **Denmark** and the **Netherlands**, with the purpose of discouraging the excess production of nutrients in manure. These are sector-wide taxes including, but not exclusive to, pig producers. In some cases they are related to the total level of nutrients from all nutrient sources, rather than those specifically from animal manure. While limited to just three countries, there has been an increase in the severity of these measures over time, in terms of both a reduction in the minimum threshold and/or an increase in the tax rate.

Taxes on phosphorus (P_2O_5) in manure were introduced in the **Netherlands** in 1986. All farms producing more than 125 kgP_2O_5/ha/year paid between EUR 0.11-0.23 kgP_2O_5, depending on the level of production. In order to stimulate lower N and P_2O_5 excretions, pig and poultry farmers were given the option of lowering the tax by proving that the N and P_2O_5 content in their feed was lower than the standard, using a "mineral input registration system". The levy system changed with the introduction of the mineral accounting system (MINAS) in 1998. Under MINAS, levies are paid by farmers on both N and P_2O_5 surpluses above a determined level per hectare, with the surplus calculated on the basis of all inputs and outputs including chemical fertiliser. Over the period 1998 to 2003 these surplus levels are decreasing (*e.g.* from 40 kgP_2O_5/ha in 1998 to 20 kgP_2O_5/ha in 2003) and the levy rate increasing (*e.g.* from EUR 1.1 kgP_2O_5 to EUR 9.1 kgP_2O_5 in 2003).[12] MINAS was introduced in 2 stages. Between 1998 and 2000, MINAS was only compulsory for all livestock farms with more than 2.5 livestock units per ha (about three-quarters of dairy farms and nearly all pig and poultry farms).[13] From 2001, all farms including arable and horticultural farms had to participate (van der Bijl, 1999), (ECOTEC, 2001).

In Flanders, **Belgium**, the 1991 decree established a levy on manure surpluses defined in terms of excess manure production in relation to land availability *i.e.* a surplus exists if the nutrient content of farm manure production exceeds a maximum application rate per hectare.[14] The initial levy rates were about EUR 0.5 kgP_2O_5 and kgN. Furthermore, producers who have to use the "manure bank" to dispose of their surplus were required to pay an additional tax of EUR 1.5 kgN and EUR 2.25 kgP_2O_5 (Hacker and Du, 1993). As part of the second Manure Action Plan in 2000, producers are taxed one EUR per kgN and per kgP_2O_5 content of manure that exceeds the farms "nutrient stop" level. A gradually increasing levy (rising from EUR 0.25 to EUR 1 kgN and kgP_2O_5 in 2003) is also paid by non family livestock farms which do not treat their surplus production as required (Dobbelaere, 1999).

In **Denmark**, the 1991 Action Plan for Agricultural Development required the establishment of maximum N quota levels for each farm from 1994 crop season. If producers exceeded these application rates by 1-5 kgN/ha or by 5-10 kgN/ha they were simply notified of their infringement or received a warning respectively. If they exceeded it by more than 10 kgN/ha then the infringement was handed over to the public prosecution with a demand that the producer be fined according to the established guidelines, with a maximum levy of less than one DKK (EUR 0.13) kgN/ha (Ambus *et al.*, 2001). Under the 1998 Action Plan for the Aquatic Environment (APAE II), the levies on the over application of N were significantly increased from the 1998/99 cropping year. If producers apply an excessive amount of N, at a rate of up to 30 kgN/ha, they are fined DKK 10 (EUR 1.35) kgN/ha. If producers apply at a rate of over 30 kgN/ha they are fined DKK 20 (EUR 2.69) kgN/ha.

Tradeable rights/quotas

Tradeable rights/quotas are measures that establish environmental quotas, permits, restrictions and bans, maximum rights or minimum obligations to economic agents which are transferable or tradeable. In terms of pig producers, such measures have only been used in the **Netherlands** where the manure production rights of livestock producers, which had been established in 1986, were made tradable in 1994. In order to reduce production levels, the government takes 25% of the quota involved in each transaction. This system continued with the establishment of MINAS in 1998. In the same year, farm manure production quotas for pig producers was transferred into a tradable system of pig production quotas, based on the number of animals (van der Bijl, 1999).

While not specifically creating a market through the establishment of tradeable rights/quotas, the main goal of the 1991 manure decree in Flanders, **Belgium** was to create an exchange between farms and regions with a manure surplus and regions with a demand for manure. The decree introduced documents for the exchange of animal manure between farms, with an obligation for farms producing large quantities of manure (above 10 000 kgP_2O_5) in regions with a high production density to transport their surpluses to regions with a low density of animal production. To assist this process, the government established a “manure bank” (Dobbelaere, 1999). As a result of this policy, the quantity of livestock manure transported from regions with manure surpluses to regions with manure deficits increased from 22 million kgN in 1992 to 60 million kgN in 1995 (van Gijseghem *et al.*, 2002).

Regulatory and legal measures

Measures classified under this category involve a compulsory restriction on the choice of economic agents, *i.e.* they are left with no choice but to comply with specific rules or face penalties (including the withdrawal of financial support).

Regulations

Regulations are compulsory measures imposing requirements on producers to achieve specific levels of environmental quality, including environmental restrictions, bans, permit requirements, maximum rights or minimum obligations. They are the most common policy measure used in OECD countries to limit the environmental impact of pig production. Again, it should be emphasised that relatively few of these regulations relate exclusively to the pig sector. These regulations range from the very broad prohibitions or requirements, to intricate details about farm management practices. In most OECD countries, *fines* and *penalties* are imposed on producers who are found to breach regulations or other legal requirements.[15]

(a) Prohibitions on discharge to water

In terms of ***water pollution***, laws prohibiting the direct discharge of animal waste to surface waters have existed in most OECD countries since the early 1970s. For example, since 1969 farmers in **Sweden** have been required to collect or treat waste water and silage effluents in a suitable manner to avoid negative impacts on human health or the environment (Swedish Ministry of Agriculture, Food and Fisheries, 2000*a*). Similarly, in **Ireland** the Local Government (Water Pollution) Act 1977 specified that a person shall not cause or permit any polluting matter to enter waters. Under this Act farmers could be issued with notices requiring improvements in their farmyard to reduce pollution potential, although these are generally issued after an incident of direct discharge into a watercourse. Failure to comply can result in a fine or imprisonment (Lara *et al.*, 2001). In **Germany**, the Water Resources Act 1996 obliges farmers to take the due care necessary according to the circumstances to prevent pollution of the water or any other negative change in its properties when implementing measures which can be connected with effects on a water body (Nies and Hackeschmidt, 1999). In **New Zealand**, all Regional Councils prohibit the discharge of untreated livestock manure to water.

(b) Distance and siting regulations

Distance and siting rules are the primary policy measure used to regulate the impact of air pollution from ***odours***. In general, local councils are given responsibility for the establishment of these requirements since concerns about odour are strongly linked to population density (Brouwer *et al.*, 2000). The impact therefore varies from producer to producer, not only between local council regions but also between producers in a local council area depending on where they are located. At a minimum, farm buildings and waste storage facilities are required to meet certain distances from residential premises or public facilities. They can also be based on the level of odour emissions, taking into account the nutrient make-up of the manure, management practices, animal housing and manure storage facilities, buffer zones, physical barriers, climatic conditions, and community consultation and involvement (Stringer and

Andersen, 2000). Overtime, these regulations are becoming more stringent. A recent survey in the **United States** found that 44 states enforce regulations on odour emissions and that these regulations are becoming more objective, relying more on odour measurement rather than odour perception (Redwin and Lacey, 2000).

In the EU planning controls, particularly to regulate the development of intensive indoor livestock units, are widely applied within member states in order to protect ***landscape quality*** in certain areas. Typical measures that apply through planning controls would include restrictions on the siting, design and size of new buildings, including pig production units (Brouwer *et al.*, 2000).

(c) Permits

Pig producers are often required to have permits. Some of these are more limited in scope, relating to a specific activity while others relate to the undertaking of pig farming as a whole. For example, in **New Zealand**, discharges into water of treated effluent require a consent permit from the Regional Council.[16] In the **United States**, the 1972 Clean Water Act (CWA) requires large confined animal feedlot operations (CAFOs), operations with over 1 000 animal units (equivalent to 2 500 pigs weighing more than 25 kg) to obtain a National Pollutant Discharge Elimination System (NPDES) permit. The standard permit states that all runoff from the site should be collected and stored, with the exception of runoff that results from a 25 year, 24 hour storm (Ribaudo, 2001). At the end of 2002, the US Environmental Protection Agency established stricter rules on livestock farms to curb excessive manure run-off that causes water pollution. All CAFOs must now apply for a permit, regardless of whether they discharge only during large storms. In the **Netherlands**, pollution permits are needed for ammonia and odour emissions under the Environmental Protection Act.

In the **European Union**, the objective of the Integrated Pollution Prevention and Control (IPPC) Directive (96/61/EC) is to achieve integrated prevention and control of pollution arising from different activities such as energy, mineral and chemical industries.[17] It requires member states to issue environmental permits for all potentially polluting plants of a given scale. The Directive is applicable to farms with more than (a) 2 000 places for production pigs (over 30 kg) or (b) over 750 places for sows. The permits impose emission limits to reduce both water and ammonia pollution, with each member state setting their own limits. The emission limits, parameters or equivalent technical measures should be based on best available techniques taking into account the technical characteristics of the installations concerned, its geographic location and local environmental conditions.[18] The Directive came into force at the end of October 1999 and will be applicable to new buildings over the first five years and then gradually extended to existing facilities (Brouwer *et al*., 2002). However, some EU countries have not yet reported to the European Commission that they have adjusted national legislation and some countries have still only partially transposed the Directive.

Pig producers in **Ireland** with more than 4 000 units are required to hold an Integrated Pollution Control (IPC) licence, which has been mandatory for new or expanding operations with more than 1 000 units since 1996 (Lara *et al.*, 2001).[19] In **Sweden**, farms with more than 200 animal units are required to apply for a permit to allow them to operate. The permit usually consists of requirements which go beyond the more general requirements of manure storage capacity, the application of manure etc. Farms with 100-200 animal units are required to register with the relevant municipal authority to be able to operate. The authority has the power to draw up specific requirements for each individual farm.

(d) Environmental assessment

Other permits are broader and require the environmental assessment of the whole production system. The **European Union** Directive on Environmental Impact Assessment (85/337/EC) has been in force for a number of years now.[20] The purpose is to ensure that the total effects of a project on both nature and people are assessed. A compulsory assessment is required for pig-rearing facilities with more than 3 000 places for production pigs (over 30 kg) or 900 places for sows. For other "intensive livestock installations" (no specific livestock numbers are given), member states are required to determine, through a case-by-case examination, if the project requires an environmental impact assessment.

In Flanders, **Belgium** all livestock producers must hold an environmental licence, which ensures that the conditions of manure storage and the environmentally sound disposal of manure are being met. Furthermore, farms with more than 2 500 cattle or 100 pigs older than 10 weeks are required to have an Environmental Effects Report giving a detailed description of air, water, soil and noise pollution (Wauters *et al.*, 1999). In **France**, livestock rearing facilities over a certain size have been required to register under the Directives on Nitrates of Agricultural Origin 1991. Farms with between 50-450 pigs must simply declare their herds while those over 450 pigs require a permit. To receive a permit an applicant has to provide an impact assessment giving details of the source, nature and magnitude of any disamenities liable to result from the installation (Vermersch, 2001).

(e) Restrictions affecting the level of manure production[21]

There are three forms of regulations placed on pig producers that directly affect the level of manure production. First, there are regulations that limit livestock density, which are common in Europe. **Norway** introduced legislation in 1975 to limit the size of livestock operations. While not introduced for environmental reasons they do reduce the environmental risks of intensive operations. Under these regulations, the maximum number of pigs for slaughter that can be kept is 1 400. In 1987, the maximum number of sows was limited to 70. Regional governments are allowed to permit larger operations but generally have done so only if the farms were larger than these limits before the regulations came into being. Furthermore, there are animal density regulations which requires farmers to have 0.4 hectares of land (either own or lease) per animal waste unit. An animal waste unit is equivalent to waste from one dairy cow and corresponds to 14 kgP_2O_5, therefore the restriction is equivalent to around 35 kgP_2O_5/ha (Morken, 1999). However, pig and poultry farmers who use phytase in their feed compound can have more animals per hectare because this additive increases the uptake of P_2O_5 by these types of animals.

Other examples include **Switzerland**, where the 1991 Law on Water Protection set a limit on livestock density equivalent to 3 livestock units (1 unit=1 cattle), equivalent to 45 kgP_2O_5/ha and 315 kgN/ha. Since 1995 in **Sweden** maximum livestock density limits have been set for all production units with more than 10 animal units.[22] For example, the number of animals per hectare may not exceed 2.2 sows in production or 10.5 fattening pigs (Swedish Ministry of Agriculture, Food and Fisheries, 2000*b*). In **Germany**, the number of animals that a livestock farmer is able to have is regulated by a maximum allowance of between 2 and 3 manure units per hectare. One manure unit is equivalent to 80 kgN/ha and 60 kgP_2O_5/ha, which in turn is equivalent under regulations to 7 fattening pigs (Hacker and Du, 1993).

Secondly, there have been measures to limit the quantity of manure produced. A system of manure production quotas was established in the **Netherlands** in 1986. The quota was based on historical standard manure production amounts per animal. Farmers were allocated manure production quota, expressed in kgP_2O_5. In Flanders, **Belgium** the first Manure Action Plan (MAP) which came into effect at the end of 1995, set a standstill on the total level of nutrient production from animal wastes at the 1992 levels of 75.1 million kgP_2O_5 and 169.1 million kgN. Within these total levels, changes can occur in production levels at the regional level depending on whether the region is classified as “white”, “grey” or “black”. In “white” or “grey” regions, where P_2O_5 production is less than 100 kg/ha, production is allowed to increase up to 100 kgP_2O_5/ha. In “black” regions, with P_2O_5 production greater than 125 kg/ha, growth is only possible when other livestock farms stop production.

Furthermore, within all regions increases in production were only allowed on farms that are defined as "family livestock farms", and only up to a maximum of 7 500 kgP_2O_5 (van Gijseghem, 1997).[23] In 2000, the second MAP introduced a "nutrient stop" level on every farm, limiting the annual level of manure nutrient production out to the year 2005 equivalent to the maximum annual level in the period 1995-97 (Dobbelaere, 1999).

Finally, there are restrictions placed on the expansion of livestock operations. These are in place at both the country level and in specific regions within countries. In Flanders, **Belgium** the first MAP banned new livestock farms. In **Spain**, the Restructuring Act stipulates minimum distances between farms and an upper limit on the size of new farms, making it difficult to set up a new farm of any size in areas which already have high pig populations, such as Catalonia (Bondt *et al.*, 2000). In the **United States**, some states have banned the introduction of new pig production facilities and/or put a limit on the expansion of existing facilities.

(f) Regulations controlling the quantity of manure that can be spread

A large number of countries impose restrictions on the quantity of manure that can be spread on land, primarily for the purposes of limiting ***water pollution*** (Annex Table 10). These restrictions vary from a set standard quantity across the whole country, to maximum levels established at each individual farm level taking into account a range of input and output factors. Most of the regulations relate to nitrogen, but some countries also impose restrictions on phosphates. Some relate to the total level of nutrients that can be spread while others include specific limitation on nutrients from animal manure. One of the major driving forces for such regulation in the **European Union** is the Nitrates Directive which set down precise limits on the quantity of nitrogen from manure that can be spread in designated areas (Box 6.1).

Box 6.1. European Union Nitrates Directive

In December 1991, the directive concerning the protection of waters against pollution caused by nitrates from agricultural sources (hereafter called the Nitrates Directive [91/676/EEC]) was announced.[1] The Directive contains three main provisions:

From December 1993, EU countries must monitor all water bodies, and have identified areas where water quality is threatened by nitrate pollution from agriculture (designated as Nitrate Vulnerable Zones [NVZs]). NVZs are identified as land areas where agricultural production contributes to drinking water quality problems (defined as containing more than 50 mg of nitrates per litre) or to the eutrophication of aquifers.

By December 1993, member states must also have established *voluntary codes of good agricultural practice* in order to secure a general level of protection against water pollution. These codes should cover, where relevant, issues such as the rate, timing and place of fertiliser (both chemical and animal manure) application, the capacity and construction of storage facilities, the use of catch crops and the establishment of fertiliser plans.

By December 1995, member states must have developed *action programmes* for their NVZs, to be implemented no later than December 1999. These mandatory programmes should consist of the standards contained in the voluntary codes but are specifically required to include rules relating to: periods when the land application of certain types of fertilisers are prohibited; a minimum capacity for manure storage facilities (related to the period of time when fertiliser application is prohibited); and limitations on the land application of fertiliser, consistent with good agricultural practices and the characteristics of the vulnerable zone. On this last point, a limit on the application of animal manure was specifically targeted in the Nitrates Directive, which set a maximum rate of 170 kgN/ha unless other actions are taken which compensate for a less restricted rate being allowed.[2] An exemption up to 210 kgN/ha was granted until 1999.

While all 15 EU members have taken steps to implement the Nitrates Directive, only **Denmark** and **Sweden** have earned recognition from the European Parliament for their work in implementing policies to meet the Nitrates Directive.[3]

Notes:

1. It should be noted that the EU first initiated nitrate policies in the 1970s. These focussed mainly on the quality of drinking water from a human health perspective. For example, the EC directive on the quality of drinking water (80/68/EEC) included 62 standards for a variety of compounds, including a maximum standard for nitrate of 50 mg/l based on the safety threshold set by the World Health Organisation. The *Nitrates Directive* is more wide ranging since it is also concerned with environmental definitions of nitrate pollution. See Council Directive 91/676/EEC in *Official Journal* No. L375, 31/12/1991, 0001-0008.

2. The maximum application rate relates to the amount of nitrogen that can be spread on the field. The Directive does not explain how or at what stage the nitrogen content in the manure should be measured. See Frederiksen (1997) for further comment on this.

3. See Goodchild (1998) for a summary of implementation measures taken by EU member states by that time and reasons why implementation is so poor. For a more recent update consult the European Commission Report COM(2002)407 on *The Implementation of Council Directive 91/676/EEC concerning the Protection of Waters against Pollution caused by Nitrates from Agricultural Sources*, http://europa.eu.int/comm/environment/water/water-nitrates/report.html.

(g) Regulations controlling the way manure is spread

In addition to regulations on the quantity of manure than can be spread, restrictions have also been placed to control the way manure is spread (Annex Table 10). Regulations governing the spreading of manure have got more restrictive over time. To limit ***water pollution***, restrictions are often placed on when manure can be spread and how close to waterways, ditches, wetlands etc. to restrict nutrient run-off nutrients. These timing restrictions are generally stricter in countries with colder climates. Additional restrictions have been established in some countries to reduce ***ammonia emissions***, involving the need to incorporate manure into the soil or restricting the manner in which manure is spread. Regulations regarding the spreading of manure are used also to reduce the impact of ***odour air pollution***.

(h) Regulations on manure storage

Because restrictions have been placed on how much and when manure can be spread, pig farmers must have some facilities for holding and storing manure. Regulations have also been introduced to regulate this activity. Differences emerge between countries in terms of the type of storage facilities required (*e.g.* clay versus concrete storage pits) and the minimum level of storage that is required, if required at all. Again requirements tend to be stricter in those regions with highest concentration of livestock or in the northern part of Europe where climatic conditions impose greater limitations on the application of livestock manure.

In **Norway**, regulations require that all farmers have concrete storage capacity for 8 months manure production. For practical purposes most farmers have capacity for 12 months and although not required most (91%) have a cover. In **Sweden**, pig farmers in the designated NVZs with more than 10 animal units must have storage facilities for 10 months of animal manure production while farmers with less than 10 units must have storage facilities of a size corresponding to 6 months manure production. Since 1995, pig farmers in non-NVZs with more than 100 animal units must also have 10 months storage capacity. Since 2000, storage facilities have been required to prevent runoff leakage into the surrounding environment (Swedish Ministry of Agriculture, Food and Fisheries, 2000*a*). In **Denmark**, under the 1987 Aquatic Environment Action Plan all livestock farms are required to have between 6 to 9 months storage capacity depending on an individual farm assessment before 1 January 1993. In practice, most farmers have 9 months capacity.

In Flanders, **Belgium,** farmers must have 6 months storage capacity. In **Germany**, the determination of the necessary storage capacity varies from state to state. National regulation require that it must be greater than the capacity necessary during the longest period when application to agricultural land is prohibited unless it can be proven that the excess quantity will be disposed of in an environmentally sound fashion. However, there are some national requirements relating to the construction of such facilities, including the requirements that storage facilities for liquid manure must be impermeable to water and facilities for the storage of solid waste must have a water-impermeable bottom plate. In areas requiring special protection, facilities for storing manure are generally prohibited in the inner protection zones, and are only permissible in the extended protection zones if they are equipped with special leak identification devices (Nies and Hackeschmidt, 1999). In the four regions of the Po Valley, **Italy**, pig farmers must have 6 months storage capacity, with some possibility for reduction in specific conditions (*e.g.* where there are slurry treatment facilities, small farm size etc.) (Cortellini and Bonazzi, 1999).

In **Japan**, the Law concerning the Appropriate Treatment and Promotion of Utilisation of Livestock Manure of November 1999 banned the open-air and earthen storage of livestock manure after a certain transitional period. From that point livestock farming will not be able to practice without appropriate compost houses and clean-up facilities (FAPRC, 2001). In **Canada**, regulations vary from province to province. For example, in Quebec livestock facilities larger than a minimum size threshold are required to maintain manure storage facilities with at least 250 days storage capacity. Location, design and construction are designed to minimise risk to surface or ground water. The Ontario Guide to Agricultural Land Use recommends 200 days storage capacity (Fox and Kidon, 2002).

Regulations have also been put in place in recent years to reduce ***ammonia emissions*** from manure storage facilities. Again, these have been primarily introduced in northern European countries. In **Sweden**, since 1997 all farms with more than 10 animal units have been required to cover their slurry and urine pits with a stable surface crust and that filling takes place below the covering. In **Denmark**, the 2001 Action Plan for Reducing Ammonia Volatilisation from Agriculture required liquid manure slurry containers to be covered on all livestock farms from 1 August 2001, except if a farmer participates in an in-house control system which documents the presence of a sufficiently tight floating layer. From 1 August 2002, solid livestock manure stores not in daily use must be covered (Ambus *et al.*, 2001).

(i) Regulations requiring on-farm budgets/fertiliser plans

Pig farmers are required to prepare and submit on-farm nutrient budgets or fertiliser plans in a number of OECD countries. The level of information required in these plans varies in relation to the importance of these plans in the overall system of measures affecting pig producers. For example, fertiliser budgets form an integral part of the system in **Belgium**, **Denmark** and the **Netherlands**, where levies are imposed on excess nutrients.[24] However, a number of other countries also require farmers to submit plans. In **Norway**, all livestock farmers must submit an annual fertiliser plan, indicating all inputs and uptakes. Farmers in parts of Cork County, **Ireland**, must maintain a monthly record of the amounts, locations and dates of application of organic and chemical fertilisers applied to farm land. In the Lombardia, Veneto and Emilia-Romagna regions of **Italy**, pig farmers are required to provide a detailed fertilisation plan when production is above a certain level, which varies depending on the area (Cortellini and Bonazzi, 1999). Mineral balances are also needed in **Germany** on holdings exceeding 10 hectares or where the supply of N exceeds 80 kg of N per hectare. N balances are required annually, while phosphate and potassium balances are required once every three years (Brouwer *et al.*, 2000).

In Quebec, **Canada** nutrient management plans were phased in over the period 1997 to 2001. Producers must provide a plan which includes among other things fertiliser and manure application rates including an estimate of the N and P_2O_5 contents, soil test results and a listing of parcels of farm land determined to be rich or excessively rich in P_2O_5 (Fox and Kidon, 2002). In the **United States**, 23 states currently require some form of nutrient management plan for at least some classes of animal operations. For example, in Illinois, facilities with more than 1 000 animal units must prepare and maintain a waste management plan and operations over 7 000 animal units must submit this plan to the state Department of Environment Protection for approval (Ribaudo, 2001). Under the new Clean Water Act regulations introduced at the end of 2002, an estimated 15 500 concentrated animal feeding operations (CAFOs), livestock farms having more than 1 000 animal units, must write and implement comprehensive nutrient management plans by December 2006 and submit annual reports with the number of animals, the amount of manure generated and disposal methods.

Cross-compliance mechanisms

Cross-compliance mechanisms are measures imposing environmentally friendly farming practices or levels of environmental performance on farmers participating in specific agricultural support programmes. They have been a common development in OECD countries over recent years. However, because there are very few direct payments provided to pig producers in OECD countries there are only a limited number of cases where such conditions have been attached. In **Switzerland** direct payments to pig producers are conditional on certain livestock nutrient management practices. Since 1999 Swiss farmers, including pig farmers, can only receive direct payments if they provide Required Environmental Services (RES). One of these RES is a balanced fertiliser budget, whereby a farm's nitrogen and phosphate inputs and outputs are calculated, with a maximum allowable surplus of 10% (Hofer, 2000). In **Norway**, livestock farmers who indicate in their annual fertiliser plan that they will fertilise at a level above established application limits are penalised with a reduction in the headage payment rate. Cross-compliance conditions requiring the development of fertiliser plans, including the proper use of manure, have been imposed on per-hectare payments in **Denmark** from 2000 (Anthonisen, 2000).

Advisory and institutional measures

Advisory and institutional measures include collective projects to address environmental issues and measure to improve information flows to promote environmental objectives. This information can be provided to both producers, in the form of technical assistance and extension, and to consumers, via labelling.

Research

Research measures grant support to institutional services to improve the environmental performance of agriculture through research on environmentally friendly production technologies, pollution prevention, quality control management systems, and green marketing. Across all OECD countries, governments are funding ***research*** investigating the relationship between pig production and the environment. This research is undertaken in order to establish best management practices to be communicated to farmers through on-farm technical assistance, or to establish the most appropriate regulations or other policy measures. It often covers a broad range of scientific enquiry including ecology, engineering, farm management practices, farmer behaviour, and economics. Attempts have been made in some countries to try and bring together research and education being undertaken across these disciplines into a common framework.

The 1998-1999 Hog Environmental Management Strategy in **Canada**, for example, was a partnership between the federal and provincial governments and the pig industry with the objective of developing a national approach to finding effective and affordable solutions to the environment challenges confronting the industry. The success of this programme led to the establishment of a Livestock Environment Initiative in 2000 focussing on the wider livestock industry. In October 2001, 17 research organisations in **France** launched a co-ordinated four-year research programme called *"Porcherie Verte"* (Green Pork). The programme has a total budget of EUR 12.7 million and involves seventy researchers who will be looking to develop pig production systems that take into account issues such as the environment, animal welfare, product quality and profitability.

The types of research undertaken can be divided into three broad areas. First, research is being undertaken to improve the understanding of the link between pig production and the environment. For example, in Flanders, **Belgium**, research is underway to investigate whether a relationship between water quality (as measured by the limit of 50 $mgNO_3/l$ water) and the nitrate residual in the soil can be established. This research is being undertaken to clarify whether the targets of the Nitrates Directive can be translated into a parcel specific controllable regulation and whether the current regulation is sufficient to prevent the eutrophication of the surface and groundwater (van Gijseghem *et al.*, 2002). In **Denmark,** on-farm indicators of resource use are being developed to enable farmers to include more accurately the environmental impact of production in their farm management decision making process (Halberg, 1999). In the **United States**, The Board on Agriculture and Natural Resources and the Board on Environmental Studies and Toxicology of the National Academy of Science are researching air emissions from livestock feeding operations. The project will review and evaluate the scientific basis for estimating the emissions of various air pollutants (including ammonia, odour, methane, and nitrous oxide) from confined livestock and poultry production systems to the atmosphere and potential best management practices, including costs and technologic feasibility.

A second area of research is focussed on finding ways to reduce the level of nutrients excreted in manure, since this is the source of most of the environmental concerns associated with pig production. The major focus here is increasing feed digestibility/feed conversion efficiency of animal feeding systems through diet manipulation, use of feed additives and the physiological alteration of livestock (Chapter 3). **Canadian** research has found that for pigs the use of specific low-N diets can reduce total N excretions by more than 50% (OECD, 2001*f*). Feed additives containing enzymes (*e.g.* phytase) have also been extensively researched in countries such as the **Netherlands. Canadian** scientists have recently developed genetically modified pigs that produce phytase in their salivary glands which excrete 75% less P_2O_5 than non-transgenic pigs (Golovan *et al.*, 2001).

Another broad area of research is looking at how best to manage the nutrients that are produced to minimise their environmental impact. This mainly involves research into areas such as livestock housing, manure storage facilities and the spreading of manure (Chapter 3). Research has traditionally focussed on water and odour concerns, with a particular emphasis on nitrogen as the nutrient of concern, with research lacking with regard to phosphorus, other chemical elements and pathogens (Williams, 2001). A growing amount of research is focussing on ammonia emissions. For example, in terms of manure spreading, research has been examining the extent to which different methods, such as shallow and deep injectors, trailing shoe spreaders and band spreaders, reduce ammonia emissions. Other techniques being investigated include covers for slurry storage tanks (such as rape seed or chopped straw) and lactic acid as a slurry additive to reduce the pH value. For example, in **Switzerland** a joint research project supported by the Ministries of Agriculture and Environment began in 1999 to work out specific recommendations for ammonia abatement measures in different regions and conditions. This project arose from the fact that initial work had shown that the maximum technically feasible abatement potential for ammonia emissions during manure application was around 70% on a low-land farm with optimal conditions but only 10-15% on a typical mountain farm (Menzi *et al.*, 1999).[25] A number of OECD countries, including **Austria**, **Canada**, **France**, the **Netherlands**, **Poland** and the **United Kingdom** are conducting research on the GHG implications of manure management (OECD, 2001*f*). In some countries research is also being conducted to develop biogas recovery systems and for processing manure into more concentrated forms to reduce transportation costs.

Technical assistance and extension

Technical assistance and extension are policy measures providing farmers with on-farm information and technical assistance to plan and implement environmentally friendly farming practices. Most OECD countries provide ***advisory services*** specifically targeted at improving the environmental performance of pig producers. This assistance can take a variety of forms including: technical advice regarding the construction of manure storage facilities; practical advice on the spreading of manure; the development of nutrient management plans; and the monitoring of environmental impacts. For example, in the **United States**, the Conservation Technical Assistance Program operated by the National Resources Conservation Service (NRCS) provides technical assistance to pig producers, with extension and advisory services provided by the Cooperative State Research Education and Education Service (CSREE) and state partners. In the **European Union**, technical assistance has been provided to assist the implementation of the Voluntary codes of good practice required by the Nitrates Directive.[26] These inform farmers about practices to reduce the risk of nutrient pollution.

Another focus of technical assistance has been to encourage farmers to alter their feeding regime. Providing a level and composition of feed that matches more closely the animal requirements allows farmers to achieve the same level of pigmeat production with less surplus N.[27] Such a strategy can be seen as an example of a win-win situation and more likely to be taken up by farmers. For example, the government in **Denmark** has encouraged the development of more efficient protein feeding of livestock by adjusting the amino acid composition of the diet (Winther, 2001).

Technical assistance is often the first type of policy measure implemented to deal with environmental issues associated with pig production. In **Sweden**, programmes to promote education, information and extension services on environmental issues relating to nutrient management have been in place since 1986. Today, funding through an agri-environmental programme promotes education, information and demonstration on environmental issues in the agricultural sector, including individual services, field and farm courses or demonstration sites (Swedish Ministry of Agriculture, Food and Fisheries, 2000*b*). Nitrate policies in **France** have been based primarily on advisory campaigns, extension services and promotion of research projects (Brouwer *et al.*, 1999).

While reducing water pollution has been a major focus, technical assistance has also been introduced in recent years in response to some of the other environmental concerns associated with pig production. In the **United States**, for example, under the AgSTAR Progam, a voluntary pollution-prevention programme launched in 1994, the Environment Protection Agency and USDA are working with livestock producers to capture the methane released from manure management systems (OECD, 2001*f*). However, little progress has been made with only 15 pig producers installing digesters for biogas production. Another common feature of technical assistance in recent years is the increasing use of the internet as a tool to distribute information and best management practices. For example the online data base ManureNet presents a partial inventory of the research, development and demonstration projects initiated in the 1990s in the area of manure management in **Canada**.[28]

Labelling standards/certification

Labelling standards/certification are voluntary participation measures defining specific eco-labelling standards that have to be met by farm products for certification. To date, no measures that specifically establish eco-labelling and certification for pig producers have been introduced. The federal government in **Canada** is currently supporting a programme (the National Environment Management Standard Initiative) administered by the Canadian Pork Council to develop an environmental management certification system for the pigmeat industry which may be introduced in the near future. However, pig producers may be able to qualify under more general eco-labelling/certification systems, for example organics, provided they comply with the appropriate regulations. In the **Netherlands**, a Green-Label housing system was introduced in 1993 to promote the adoption of housing techniques that reduce ***ammonia emissions***. For pig farmers, there are currently 30 possible systems that they can adopt to receive a Green-Label. A farmer who invests in such a system is supported by a special income tax rate and a guarantee that the government will not require them to rebuild their barns for 15 years (van der Peet-Schwering *et al*., 1999). However, little or no use has yet been made of low-emission housing for pigs (RIVM, 2001).

Community-based measures

Community-based measures are those granting support to public agencies or community-based associations (*e.g.* Landcare groups, conservation clubs, environmental co-operatives) to implement collective projects to improve environmental quality in agriculture. Some governments have supported the ***development of alternative uses of manure*** to reduce environmental pressure and alleviate some of the constraints placed on farmers by restrictions imposed on the land application of manure. Since 1987, the government in **Denmark** has developed a series of action plans for developing centralised biogas plants, to which manure is transported from nearby farms. After an initial development and demonstration programme, 20 large community-sized biogas plants have been established, using both pig and dairy manure. The development of these plants have been supported by a number of government policies: investment grants of between 20-40% of construction costs; an exemption of biogas and heat from biogas from energy tax; a state production grant of DKK 0.27 per kW electricity produced; and low interest rate, long term loans from local government (Hjort-Gregersen, 1999). In **Austria**, the government has also supported the construction of biogas fermentation plants that utilise animal manure (OECD, 2001*f*). In **Germany**, public funding has also been used to establish biogas plants, and in September 1999 a new four-year programme was launched (OECD, 2001*f*). Since the early 1990s, the government in **Korea** has financially supported the development of co-operatively based manure processing facilities in areas densely populated with livestock. In these facilities, manure is passed through a process of aeration, aerobic fermentation and chemical treatment to produce fertiliser that is then sold to horticultural farmers (Han, 1995).

In addition to government established codes discussed above, ***producer groups have established own codes of practice*** in a number of countries. For example, in **New Zealand**, the pig farming industry has responded to the growing public concern on environmental issues by forming an Environmental Task Force, developing a Code of Practice for Pig Farming and funding research for specific environmental and animal welfare issues. The codes define methods by which piggeries and their manure collection, treatment, handling and utilisation facilities may be correctly sited, designed and managed to meet legislative requirements and avoid nuisance. The Monogastric Research Centre, established by the industry, promotes liaison group meetings between Regional Councils and local pigmeat producers, undertakes research and provides educational opportunities for pig farmers (Dobson, 2001).

In **Germany**, a feeding programme has been developed between farmers and feed manufacturers with the aim of reducing phosphorus and N output from pig and poultry farms. The RAM-feeding programme involves the use of feeds with fixed upper limits on dietary protein, combined with minimum levels of lysine for the different stages of growth (Hacker and Du, 1993). The programme operates on a contractual basis and is controlled by the regional Chambers of Agricultural. Studies have shown that the excretion of phosphorus and nitrogen from finishing pigs can be reduced by 33% and 24% respectively as a result of this feeding regime (Brouwer *et al.*, 1999).

The government in the **Netherlands** has taken a particularly active stance in supporting these kinds of private-sector, producer-led environmental initiatives in recent years across a broad range of issues (Brouwer *et al.*, 2002). An interesting approach has been to foster and develop a dialogue between pig farmers, societal groups (including the Foundation for Nature and Environment), pig processing firms and government representatives. The aim of the project was to develop a business perspective for pig farmers in the Netherlands that would enable them to produce for the market while taking into account societal concerns, including the environment. Pig farmers consider that because of growing public concern they require a “licence to produce” from the Dutch Society and have taken steps to try and obtain this (Brackus and van der Schans, 2000).

NOTES

1. The information contained in this Chapter may not fully represent the situation faced by every producer in every country. This is especially true when having to incorporate sub-national information for provincial/state or municipal policies. This was done on a limited basis to be representative and does not fully explore the situation for all producers at the local level.

2. For further information on the Water Framework Directive, see www.europa.eu.int/comm/environment/water/water-framework/index_en.html.
Directives are the primary form of legislation for most EU environmental policy. They are binding as to the results to be achieved but they leave to the member states the choice of form or method to be used. Further, they may contain different requirements reflecting the different environment and economic conditions in member states. As a result, there can be significant differences in legislation in place in different parts of the EU (Brouwer *et al.*, 2002).

3. See, for example, OECD (2001*f*) which includes information about the impact on greenhouse gas emissions from agriculture that arise from policy measures with other objectives.

4. For details of the Helsinki Convention and its status see www.unece.org/env/water/.

5. Concerning background to the OSPAR Convention see www.ospar.org/; for the North America International Joint Commission see www.ijc.org/ijcweb-e.html.

6. Details of the Gothenburg Protocol to abate acidification, eutrophication and ground-level ozone can be found at www.unece.org/env/lrtap/gothenb_h1.htm.

7. The 1987 Action Plan for the Aquatic Environment's target was to achieve a 50% reduction in nitrogen emissions to the aquatic environment by 1993 compared to the mid-1980s. For agriculture, the target was to be obtained by reducing direct nitrogen discharges from farms by 27 000 tonnes and nitrogen leaching from fields by 100 000 tonnes. The 1991 Action Plan for Sustainable Agriculture postponed the achievement of these targets until 2000. A further review in the mid 1990s lead to the establishment of a second Action Plan for the Aquatic Environment (APAE II) in 1998 which postponed these targets to 2003.

8. This study only reports policy measures introduced in the Flanders region of Belgium and not in either the Walloon or Brussels regions. Around 95% of Belgium's pig population are reared in Flanders.

9. See the *Official Journal* No. L215, 30/07/1992, 0085-0090. In 1996, the Commission established a regulation (Commission Regulation 746/93/EC) setting out detailed rules for the application of this Council Regulation, see Official Journal No. L102, 25/04/1996, 0019-0027. As part of the Agenda 2000 CAP reform, this regulation was strengthened and enlarged as a single chapter within Regulation 1257/1999 on Rural Development.

10. The Nitrate Sensitive Area (NSA) scheme began in 1990 in response to the EU Water Directive. There are 32 designated NSAs in England and Wales, accounting for 35 000 hectares. Since 1994, the NSA scheme has been carried out under EU Regulation 2078/92 to ensure EU co-financing.

11. Fines imposed on producers for failure to meet regulations are not classified as taxes/charges. They provide an economic incentive to adhere to a mandatory regulation, like cross-compliance payments.

12. The original time frame over which the reduction was to occur was ten years, 1998-2007. However, in late 1998 the Dutch Government decided to achieve the same reduction over the period 1998-2003.

13 In the Netherlands one Livestock Unit is equivalent to one dairy cow.

14. The 1991 decree also provided for the establishment of Manure Action Plans, the first introduced in 1995 and then updated in 2000.

15. For example, in Quebec, Canada, failure to comply with regulations can result in a fine of between USD 1 000 to USD 500 000 depending on the nature of the offence (Fox and Kidon, 2002)

16. This method of disposal is being phased out and consents are generally much harder to obtain. Where treatment of effluent is carried out on farm, a simple two-pond system is used. This reduces suspended solid, nutrient and microbial levels. Manure from pig farms is usually spread on land although two-pond treatment systems are still quite common in the pig industry.

17. See Council Directive 96/61/EC in the *Official Journal* dated 25 March 1996.

18. See, for example, Magette *et al.* (2001) which outlines the work done to establish best available techniques for pig and poultry sectors in Ireland.

19. Under Irish law, 1 pig = 1 unit, 1 sow = 10 units.

20. In 1997, the Council extended the number of projects covered by the original Directive (97/11/EC).

21 . Restrictions on the quantity of animal manure that can be spread also has an impact on animal numbers but this Chapter deals specifically with measures that impose direct limitations on livestock density for environmental reasons.

22. In Sweden, one animal unit corresponds to one full-grown cattle, one horse, 10 fattening pigs, 100 poultry, etc.

23. The definition of a "family livestock farm" is based on: (a) the farm management structure (*i.e.* must show economic independence from feed processors and that farming is main source of income; (b) farm size (*i.e.* should not exceed 1 800 pigs, 100 dairy cows, 700 calves or 70 000 laying hens) and (c) sufficient land to dispose of 25% of the manure produced on the farm.

24. In Denmark, the 1987 APAE established the compulsory preparation of fertiliser management plans for all farms with at least 10 hectares of agricultural land. Investigations had found that farmers were generally applying 5-10% more nitrogen than they needed, and so it was hoped by preparing plans some farmers may voluntarily reduce the amount of fertiliser applied (Dubgaard, 1991).

25. See Rom and Sorensen (2001) for an example of the technical and economic research going on in the field of ammonia emissions. See Hendricks *et al.* (1999) for an estimation of the cost to Belgium pig farmers of implementing different ammonia emission reduction techniques. See Klimont and Amann (1999) for a summary of the computer model developed to support the Acidification Strategy of the European Union.

26. Austria, Denmark, Finland, Germany, the Netherlands and Luxembourg have all designated their entire country as a NVZ under the Nitrates Directive. As a consequence all farms in these countries face mandatory requirements including compliance with the "voluntary" codes of good practice.

27. Such technologies can reduce N-output in pig manure by 20% (Vrillon *et al.*, 1999).

28. See http://res2.agr.ca/initiatives/manurenet/manurenet_en.html.

Chapter 7

THE EFFECT OF MANURE MANAGEMENT REGULATIONS ON INTERNATIONAL COMPETITIVENESS

Significant differences in the competitiveness of pig production along with growing international competition in the pigmeat market have raised concerns about the cost impact of environmental regulations on producers, particularly those regarding the management of manure. There appears to be a U-shaped relationship between farm size and the costs imposed by manure management regulations. This results from the additional application and transport costs for large-scale producers, and the lack of scale advantages for smaller farms in meeting regulations. Costs imposed on producers by manure management regulations in different countries do not appear to be of a scale that could explain the general difference in pigmeat competitiveness between countries.

The world market for pigmeat has grown rapidly during the past decade and the market is expected to expand further. The international pigmeat market is highly competitive and economies of scale are important to obtain, hence stimulating the development of large-scale livestock operations. This Chapter examines the impact of environmental regulations concerning the storage and disposal of manure on the competitiveness of pig farming.

The general competitiveness debate

In general, national approaches to environmental regulations vary considerably. Some countries have rather vague requirements while others have developed very strict and demanding regulations. Notable differences in the scope and character of national environmental regulations have raised concerns about their impact on trade. Three main issues have been raised.

First, concerns about the risk of a "race-to-the-bottom" in pollution control arise in countries with higher domestic environmental standards. According to this hypothesis, if free trade occurs between countries with different environmental standards, countries with higher environmental standards will be forced by their domestic interest groups to lower their standards to ensure the survival of environmentally sensitive industries.

Secondly, the "pollution haven" hypothesis predicts that if free trade occurs between countries with different environmental standards, countries with lower standards will possess a comparative advantage in environmentally sensitive industries. This will result in "havens" for the dirty industries and production will shift to these areas (Box 7.1). One of the differences between the "pollution haven" hypothesis and the "race-to-the-bottom" hypothesis is that the latter implies an overall world level of environmental regulation that is less than optimal, while the former does not (Frankel and Rose, 2002). In the "pollution haven" case, differences in environmental regulation can reflect public preferences for environmental quality.

Box 7.1. The impact of environmental regulations on pig producers' location decisions

It has been hypothesised that geographic variations in the stringency of environmental regulations and enforcement can induce the migration of industries across state or national borders to "pollution havens" where compliance costs associated with environmental regulations are lower.

Regional concerns surrounding the environmental management of pig operations have created a mosaic of state level environmental policies across the **United States** and the **European Union**. In some cases these environmental regulations have imposed compliance costs on producers that have ultimately reduced profits. In the United States, manure management costs range from USD 0.40 to USD 3.20 per pig depending on the state selected (Sullivan *et al.*, 2000). This represents between 1% and 8% of the total pig production cost. These costs were found to be higher than in previous years due to the added costs of regulatory compliance. In the European Union, compliance costs for pig producers were found to have increased overtime as a result of the Nitrates Directive.

Four key factors have traditionally influenced business location decisions: natural resources, economic costs, business climate, and public policies (including environmental regulations). A study based on interviews with business executives concludes that perceived levels of political stability, tax and exchange rates and the ease with which profits can be repatriated further influence international location decisions. Environmental regulations were ranked much lower on the list of considerations (Levinson, 1996). Studies focusing specifically on pig production indicate that precipitation, feed costs, animal health risks, transportation costs, and the existing concentration of pigmeat production in an area also affect location decisions. Others suggest that producers might be attracted to areas with stringent regulations as the uncertainty of having to deal with new regulations is removed (Sullivan *et al.*, 2000).

It is difficult to estimate the degree to which environmental regulations and their enforcement mpact upon location decisions, primarily because of the complexity underlying the two relationships. It is hard to quantify or rank the stringency of different environmental regulations, as the policy targets, instruments used, and levels of application vary to such a great extent. Furthermore, it is problematic to compare enforcement rates due to the lack of information available from both regulator and industry. Even if this information were available, neither a prosecution rate nor a compliance rate could adequately convey the collective producers' perception of enforcement stringency, which is ultimately what determines location decisions.

In the **United States**, most studies conclude that to date geographic variations in environmental policy have had little effect on pig producers' location decisions due to the minimal compliance costs imposed (Mo and Abdalla, 1998; Martin and Norris, 1998; Park *et al.*, 2000; Park *et al.*, 2001; Metcalfe, 2001). Although environmental policy may increase production costs differentially across states and operation sizes, either sunk costs in infrastructure and market development, or other advantages, deter most producers from shifting the location of their operation to avoid these additional costs (Park *et al.*, 2000). Others found that the more a state spends on environmental enforcement, the less likely a given firm will locate there *i.e.* it was not the stringency of the regulations but the perceived stringency of their enforcement that was most likely to affect producer decisions (Sullivan *et al.*, 2000). However, very few operations in any state have been penalised so far for breaching environmental regulations. And where penalties have been levied, they have usually been minimal when compared to the overall costs of the operation.

Evidence of a negative correlation between stringency of environmental regulations and plant location decisions has been show in some cases (Henderson, 1996; Gray, 1997), but neither of these studies included pig or livestock production. While compliance costs associated with environmental regulations have to date only played a minimal role in influencing **United States** pig producers' location decisions, this may change in the future as regulations become stricter and enforcement improves. Evidence in the **Netherlands** indicates that regulation can halt the regional migration of pig farms (Maas and Wisserhof, 2000).

Finally, concerns are expressed about the impact of higher environmental standards on competitiveness. Since strict environmental regulations may increase costs and limit the competitiveness of environmentally sensitive industries, they may reduce exports of such goods. Others argue that the relationship between environmental regulations and international competitiveness can be complementary rather than mutually exclusive (Porter and van der Linde, 1995). Well-designed environmental regulations can induce technological innovations, which may offset the costs of complying with them, such as through increased efficiency in use of energy and resources, or through more radical changes in production technologies. Efficiency improvements and innovation by pig producers in the **Netherlands**, particularly in terms of the development of modified feeding regimes, are estimated to have offset the compliance costs incurred by increasing environmental standards during the period 1987-1996 (Wossink and Wefering, 2002).

The literature on the competitiveness effect of environmental regulations is ambiguous. The ambiguity stems from the complexity of the issue and the predominance of aggregated research approaches that survey the competitiveness issue at a macro-level, based on data from several countries, industries and time-periods. Several studies conclude that negative effects on competitiveness cannot be clearly identified (Jaffe *et al*., 1995). One reason often given for this finding is that costs imposed by environmental regulations are relatively modest as compared to other costs and generally do not exceed 1-2% of production costs. Most of these studies are based on data from the 1980's and earlier, and focus on industry — there have hardly been any studies related to specific agricultural sectors.

Competitiveness issues in the pig sector

In many respects, the potential competitiveness impact of environmental regulations imposed on pig farming remains an adjunct to the overall debate on the relative competitiveness of pigmeat production in various countries. Empirical studies of competitiveness and relative factor cost advantages are hampered by basic differences in pig farming systems among different countries. First, the final product, the pig for slaughter, is by custom delivered at different sizes and weights. In some markets the emphasis has deliberately been on the development of leaner pigmeat types. Hence, products can hardly be compared on a per-weight basis. Secondly, the feed types and feed intakes vary with production systems. In some markets grain and soybean prices are distorted by subsidies so that farmers have substituted non-grain feed ingredients for feed-grains. Feed choices will vary over time with relative price changes.

A recent study compared factor costs in different jurisdictions in **Canada** and **United States**, with the **Netherlands** and **Denmark** (Martin and Kruja, 2000). It found that when costs were totalled there were clear cost advantages for North American pig producers. The lowest costs were found in the prairies of western Canada, followed by the western corn-belt of the United States. Total costs per live weight were 80-85% higher in the Netherlands and Denmark. Although this difference is very substantial, a similar scale of difference has been found in earlier studies by other North American authors *e.g.* Brewer *et al*., 1998.

The main factors explaining the higher costs in Europe were found to be labour and interest costs. However, the study only included labour, capital, buildings and feed costs. Omitted from the study were veterinary, manure disposal and marketing costs. The study nevertheless raised an interesting question: "If Western Canada has such an advantage especially over Europe why does Denmark continue to have such a large share of the export market?" They discard explanations related to subsidies and point to the more integrated nature of the Danish industry, based on co-operatively owned processing plants and alleged system efficiencies.

A further explanation could be that a per-weight comparison is not meaningful. One of the competitive advantages of Denmark is with the leaner types of pigs that have been developed with less fat and more meat. In general, Danish market pigs are 10-15% lighter in weight than the standard North American pig. "Leanness" is measurable, but measurement methods differ and no adequate method for comparison of leanness seems to exist (Brewer *et al*., 1998). Whether North American produced pigs are more competitive than European produced pigs seems to depend on a wider set of considerations than just differences in environmental regulations.

Comparative analysis of manure regulations

It is difficult to compare the few national studies which estimate the costs of environmental regulations because they use different cost-bases and costing principles. It is not meaningful in an economic sense to compare costs unless they have been calculated according to a rigorous methodology where, for example, depreciation periods for investments and discounting rates are similar.

The analysis in this study compares, on a consistent basis using Danish factor costs and costing principles, the costs of manure regulations in five countries: **Australia** (New South Wales), **Denmark**, **Korea**, the **Netherlands** and the **United States** (Iowa). First, as a reference case, the costs of complying with Danish regulations for three representative pig farm sizes are calculated. Then, to compare differences in regulatory requirements, the costs are estimated as if Danish producers were to comply with the regulations applying in the other four countries (states). The cost assessment is based on a bottom-up approach, starting with the physical and regulatory requirements imposed on pig producers. It identifies the requirements for manure storage capacity and for manure spreading as well as the administrative and control costs associated with pollution control permitting, Environmental Impact Assessment, manure accounting etc.

This method of comparison provides the cost impact of different regulatory approaches *i.e.* the relative importance of environmental regulations rather than the significance of absolute cost differences as derived from environmental requirements. It also produces an estimate of the share of environmental costs relative to total production costs. However, because the cost assessment is undertaken only for pig producers, the social costs of environmental regulations *i.e.* in terms of lost opportunity costs due to restrictions on how much the production could be extended, are not estimated.

Although not a major pigmeat producer at the world level, there has recently been a substantial growth in pigmeat exports from **Australia**, due in part to the country's proximity to the important Asian markets. Some large European producers have considered establishing production there. Australia faces water shortages and obtaining water extraction rights are a precondition for increased livestock production. This is possible under the tradeable water rights scheme that has been established as part of the water policy reform, but the reform also implies that water costs are increasing.

In absolute terms, **Denmark** is not among the largest producers of pigmeat but is significant on the world market, ranking as the second largest exporter or the largest if intra-EU trade is included. The historical reason for specialisation in pig production was the lack of competitiveness in cereal production, so more value could be obtained by using cereal as livestock feed. In the past two decades livestock production has been shifting towards pigs, and concentrations in the western part of the country are similar to those found in the Netherlands.

Intensive livestock farming has increased at a rapid rate in **Korea**, which is now the eighth largest exporter of pigmeat, with a higher export rate than the Netherlands when trade within the EU is excluded. The first environmental measures were introduced as early as 1986, and in 1991 a more comprehensive act regulating disposal of livestock manure was introduced. Manure is mostly composted; only 20% is spread on agricultural land as liquid manure.

The **Netherlands** has the highest concentration of livestock production in the world. The annual number of pigs slaughtered is approximately 19.5 million, slightly less than Denmark, and the country ranks number six in world pigmeat production. Dutch pig producers were early to specialise in livestock farming taking advantage of their close proximity to port facilities to import feed. As a densely populated country, with a limited amount of agricultural land available for manure disposal the Netherlands gradually experienced severe environmental problems. Environmental regulations have been changed many times over the past 15 years but as for all five countries, this analysis focuses on the current manure management regulations.

The **United States** is the world's second largest pigmeat producer behind China, but it is only since 1995 that the US has also become a major pigmeat exporter. Exports now exceed the imports by 40-50%. Pig production is concentrated in the Midwest and the central East Coast area, with Iowa and North Carolina the main pigmeat producing states responsible for over 40% of total production and nearly 60% of exports. Environmental regulations have been in place since the 1972 Clean Water Act, supplemented by additional requirements at the state level.

Agricultural environmental regulations often rely on regional or local government decisions (Chapter 6). It is therefore important not only to focus on regulations at the federal level (whether the **European Union**, **United States** or **Australia**) but also to take full account of the regulatory requirements at the state level. Consequently, the states of Iowa (United States) and New South Wales (Australia) were chosen as examples in these countries. An overview of the current regulatory requirements in the five countries (or states, as appropriate) is provided in Table 7.1.

The costs of manure management regulations in Denmark

In the following assessment the cost of manure management is calculated for three representative pig farm sizes, where one animal unit is approximately, but not exactly, 1 sow and 22 piglets per year.

A – a medium-sized pig farm of 125 AU (animal units);

B – a large pig farm of 249 AU;

C – a very large pig farm of 500 AU.

The most recent data concerning the numbers of pigs per sow and the quantity of manure per animal published by the Danish Institute of Agricultural Sciences (DJF) are used to calculate annual pig and manure production on the three model farms (Table 7.2). It is assumed that all animal manure is in the form of slurry. This is a simplification, since the form of animal manure depends on the type and model of the housing structure. However, slurry manure is the dominant form on intensive pig farms.

Large pig farms (such as B) enjoy competitive advantages of scale, and farms in the range of 126-249 animal units (AU) are now the most common in **Denmark** because below the threshold of 250 AU the lengthy procedure of an Environmental Impact Assessment (EIA) can normally be avoided. However, more farms are being established above this level (such as C) and these are the most direct competitors to large-scale production facilities in other countries. Medium-sized farms (such as A) remain more numerous but are declining in numbers and significance.

Table 7.1. Regulatory requirements for manure management in five countries

	New South Wales (Australia)	Denmark	Korea	Nether-lands	Iowa (United States)
Maximum allowable nutrient application	50-200 kgN /ha	140 kgN /ha (average value)[1]	340-640 m^2 of land per pig	170 kgN /ha (average value)[2]	Up to 1.5 times crop usage rates of N
Manure storage capacity and technology	Sufficiency requirement (6 months)	Minimum 6 months capacity; In practice 9 months	6 months; For compost, 1-2 months	Minimum 6 months	Minimum 7.5 months
Required storage technology	Tank or lagoon	Tank or lagoon with floating cover	Tanks are common	Tank with seal cover	Tank or lagoon, with straw cover
Required manure application technology	Any	Liquid drag line or injection	Any	Injection	Any
Application-prohibited period	Winter	From harvest to 1 February	Summer rainy season	15 Sept – 1 February	Winter
Nutrient planning	Yes	Yes	No	Yes	Yes, except small farms
Nutrient book-keeping	Yes	Yes	No	Yes	Yes
Nutrient accounting	Yes	Yes	No	Yes	Yes
Pollution permit requirements	Yes	For farms larger than 250 animal units[3]	Some	Yes (for ammonia and odour emissions)	Yes
Environmental impact assessment	Yes	For farms larger than 250 animal units[3]	No	Yes	Yes
Land ownership requirements	No	Yes	Yes	Yes	No
Buffer zone requirements	200 m from plant	Up to 300 m from plant	No	Yes	Yes
Compliance incentives	Fines	Levies	Fines	Levies	Fines

Notes:
1. The maximum quantity of manure that can be spread on pig farms in Denmark was set by the 1998 Action Plan for the Aquatic Environment at 1.4 animal units per hectare, equivalent to 140 kgN/ha. This is lower than the maximum of 170 kgN/ha set by the EU Nitrates Directive.
2. In 2003 the maximum application rate of livestock manure varied between 170 kgN/ha on arable land to 300 kgN/ha on grassland. An average of 170 kgN/ha is assumed in this study. A higher average would lower the estimated costs of manure management regulation in the Netherlands, but only marginally.
3. One animal unit in Denmark is approximately, but not exactly, 1 sow and 22 piglets per year.
Source: Department of Policy Analysis, National Environmental Research Institute, Denmark.

Table 7.2. Properties of the three representative Danish pig farms

Model farms	Unit	Farm A 125 animal units	Farm B 249 animal units	Farm C 500 animal units
Annual production of pigs for slaughter	number	2 568	5 116	10 252
Annual amount of manure	tonnes	1 968	3 921	7 858

Source: Poulsen *et al.,* 2001

The costs of manure storage and application have been calculated on the basis of prices surveyed and published in the annual publication of the Danish Agricultural Advisory Service (LR, 2001). All capital costs have been annualised, assuming a 6% interest rate and depreciation periods according to those applied by the Danish Agricultural Advisory Service. The use of the most cost-efficient external contractor for the application of manure is also assumed.

The following costs of manure management regulations are calculated:

1. Manure storage facility: Storage tanks are almost exclusively used for the storage of slurry manure in **Denmark**. Lagoons have recently been allowed but only exist in a few places. The relative costs of storage tanks decrease with scale, which is reflected in the price per storage volume. The formal requirement is for a minimum of six months of storage capacity but the Danish circular on commercial livestock production and animal wastes requires that pig farms have nine months capacity (Miljøstyrelsen, 1998). This larger requirement is used for the cost assessment. Storage tank capacity is adjusted for precipitation as covers are fairly simple.

2. Storage tank cover: Up until recently storage tank covers have been of straw. Since August 2001, complete floating covers have been required although there are some possibilities for continued use of straw covers provided that they are effective. The cost assessment assumes that floating covers are employed. The surface area for coverage is calculated on the basis of an average height for the storage tank of 4 metres.

3. Application equipment: Up until August 2002 there were no specific requirements for field application techniques although the use of liquid dragline or injection was encouraged. In August 2002, liquid dragline became the required minimum technology and is the assumed method of application.

4. Additional transport: There is a substantial amount of transportation involved in manure application. Slurry manure is voluminous and 1 tonne is assumed to be equivalent to 1 m^3. Large manure applicators carry up to 18-20 tonnes. Even though the delivery of all the manure on the large farm (B) can be done within a distance of about one kilometre from the storage facility without exceeding the application limit, provided the facility is located exactly in the centre, the delivery will require nearly 1 000 km of road transport back-and-forth from the storage facility to the field. Field application transport itself is less than one-third of this distance; the greater part is transport to and from the storage facility. In many cases pig farms do not have sufficient land and need to rely on neighbouring land for application. It is assumed that only the very large farm (C) has this additional transport requirement and costs are calculated on the assumption that 40% of the manure is applied on a farm 5 km away from the storage tank. The cost of acquiring additional land for spreading is not included.

5. Paperwork related to licensing, nutrient planning etc.: While an EIA is not required for farms with less than 250 AU, a screening procedure with regard to a possible EIA applies. The time required for this purpose, as well as the annual time required for nutrient planning, nutrient accounting and nutrient trading etc., has been assessed according to best estimates from county officials and local farm advisory centres.

6. Environmental Impact Assessment (EIA): The very large farm (C) requires on EIA and the procedure may entail soil and groundwater tests at substantial costs. Such costs are treated as investments and depreciated over a 10 year period.

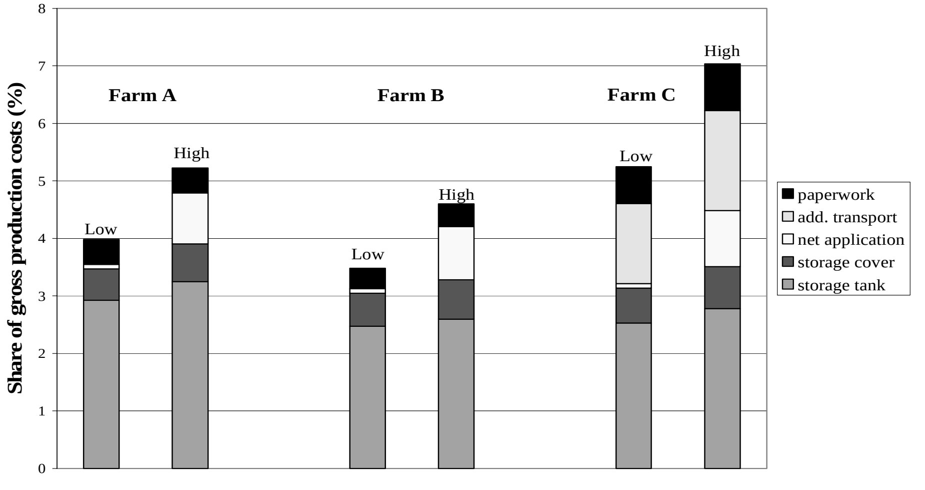
7. Value of nutrients in manure: The nutrient content of manure is variable and depends on the feeding regime. On the basis of the most recent data published by DJF, the nitrogen content of one tonne of manure is assumed on average to be 5.3 kg (Poulsen *et al.*, 2001). In the past many farmers disregarded the value of manure nutrients but the manure accounting system now requires farmers to account for this value. The value of manure is calculated on the basis of a shadow

price for fertiliser according to the principles of the Danish Agricultural Economics Institute and based on the legally required utilisation rate for pig farms. Only the nitrogen content is priced because phosphorous is often in surplus. It is assumed that manure utilisation and value is reduced by 20% when simple and conventional spreading equipment is used. The value of nutrients in manure is subtracted from the cost of field application.

The results of the cost assessment for pig producers in **Denmark** are presented for the three different farm sizes, with a low and high estimate for each farm (Figure 7.1). The relative costs of the various requirements have been calculated and are shown here as a share of the total production costs per pig weighing 98-100 kg ready for slaughter. The results show that in Denmark the general level of manure management costs is within a band of 3.5-7.0% of total production costs. These costs are moderately higher than the environmental costs in conventional manufacturing industries (Jaffe *et al.*, 1995).

Figure 7.1. Manure management costs of Danish regulations

Share of total production costs of a pig for slaughter[1]



Notes:
1. A pig for slaughter weighs 98-100 kg.
2. Farm A – 125 animal units (AU); Farm B – 249 AU; Farm C – 500 AU, see Table 7.2 for further details.
Source: Department of Policy Analysis, National Environmental Research Institute, Denmark.

The results also indicate a U-shaped relationship between manure management costs and farm size. For the medium-sized farm (A), which does not enjoy the full advantages of scale in manure technologies, the relative costs are from 4.0-5.2% of total production costs. On the large farm (B), the relative costs are a half percentage band lower from 3.6-4.6%, while on the very large farm (C) the cost level is significantly higher from 5.2-7.0%.

The study confirms the findings of previous research that manure transport is one of the most significant cost factors in manure management. The very large farm (C) requires additional land on which to apply manure, which drives its management costs above the level of the two other farms. The requirement for land is primarily a function of farm size and allowable application rates, and not legal requirements for land ownership or for manure contracts. It is simply uneconomical to transport manure very far. An additional reason for the higher relative significance of manure management costs on the very large farm (C) is that such farms enjoy general economies of scale in the production costs so that the environmental costs are assessed against the background of lower average production costs per pig for slaughter.

The costs of manure management under different regulations

Manure management costs for the three representative Danish pig farms are then calculated using the same cost methodology but under the manure management regulations imposed in New South Wales (**Australia**), **Korea**, the **Netherlands** and the Iowa (**United States**) (Figures 7.2-7.5). In the Dutch case, it is assumed that the required storage capacity is seven months and that tanks must be fully covered. Further, manure application is allowed only by injection. It is also assumed that Dutch farms are liable to the same EIA procedure as Danish farms due to the EU directive on EIA. Costs of building requirements are not included.

In Iowa **(United States),** the required storage capacity is 7.5 months, and because lagoons account for less than 11% of storage, the use of storage tanks is assumed. Cover requirements are almost similar to those now being introduced in Denmark. There are no restrictions on application methods and no EIA requirements (ISU, 2000 and 2001).

In New South Wales **(Australia),** six months storage capacity is assumed and no requirements for either cover or application methods. New pig farms must acquire water rights under the tradeable water rights scheme but these costs are not directly related to manure and are not included (Brewster, 2001; and DLWC, 2001).

In **Korea,** six months of storage capacity is required, and sealed or floating covers are mandatory. There are no requirements for a specific field application technology or for nutrient planning. Application rates for nitrogen to crops have been established.

The comparison of the approaches shows that on average manure management costs appear to be lower in New South Wales (**Australia)**, **Korea** and Iowa (**United States)** than in the **Netherlands** and **Denmark**. The Dutch approach is the most restrictive and also the most costly, closely followed by the Danish. The differences between Europe and the others are explained mainly by the requirements for storage tank cover and application techniques, and to some extent, the required storage capacity. The more advanced technologies used for manure spreading in Europe help increase the utilisation and value of manure.

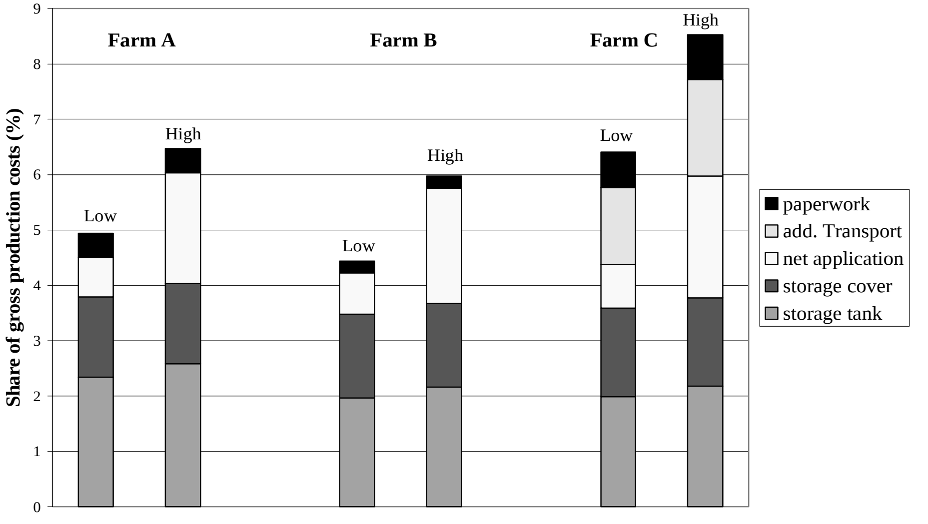
There is also substantial variation between farm types within the countries. Medium-sized farms (A) do not reap the full economies of scale, and experience a higher share of manure management costs than large farms (B). Very large farms (C), on the other hand, while enjoying economies of scale in production, are apparently faced with the highest relative manure management costs under all five regulatory regimes. This situation is explained by the increased need to transport manure from the farm to other land for disposal and spreading. Large farms (B) appear to obtain some economies of scale in the production, while avoiding excessive transport and disposal costs for manure.

Findings and conclusions

Previous economic analysis has shown that North American producers have substantially lower production costs per pig than European producers. Some studies point to a cost disadvantage of up to 80% for European producers. These differences are mainly explained by higher labour and interest costs in Europe. However, such comparisons fail to take into account differences in the type of pig produced and seem to exaggerate the competitiveness position of North American producers. They also do not address the role of environmental regulations.

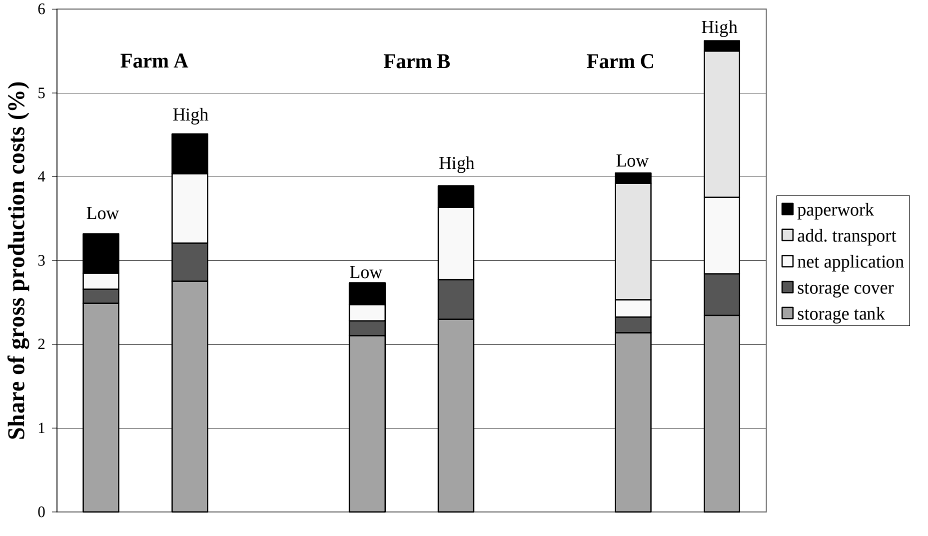
This Chapter has examined the effects of differences in manure management regulations on the competitiveness of pig producers. The analysis compared the impact of different regulatory approaches in five countries on three model Danish pig farms and revealed some differences in manure management costs. There are differences both between farm types and between countries (Figure 7.6).

Figure 7.2. Manure management costs of Dutch regulations
Share of total production costs of a pig for slaughter



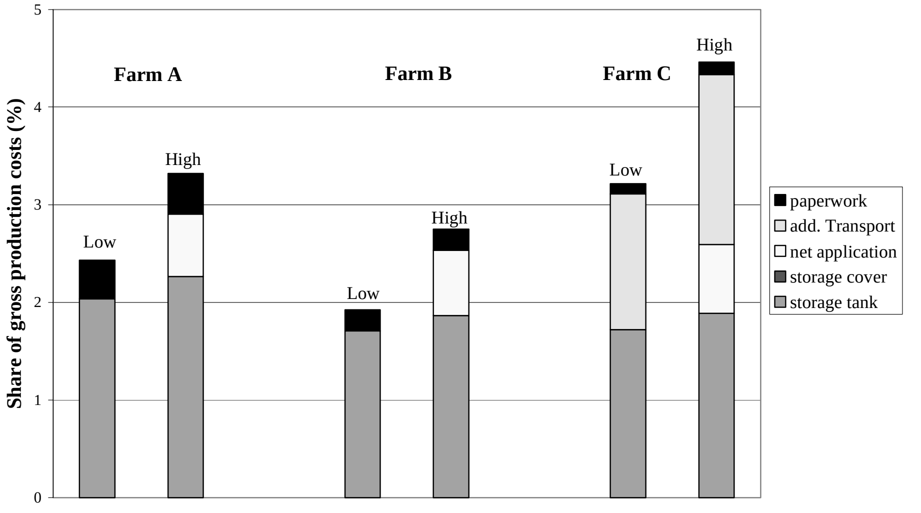
Source: Department of Policy Analysis, National Environmental Research Institute, Denmark.

Figure 7.3. Manure management costs of Iowa (United States) regulations
Share of total production costs of a pig for slaughter



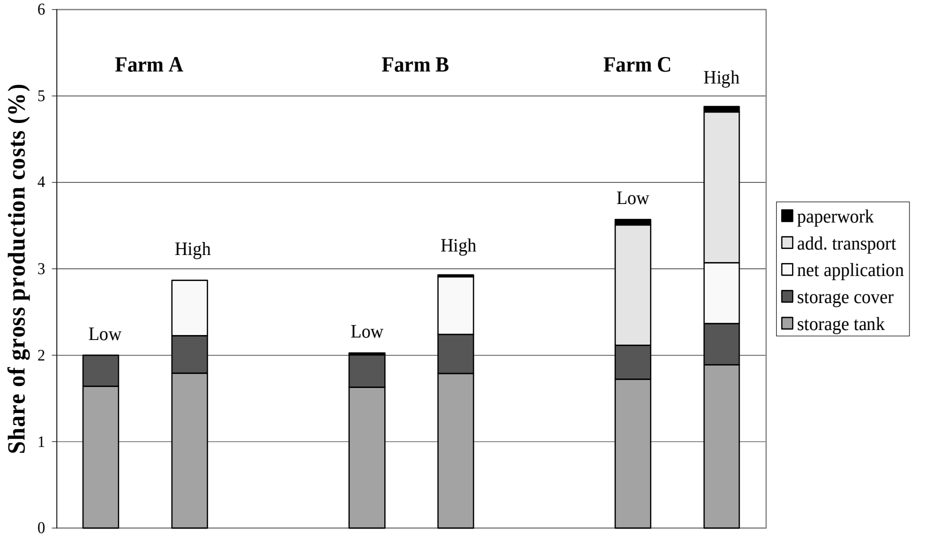
Source: Department of Policy Analysis, National Environmental Research Institute, Denmark.

Figure 7.4. Manure management costs of New South Wales (Australia) regulations
Share of total production costs of a pig for slaughter



Source: Department of Policy Analysis, National Environmental Research Institute, Denmark.

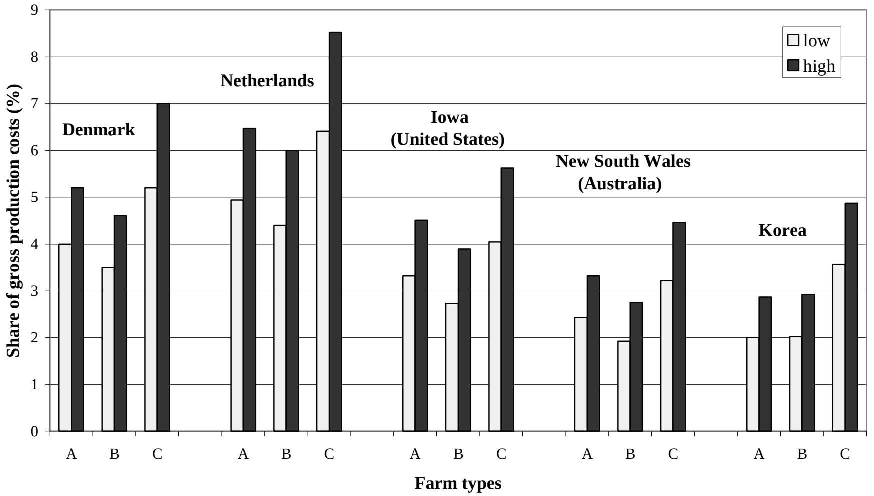
Figure 7.5. Manure management costs of Korean regulations
Share of total production costs of a pig for slaughter



Source: Department of Policy Analysis, National Environmental Research Institute, Denmark.

Figure 7.6. Comparison of manure management costs in five countries

Share of total production costs of a pig for slaughter



Source: Department of Policy Analysis, National Environmental Research Institute, Denmark.

As regards farm types, there is a common cost pattern imposed by all five regulatory approaches on the three representative Danish pig farms. Manure management costs are relatively lowest for the large farm (B), while transport costs drive up the costs for the very large farm (C), and diseconomies of scale drive up the costs for the medium-sized farm (A). There appears to be a U-shaped relationship between farm size and manure management costs. The difference between the high and low assessments is about 2-3%. Individual producers can influence their manure management costs by optimising the scale and type of operation. The highest costs, for instance, occur with a very large farm (C), which is uncommon in **Denmark**.

This result is consistent with findings from other studies. Some indicate that environmental compliance costs are more significant for small pig producers because diseconomies of scale result in a greater cost per head of regulatory compliance (Metcalfe, 2001; Martin and Zering, 1997). An important reason for the fall in the number of Japanese pig farms with 50-100 sow has been the difficulty in meeting manure management regulations (Arai, 2001).

Others found that the most stringent environmental regulations usually target larger farms (Park *et al*., 2000).

Comparing countries, manure management costs per pig for slaughter varies between 3.5-6.4% with European regulations (4.6-8.5% in “high” case) and between 1.9-4.0% in the other three countries (2.8-5.6% in “high” case). The differences arise from the technical requirements for storage capacity, tank seal covers and required transport for disposal.

While there are variations between countries, environmental costs do not appear to be of a scale that may explain the basic differences in pig production competitiveness. They appear to be of a magnitude that is relatively marginal as compared to basic factor costs of labour and capital, and more variable factors such as exchange rates. While differences in the cost of manure management in each country may be reinforced by differences in, for instance, labour costs, it is important to stress that this does not stem from differences in environmental regulations. All five countries have extensive environmental regulations, although regulations in **Australia**, **Korea** and the **United States** seem to have been developed and introduced about 5-10 years later than in **Denmark** and the **Netherlands**, and mainly from 1995 onwards.

Whether differences in regulatory requirements have implications from a trade perspective depends on a closer analysis of the degree to which nutrient losses are a problem for the local and regional environment. Evidence suggests that environmental problems are relatively greater in **Europe** due to the concentrated nature of pig production, and that more space and a higher absorption capacity in the **United States** and **Australia** could justify the notion of a competitive advantage in terms of environmental conditions. On the other hand, pig production appears also to be fairly concentrated in specific areas in these countries so that the practical differences in absorption capacity might not be significant at all in some areas (Chapter 3).

In order to present a comprehensive assessment of the appropriateness of the differences in environmental regulations, a monetary valuation of the aggregated costs and benefits could be developed. Cost-benefit measurements have become a more common undertaking and would require an explicit environmental accounting of the consequences of nutrient pollution on the environment. Cost-benefit estimates of the value of nitrogen reductions have been made in both the **United States** and the **European Union**, but they differ considerably and provide no clear-cut answers to an internationally based benefit estimation (Smith *et al.*, 2000; RIVM, 2001). A comprehensive review of the valuation literature suggests that an upper bound value for the willingness-to-pay for nitrogen control is in the order of magnitude EUR 25-45 kgN (Branth Pedersen, 2003). Whether these figures justify the present regulatory requirements remain to be analysed.

From the perspective of the polluter-pays-principle (PPP), as formulated by the OECD, environmental costs should be internalised in the production costs, and hence reflected in prices (OECD, 1975). It is important that the costs of the environmental regulations are not offset by national subsidies, whether these are direct subsidies or tax allowances. If there are differences in the capacity of the local environment to absorb nutrient pollution, it would justify differences in national regulations and hence in relative competitiveness. The concentrated character of pig production in most countries suggests that such differences would appear to be rather moderate.

ANNEX

Annex Table 1. Pigmeat production and consumption

	Average volume				Annual growth rate (%)	
	1980-84	1985-89	1990-94	1997-01[1]	1980-89	1990-2001[1]
Production ('000 tonnes)						
Australia	235	295	334	360	3.8	1.3
Canada	1 026	1 140	1 201	1 517	1.5	4.0
China	13 540	21 236	29 864	40 497	7.0	5.4
European Union (15)	13 856	15 233	15 740	17 533	1.4	1.2
Belgium	694	792	986	1 054	2.4	3.0
Denmark	1 004	1 166	1 432	1 626	2.0	3.2
France	1 712	1 766	1 994	2 306	0.3	2.7
Germany	4 413	4 607	3 650	3 911	0.1	-0.8
Italy	1 137	1 260	1 352	1 454	2.0	1.1
Netherlands	1 217	1 570	1 644	1 573	4.0	-1.3
Spain	1 303	1 621	2 037	2 789	4.1	4.8
United Kingdom	952	978	1 010	998	0.2	-1.7
Japan	1 430	1 572	1 409	1 270	0.9	-2.0
Korea	330	431	727	935	5.6	4.9
Mexico	1 373	844	850	996	-5.9	3.1
Poland	1 444	1 799	1 906	1 947	0.9	0.0
Russia	n.a.	n.a.	2 296	1 530	---	-5.2
United States	6 961	6 830	7 790	8 501	-0.5	2.0
World	54 365	66 062	75 073	88 243	2.9	2.5
Consumption ('000 tonnes)						
Australia	231	278	325	353	3.8	1.6
Canada	810	813	817	878	-0.7	1.6
China	13 400	19 716	27 630	38 494	7.0	5.3
European Union (15)	13 603	14 547	14 905	16 077	1.2	1.0
Belgium	444	485	503	388	1.4	-1.3
Denmark	266	326	335	351	1.8	1.1
France	1 953	2 012	2 000	2 162	0.2	1.5
Germany	4 767	4 935	4 453	4 431	0.1	-0.7
Italy	1 465	1 667	1 885	2 159	2.6	2.2
Netherlands	580	635	708	797	1.7	1.9
Spain	1 316	1 595	1 996	2 448	4.8	3.2
United Kingdom	1 460	1 450	1 426	1 456	-0.4	0.2
Japan	1 567	1 821	1 894	2 168	2.4	1.7
Korea	321	392	665	936	5.4	6.3
Mexico	1 373	976	913	1 075	-4.9	4.0
Poland	1 394	1 612	1 897	1 800	1.3	0.3
Russia	n.a.	n.a.	2 696	2 158	---	-3.6
United States	7 105	7 143	7 678	8 162	-0.2	1.4
World	53 678	63 204	72 379	84 979	2.9	2.4
Consumption per capita (kg)						
Australia	15	17	19	19	2.2	0.4
Canada	32	31	29	29	-1.9	0.6
China	13	18	23	31	5.4	4.3
European Union (15)	38	40	40	43	0.9	0.8
Belgium	43	47	48	36	1.3	-1.6
Denmark	52	64	65	66	1.8	0.8
France	36	36	35	37	-0.3	1.0
Germany	61	63	55	54	0.0	-1.0
Italy	26	29	33	38	2.5	2.1
Netherlands	41	43	47	51	1.1	1.3
Spain	35	41	51	61	4.3	3.0
United Kingdom	26	25	25	25	-0.6	-0.1
Japan	13	15	15	17	1.8	1.5
Korea	8	9	15	20	4.1	5.4
Mexico	19	13	11	11	-6.8	2.4
Poland	39	43	49	47	0.5	0.2
Russia	n.a.	n.a.	18	15	---	-3.4
United States	30	29	30	29	-1.2	0.4
World	12	13	13	14	1.2	1.0

Note:
1. For consumption the period refers to 1996-2000 and 1990-2000.
n.a.: Not available.
Source: FAO database, 2003.

Annex Table 2. Pigmeat exports and imports

	Average volume				Annual growth rate (%)	
	1980-84	1985-89	1990-94	1997-01	1980-89	1990-2001
Exports ('000 tonnes)						
Australia	4	6	7	31	7.7	19.8
Canada	149	239	265	507	9.9	8.5
China	200	324	467	220	10.1	-4.7
European Union (15)[1]	2 039	2 971	3 965	5 784	6.5	4.9
Belgium	285	342	500	426	4.5	-30.7
Denmark	723	788	972	1 221	1.9	4.1
France	55	116	279	524	12.1	9.9
Germany	110	243	230	398	11.1	5.3
Italy	25	32	49	115	5.6	11.4
Netherlands	672	921	1 001	870	5.8	-2.4
Spain	5	5	49	339	15.7	40.8
United Kingdom	38	59	104	198	10.8	-0.3
Japan	<0.5	<0.5	1	1	11.5	5.8
Korea	<0.5	5	9	72	47.5	18.9
Mexico	<0.5	1	3	50	20.3	53.0
Poland	42	49	20	146	-4.7	7.2
Russia	n.a.	n.a.	1	8	---	53.2
United States	81	59	158	523	1.9	18.3
World (including intra-EU)	2 848.6	3 699.0	4 578.4	6 725.5	5.0	5.0
World (excluding intra-EU)	809.2	1 441.5	1 883.4	3 164.5	9.4	6.8
Imports ('000 tonnes)						
Australia	1	1	4	25	-0.9	39.6
Canada	16	15	22	74	-2.6	17.5
China	61	90	118	311	12.0	11.3
European Union (15)[1]	1 775	2 200	2 734	3 704	3.5	4.6
Belgium	35	44	78	76	6.2	-13.9
Denmark	1	6	12	44	50.6	10.9
France	296	371	370	431	3.2	1.5
Germany	469	539	846	881	3.6	1.4
Italy	345	472	584	841	4.2	5.7
Netherlands	38	42	69	107	3.4	7.9
Spain	16	58	79	90	23.2	-0.4
United Kingdom	507	487	491	618	-0.4	3.1
Japan	168	288	470	816	13.8	9.3
Korea	<0.5	2	15	120	71.8	31.5
Mexico	<0.5	25	86	182	94.9	18.2
Poland	63	16	56	45	4.0	-2.7
Russia	n.a.	n.a.	287	522	---	11.5
United States	268	452	332	365	6.7	0.9
World (including intra-EU)	2 660	3 468	4 387	6 653	5.0	5.7
World (excluding intra-EU)	884	1 380	1 749	3 077	8.5	7.0
Export performance (%)[2]						
Australia	2%	2%	2%	9%		
Canada	15%	21%	23%	33%		
China	1%	2%	2%	1%		
European Union(15)	15%	20%	25%	33%		
Belgium-Luxembourg	41%	44%	53%	41%		
Denmark	72%	69%	71%	75%		
France	3%	7%	14%	23%		
Germany	2%	5%	6%	10%		
Italy	2%	3%	4%	8%		
Netherlands	55%	60%	61%	55%		
Spain	0%	0%	2%	12%		
United Kingdom	4%	6%	10%	19%		
Japan	0%	0%	0%	0%		
Korea	0%	1%	1%	8%		
Mexico	0%	0%	0%	5%		
Poland	3%	3%	1%	7%		
Russia	n.a.	n.a.	n.a.	1%		
United States	1%	1%	2%	6%		
World (including intra-EU)	5%	6%	6%	8%		

Note:
1. Data for the European Union include intra-EU trade.
2. Export performance = ratio of exports to production (volume).
n.a.: Not available.
Source: FAO database, 2003.

Annex Table 3. Share of pig holdings by size group in selected countries, various years (%)

Country	Size of holding	1990	1993	1995	1997	2000
EU12[1]	1-99	89	87	86	85	84
	100-499	6	7	7	7	7
	500-999	3	4	4	5	5
	>1000	1	2	2	3	4
Belgium	1-99	45	32	27	24	n.d.
	100-499	29	31	29	27	n.d.
	500-999	18	23	26	27	n.d.
	>1000	8	14	18	21	26
Denmark	1-99	47	40	37	34	31
	100-499	30	29	27	25	22
	500-999	16	19	21	21	20
	>1000	6	12	16	20	26
France	1-99	86	81	80	77	n.d.
	100-499	7	8	8	9	n.d.
	500-999	5	7	8	8	n.d.
	>1000	2	4	5	6	8
Germany	1-99	80	78	76	74	n.d.
	100-499	14	15	15	16	n.d.
	500-999	5	6	7	8	n.d.
	>1000	1	1	1	2	3
Greece	1-99	97	98	97	97	n.d.
	100-499	2.0	1.3	1.6	1.5	n.d.
	500-999	0.8	0.6	0.7	0.6	n.d.
	>1000	0.5	0.2	0.4	0.5	0.6
Ireland	1-99	74	70	66	71	n.d.
	100-499	8	7	9	3	n.d.
	500-999	7	9	9	8	n.d.
	>1000	11	15	15	18	18
Italy	1-99	98	98	98	98	n.d.
	100-499	0.8	1.0	1.2	0.9	n.d.
	500-999	0.5	0.6	0.6	0.6	n.d.
	>1000	0.5	0.7	0.6	0.8	0.8
Netherlands	1-99	25	21	18	15	n.d.
	100-499	38	37	36	36	n.d.
	500-999	24	25	26	25	n.d.
	>1000	13	17	21	24	28
Portugal	1-99	99	98	98	98	n.d.
	100-499	0.9	1.1	1.0	1.0	n.d.
	500-999	0.2	0.4	0.3	0.4	n.d.
	>1000	0.1	0.3	0.3	0.3	0.4
Spain	1-99	94	93	92	88	n.d.
	100-499	3	4	4	6	n.d.
	500-999	2	2	2	4	n.d.
	>1000	1	1	1	3	3
United Kingdom	1-99	56	57	54	55	n.d.
	100-499	18	17	14	16	n.d.
	500-999	13	12	13	12	n.d.
	>1000	13	14	18	16	17
Japan	1-99	50	35	32	23	18
	100-499	34	37	37	37	35
	500-999	10	16	18	21	23
	>1000	5	12	13	19	24
Korea	1-99	93	82	74	63	58
	100-499	5	15	18	22	21
	500-999	1	3	5	10	11
	>1000	0.3	1	2	6	10
United States	1-99	64	60	57	57	57
	100-499	25	26	26	23	19
	500-999	7	8	9	10	9
	>1000	4	6	7	11	16

Note:
1. The size groupings for EU countries are 1-99, 100-399, 400-999, and > 1 000.
n.d.: No data available.
Sources: EUROSTAT, MAFF (various), NACF (2002), NASS (various).

Annex Table 4. Share of pig population by size group in selected countries, various years (%)

Country	Size of holding	1990	1993	1995	1997	2000
EU12[1]	1-99	10	8	7	6	n.d.
	100-499	19	17	15	13	n.d.
	500-999	29	28	27	25	n.d.
	>1000	41	48	51	56	59
Belgium	1-99	4	2	2	1	n.d.
	100-499	19	14	12	10	n.d.
	500-999	35	32	31	29	n.d.
	>1000	42	51	56	60	66
Denmark	1-99	6	4	3	2	1
	100-499	22	15	11	9	7
	500-999	35	28	26	23	18
	>1000	37	54	61	66	74
France	1-99	6	4	3	2	n.d.
	100-499	18	14	11	10	n.d.
	500-999	40	35	31	27	n.d.
	>1000	35	48	55	61	65
Germany	1-99	14	14	12	10	n.d.
	100-499	29	30	28	26	n.d.
	500-999	31	34	37	38	n.d.
	>1000	25	22	23	26	34
Greece	1-99	15	25	16	19	n.d.
	100-499	13	19	12	12	n.d.
	500-999	17	22	15	14	n.d.
	>1000	54	34	56	55	59
Ireland	1-99	2	1	2	1	n.d.
	100-499	4	2	3	1	n.d.
	500-999	10	9	10	8	n.d.
	>1000	85	87	86	89	94
Italy	1-99	13	12	13	11	n.d.
	100-499	7	7	9	6	n.d.
	500-999	14	12	13	12	n.d.
	>1000	66	69	65	71	79
Netherlands	1-99	2	2	1	1	n.d.
	100-499	17	15	12	11	n.d.
	500-999	33	29	26	22	n.d.
	>1000	48	54	61	66	70
Portugal	1-99	37	25	24	23	n.d.
	100-499	15	13	14	13	n.d.
	500-999	12	16	15	15	n.d.
	>1000	35	46	48	49	57
Spain	1-99	15	11	10	7	n.d.
	100-499	17	14	14	12	n.d.
	500-999	27	24	24	22	n.d.
	>1000	41	50	52	59	68
United Kingdom	1-99	3	2	7	2	n.d.
	100-499	8	8	15	6	n.d.
	500-999	19	16	27	14	n.d.
	>1000	70	74	51	78	81
Korea	1-99	24	12	8	4	2
	100-499	38	40	30	21	15
	500-999	15	22	26	26	23
	>1000	23	26	26	49	60
United States	1-99	6	5	4	2	1
	100-499	29	23	18	11	6
	500-999	24	22	17	12	8
	>1000	41	51	62	75	85

Note:
1. The size groupings for EU countries are 1-99, 100-399, 400-999, and > 1 000.
n.d.: No data available.
Sources: EUROSTAT, NACF (2002), NASS (various).

Annex Table 5. Total OECD PSE for pigmeat

	Unit	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Total OECD PSE for pigmeat	USD mn	8 366	5 622	12 302	8 425	6 000	8 609	4 508	9 415	11 213	10 218	10 772	9 192	8 986	12 769	9 701	9 675
Three year average	USD mn			*8 764*	*8 783*	*8 909*	*7 678*	*6 372*	*7 511*	*8 378*	*10 282*	*10 734*	*10 060*	*9 650*	*10 316*	*10 485*	*10 715*
Total OECD PSE for pigmeat	EUR mn	8 525	4 878	10 411	7 652	4 727	6 965	3 483	8 038	9 453	7 816	8 486	8 111	8 035	11 984	10 527	10 803
Three year average	EUR mn			*7 938*	*7 647*	*7 597*	*6 448*	*5 058*	*6 162*	*6 991*	*8 436*	*8 585*	*8 138*	*8 211*	*9 377*	*10 182*	*11 105*
%PSE		19	12	25	16	10	15	8	18	21	18	17	15	19	30	20	18
Three year average				*18*	*18*	*17*	*14*	*11*	*14*	*16*	*19*	*19*	*17*	*17*	*21*	*23*	*23*
Nominal Assistance Coefficient (NAC)		1.23	1.13	1.33	1.20	1.12	1.18	1.08	1.22	1.27	1.22	1.20	1.18	1.24	1.42	1.25	1.22
				1.23	1.21	1.21	1.16	1.12	1.16	1.19	1.24	1.23	1.20	1.21	1.27	1.30	1.29
Volume of Production	000 tonne	27 868	28 637	29 919	29 843	29 774	30 911	31 683	32 258	32 267	32 656	32 798	32 621	35 184	35 952	35 341	36 217
Per unit PSE	USD/tonne	300	196	411	282	202	279	142	292	347	313	328	282	255	355	274	267
Three year average	USD/tonne			*304*	*298*	*299*	*254*	*207*	*238*	*261*	*317*	*330*	*308*	*288*	*298*	*295*	*299*
PSE for pigmeat by country																	
EU15	USD mn	3 889	781	4 579	2 291	601	2 204	- 812	2 622	2 927	3 709	5 425	5 109	3 644	6 564	5 467	5 269
Japan	USD mn	1 557	1 898	2 701	1 981	1 205	2 044	2 649	2 629	3 028	3 199	2 476	1 788	1 831	2 267	1 976	1 814
United States	USD mn	447	381	374	381	382	364	300	741	713	305	357	406	442	324	476	527
Switzerland	USD mn	515	760	707	450	705	721	478	580	661	576	675	576	615	582	509	524
Poland	USD mn	203	- 210	587	- 25	- 122	467	- 230	457	931	537	198	249	864	772	11	297
Hungary	USD mn	737	758	925	778	464	196	246	185	343	369	133	159	421	276	143	255
Korea	USD mn	390	219	557	525	1 101	1 243	859	848	1 188	1 242	1 121	703	443	1 051	501	252
Czech Republic	USD mn	423	206	430	533	286	156	- 122	83	70	124	166	- 83	209	205	128	252
Canada	USD mn	59	47	126	287	33	87	106	24	81	165	167	113	114	199	187	144
Mexico	USD mn	- 827	- 452	52	30	- 28	42	138	89	241	- 254	- 132	- 35	50	180	78	135
Norway	USD mn	185	231	277	208	236	246	186	160	153	164	161	144	196	203	127	123
Slovak Republic	USD mn	261	181	218	369	357	18	- 15	69	85	51	- 5	39	134	113	73	64
Australia	USD mn	9	11	12	13	14	15	17	17	20	21	22	18	15	21	17	14
Iceland	USD mn	6	8	12	9	8	10	10	10	8	8	6	6	8	11	7	4
New Zealand	USD mn	3	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Contribution to OECD total																	
EU15	%	46.5%	13.9%	37.2%	27.2%	10.0%	25.6%	-18.0%	27.8%	26.1%	36.3%	50.4%	55.6%	40.6%	51.4%	56.4%	54.5%
Japan	%	18.6%	33.8%	22.0%	23.5%	20.1%	23.7%	58.8%	27.9%	27.0%	31.3%	23.0%	19.5%	20.4%	17.8%	20.4%	18.7%
United States	%	5.3%	6.8%	3.0%	4.5%	6.4%	4.2%	6.7%	7.9%	6.4%	3.0%	3.3%	4.4%	4.9%	2.5%	4.9%	5.4%
Switzerland	%	6.2%	13.5%	5.8%	5.3%	11.8%	8.4%	10.6%	6.2%	5.9%	5.6%	6.3%	6.3%	6.8%	4.6%	5.2%	5.4%
Poland	%	2.4%	-3.7%	4.8%	-0.3%	-2.0%	5.4%	-5.1%	4.9%	8.3%	5.3%	1.8%	2.7%	9.6%	6.0%	0.1%	3.1%
Hungary	%	8.8%	13.5%	7.5%	9.2%	7.7%	2.3%	5.5%	2.0%	3.1%	3.6%	1.2%	1.7%	4.7%	2.2%	1.5%	2.6%
Korea	%	4.7%	3.9%	4.5%	6.2%	18.4%	14.4%	19.1%	9.0%	10.6%	12.2%	10.4%	7.7%	4.9%	8.2%	5.2%	2.6%
Czech Republic	%	5.1%	3.7%	3.5%	6.3%	4.8%	1.8%	-2.7%	0.9%	0.6%	1.2%	1.5%	-0.9%	2.3%	1.6%	1.3%	2.6%
Canada	%	0.7%	0.8%	1.0%	3.4%	0.5%	1.0%	2.3%	0.3%	0.7%	1.6%	1.6%	1.2%	1.3%	1.6%	1.9%	1.5%
Mexico	%	-9.9%	-8.0%	0.4%	0.4%	-0.5%	0.5%	3.1%	0.9%	2.1%	-2.5%	-1.2%	-0.4%	0.6%	1.4%	0.8%	1.4%
Norway	%	2.2%	4.1%	2.3%	2.5%	3.9%	2.9%	4.1%	1.7%	1.4%	1.6%	1.5%	1.6%	2.2%	1.6%	1.3%	1.3%
Slovak Republic	%	3.1%	3.2%	1.8%	4.4%	6.0%	0.2%	-0.3%	0.7%	0.8%	0.5%	0.0%	0.4%	1.5%	0.9%	0.7%	0.7%
Australia	%	0.1%	0.2%	0.1%	0.2%	0.2%	0.2%	0.4%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%
Iceland	%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.2%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.0%
New Zealand	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Source: OECD PSE/CSE database, 2003.

Annex Table 6. Pigmeat producer support in OECD countries

Year		1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
%PSE																	
OECD	**%PSE**	**19**	**12**	**25**	**16**	**10**	**15**	**8**	**18**	**21**	**18**	**17**	**15**	**19**	**30**	**20**	**18**
Switzerland	%PSE	56	62	61	46	55	57	43	55	60	51	57	56	63	69	63	63
Japan	%PSE	35	40	52	43	28	43	54	52	59	60	51	43	50	56	48	45
Norway	%PSE	54	55	64	53	53	56	42	45	46	46	43	40	54	59	48	44
Iceland	%PSE	73	71	78	64	61	69	61	68	62	57	43	43	60	69	54	39
Czech Republic	%PSE	42	21	41	40	22	26	(18)	13	11	17	19	(12)	29	40	26	37
Hungary	%PSE	52	50	62	50	29	19	24	21	38	37	13	18	48	38	20	29
Slovak Republic	%PSE	48	33	38	50	50	6	(4)	21	25	13	(1)	10	39	43	30	26
EU15	%PSE	22	4	22	10	2	8	(3)	12	13	13	17	17	16	32	25	20
Poland	%PSE	10	(12)	27	(1)	(6)	19	(9)	19	36	19	7	9	31	35	1	15
Korea	%PSE	36	21	41	36	48	55	44	41	52	51	42	32	27	48	26	14
Mexico	%PSE	(118)	(40)	4	3	(2)	3	11	7	19	(26)	(10)	(2)	5	15	5	8
Canada	%PSE	4	3	8	15	2	5	6	1	5	9	7	5	7	11	8	5
United States	%PSE	4	3	4	4	3	3	3	7	7	3	3	3	5	4	4	4
Australia	%PSE	3	3	3	3	3	3	4	4	4	5	4	4	4	4	4	3
New Zealand	%PSE	5	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0
PSE per kilogram																	
OECD	**USD/kg**	**0.30**	**0.20**	**0.41**	**0.28**	**0.20**	**0.28**	**0.14**	**0.29**	**0.35**	**0.31**	**0.33**	**0.28**	**0.26**	**0.36**	**0.27**	**0.27**
Switzerland	USD/kg	1.81	2.74	2.54	1.61	2.62	2.72	1.81	2.22	2.69	2.30	3.05	2.69	2.66	2.58	2.26	2.24
Japan	USD/kg	1.00	1.20	1.71	1.24	0.77	1.38	1.85	1.83	2.18	2.42	1.96	1.39	1.42	1.78	1.56	1.46
Norway	USD/kg	2.17	2.51	3.09	2.49	2.84	2.89	2.05	1.78	1.68	1.72	1.57	1.36	1.84	1.86	1.23	1.13
Iceland	USD/kg	3.30	3.89	4.72	3.17	3.27	3.95	3.63	3.36	2.59	2.51	1.58	1.49	2.11	2.24	1.45	0.95
Czech Republic	USD/kg	0.86	0.41	0.81	0.96	0.52	0.32	(0.23)	0.16	0.15	0.27	0.33	(0.17)	0.44	0.45	0.31	0.61
Hungary	USD/kg	0.73	0.71	0.88	0.74	0.45	0.21	0.33	0.28	0.57	0.65	0.20	0.28	0.74	0.44	0.23	0.46
Slovak Republic	USD/kg	1.14	0.76	0.85	1.39	1.37	0.08	(0.07)	0.34	0.42	0.25	(0.02)	0.19	0.72	0.65	0.44	0.42
EU15	USD/kg	0.31	0.06	0.34	0.17	0.05	0.15	(0.06)	0.17	0.19	0.23	0.33	0.31	0.21	0.36	0.31	0.29
Korea	USD/kg	0.95	0.45	1.01	0.84	1.70	1.94	1.11	1.07	1.49	1.52	1.26	0.79	0.47	1.17	0.55	0.27
Poland	USD/kg	0.12	(0.12)	0.33	(0.01)	(0.07)	0.23	(0.11)	0.23	0.54	0.27	0.10	0.13	0.42	0.37	0.01	0.16
Mexico	USD/kg	(0.86)	(0.49)	0.06	0.04	(0.04)	0.06	0.17	0.11	0.29	(0.28)	(0.15)	(0.04)	0.06	0.18	0.08	0.12
Canada	USD/kg	0.05	0.04	0.10	0.23	0.03	0.07	0.08	0.02	0.06	0.12	0.12	0.07	0.07	0.10	0.09	0.07
United States	USD/kg	0.07	0.06	0.05	0.05	0.05	0.05	0.04	0.10	0.09	0.04	0.05	0.05	0.05	0.04	0.06	0.06
Australia	USD/kg	0.03	0.04	0.04	0.04	0.05	0.04	0.05	0.05	0.05	0.06	0.07	0.05	0.04	0.06	0.05	0.04
New Zealand	USD/kg	0.07	0.03	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Note: Countries are ranked according to their 2001 level.
Source: OECD PSE/CSE database, 2003.

Annex Table 7. Composition of total OECD PSE for pigmeat by support category, 1999-2001

PSE by country and category	Australia	Canada	Czech Republic	EU15	Hungary	Iceland	Japan	Korea	Mexico	New Zealand	Norway	Poland	Switzerland	Slovak Republic	United States	OECD
Average PSE 1999-2001 (USD million)																
Market Price Support	-	-	171.8	5 083.9	155.2	6.8	1 965.7	551.2	81.7	-	113.6	320.6	340.2	54.0	-	8 844.7
Payments based on output	-	73.8	-	-	19.0	0.1	-	-	-	-	6.1	-	-	0.6	-	99.6
Payments based on input use	14.9	35.1	12.8	495.7	42.0	0.4	53.3	23.3	42.9	0.1	19.7	38.1	27.8	14.6	332.5	1 153.1
Payments based on animal numbers	-	-	-	114.7	8.5	-	-	1.8	1.7	-	8.6	-	28.0	13.7	-	177.1
Payments based on historical entitlements	-	0.5	10.0	53.2	-	-	-	-	-	-	-	-	122.2	-	-	185.9
Payments based on input constraints	-	-	-	81.5	0.0	-	-	11.3	-	-	1.9	0.2	-	-	5.9	100.8
Payments based on overall farm income	2.4	61.9	0.6	-	-	-	-	13.9	4.5	-	1.1	-	-	0.6	104.0	188.9
Miscellaneous payments	-	5.5	-	- 62.2	-	-	-	-	0.1	-	-	1.0	20.2	-	-	- 35.4
Producer Support Estimate	**17.3**	**176.7**	**195.1**	**5 766.7**	**224.8**	**7.3**	**2 019.0**	**601.4**	**131.0**	**0.1**	**151.1**	**359.9**	**538.5**	**83.4**	**442.4**	**10 714.6**
Share of country PSE for pigmeat																
Market Price Support	-	-	88%	88%	69%	94%	97%	92%	62%	-	75%	89%	63%	65%	-	83%
Payments based on output	-	42%	-	-	8%	1%	-	-	-	-	4%	-	-	1%	-	1%
Payments based on input use	86%	20%	7%	9%	19%	5%	3%	4%	33%	100%	13%	11%	5%	17%	75%	11%
Payments based on animal numbers	-	-	-	2%	-	-	-	0%	1%	-	6%	-	5%	16%	-	2%
Payments based on historical entitlements	-	0%	5%	1%	-	-	-	-	-	-	-	-	23%	-	-	2%
Payments based on input constraints	-	-	-	1%	0%	-	-	2%	-	-	1%	0%	-	-	1%	1%
Payments based on overall farm income	14%	35%	0%	-	-	-	-	2%	3%	-	1%	-	-	1%	24%	2%
Miscellaneous payments	-	3%	-	-1%	-	-	-	-	0%	-	-	0%	4%	-	-	0%
Country Totals	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
Share of OECD PSE for pigmeat																
Market Price Support	-	-	1.6%	47.4%	1.4%	0.1%	18.3%	5.1%	0.8%	-	1.1%	3.0%	3.2%	0.5%	-	82.5%
Payments based on output	-	0.7%	-	-	0.2%	0.0%	-	-	-	-	0.1%	-	-	0.0%	-	0.9%
Payments based on input use	0.1%	0.3%	0.1%	4.6%	0.4%	0.0%	0.5%	0.2%	0.4%	0.0%	0.2%	0.4%	0.3%	0.1%	3.1%	10.8%
Payments based on animal numbers	-	-	-	1.1%	-	-	-	0.0%	0.0%	-	0.1%	-	0.3%	0.1%	-	1.7%
Payments based on historical entitlements	-	0.0%	0.1%	0.5%	-	-	-	-	-	-	-	-	1.1%	-	-	1.7%
Payments based on input constraints	-	-	-	0.8%	0.0%	-	-	0.1%	-	-	0.0%	0.0%	-	-	0.1%	0.9%
Payments based on overall farm income	0.0%	0.6%	0.0%	-	-	-	-	0.1%	0.0%	-	0.0%	-	-	0.0%	1.0%	1.8%
Miscellaneous payments	-	0.1%	-	-0.6%	-	-	-	-	0.0%	-	-	0.0%	0.2%	-	-	-0.3%
Total OECD	**0.2%**	**1.6%**	**1.8%**	**53.8%**	**2.1%**	**0.1%**	**18.8%**	**5.6%**	**1.2%**	**0.0%**	**1.4%**	**3.4%**	**5.0%**	**0.8%**	**4.1%**	**100%**

Source: OECD PSE/CSE database, 2003.

Annex Table 8. Composition of total OECD PSE for pigmeat by support category

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Composition of PSE (USD million)																
Total producer support (PSE)	**8 366**	**5 622**	**12 302**	**8 425**	**6 000**	**8 609**	**4 508**	**9 415**	**11 213**	**10 218**	**10 772**	**9 192**	**8 986**	**12 769**	**9 701**	**9 675**
Market price support	6 470	3 586	10 126	6 162	3 625	6 604	2 189	7 457	9 156	8 019	8 575	5 769	6 789	10 943	7 839	7 752
Payments based on output	173	183	294	520	322	152	191	75	86	85	91	34	63	145	97	57
Payments based on input use	1 284	1 473	1 473	1 321	1 626	1 493	1 578	1 437	1 332	1 351	1 442	2 207	1 197	1 034	1 208	1 217
Payments based on animal numbers	77	96	117	144	186	203	252	196	215	271	276	320	392	201	166	164
Payments based on historical entitleme	49	48	66	84	89	54	160	181	201	376	262	211	179	207	179	172
Payments based on input constraints	13	20	19	19	17	18	29	39	201	132	155	613	284	116	88	100
Payments based on farm income	256	213	184	193	156	83	83	51	60	74	83	113	116	142	193	232
Miscellaneous payments	45	3	24	- 18	- 20	2	27	- 20	- 38	- 90	- 112	- 75	- 34	- 19	- 67	- 20
Share of PSE																
Total producer support	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**
Market price support	77.3%	63.8%	82.3%	73.1%	60.4%	76.7%	48.6%	79.2%	81.7%	78.5%	79.6%	62.8%	75.6%	85.7%	80.8%	80.1%
Payments based on output	2.1%	3.2%	2.4%	6.2%	5.4%	1.8%	4.2%	0.8%	0.8%	0.8%	0.8%	0.4%	0.7%	1.1%	1.0%	0.6%
Payments based on input use	15.3%	26.2%	12.0%	15.7%	27.1%	17.3%	35.0%	15.3%	11.9%	13.2%	13.4%	24.0%	13.3%	8.1%	12.5%	12.6%
Payments based on animal numbers	0.9%	1.7%	1.0%	1.7%	3.1%	2.4%	5.6%	2.1%	1.9%	2.7%	2.6%	3.5%	4.4%	1.6%	1.7%	1.7%
Payments based on historical entitleme	0.6%	0.9%	0.5%	1.0%	1.5%	0.6%	3.5%	1.9%	1.8%	3.7%	2.4%	2.3%	2.0%	1.6%	1.8%	1.8%
Payments based on input constraints	0.2%	0.4%	0.2%	0.2%	0.3%	0.2%	0.6%	0.4%	1.8%	1.3%	1.4%	6.7%	3.2%	0.9%	0.9%	1.0%
Payments based on farm income	3.1%	3.8%	1.5%	2.3%	2.6%	1.0%	1.8%	0.5%	0.5%	0.7%	0.8%	1.2%	1.3%	1.1%	2.0%	2.4%
Miscellaneous payments	0.5%	0.1%	0.2%	-0.2%	-0.3%	0.0%	0.6%	-0.2%	-0.3%	-0.9%	-1.0%	-0.8%	-0.4%	-0.1%	-0.7%	-0.2%
Share of gross farm receipts																
Total producer support (%PSE)	**18.8%**	**11.6%**	**25.0%**	**16.4%**	**10.5%**	**15.1%**	**7.7%**	**18.2%**	**21.4%**	**18.2%**	**16.9%**	**15.2%**	**19.3%**	**29.5%**	**20.2%**	**17.9%**
Market price support	14.6%	7.4%	20.6%	12.0%	6.3%	11.6%	3.7%	14.4%	17.5%	14.3%	13.4%	9.5%	14.6%	25.3%	16.3%	14.4%
Payments based on output	0.4%	0.4%	0.6%	1.0%	0.6%	0.3%	0.3%	0.1%	0.2%	0.2%	0.1%	0.1%	0.1%	0.3%	0.2%	0.1%
Payments based on input use	2.9%	3.1%	3.0%	2.6%	2.8%	2.6%	2.7%	2.8%	2.5%	2.4%	2.3%	3.6%	2.6%	2.4%	2.5%	2.3%
Payments based on animal numbers	0.2%	0.2%	0.2%	0.3%	0.3%	0.4%	0.4%	0.4%	0.4%	0.5%	0.4%	0.5%	0.8%	0.5%	0.3%	0.3%
Payments based on historical entitleme	0.1%	0.1%	0.1%	0.2%	0.2%	0.1%	0.3%	0.4%	0.4%	0.7%	0.4%	0.3%	0.4%	0.5%	0.4%	0.3%
Payments based on input constraints	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.4%	0.2%	0.2%	1.0%	0.6%	0.3%	0.2%	0.2%
Payments based on farm income	0.6%	0.4%	0.4%	0.4%	0.3%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.2%	0.2%	0.3%	0.4%	0.4%
Miscellaneous payments	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%	-0.2%	-0.2%	-0.1%	-0.1%	0.0%	-0.1%	0.0%

Source: OECD PSE/CSE database, 2003.

Annex Table 9. Calculation of total OECD Market Price Support for pigmeat

	Unit	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Producer price	USD/tonne	1 527.51	1 614.27	1 572.41	1 644.36	1 847.08	1 780.01	1 784.44	1 542.64	1 559.81	1 655.80	1 878.94	1 750.43	1 257.76	1 151.88	1 307.39	1 435.21
Three year average	USD/tonne			1 571.40	1 610.35	1 687.95	1 757.15	1 803.84	1 702.36	1 628.96	1 586.08	1 698.18	1 761.72	1 629.04	1 386.69	1 239.01	1 298.16
World reference price	USD/tonne	1 164.00	1 344.69	1 143.26	1 388.56	1 636.75	1 449.20	1 629.63	1 240.05	1 214.55	1 382.02	1 620.93	1 567.75	1 029.36	812.37	1 074.32	1 221.78
Three year average	USD/tonne			1 217.32	1 292.17	1 389.52	1 491.50	1 571.86	1 439.63	1 361.41	1 278.87	1 405.83	1 523.57	1 406.01	1 136.49	972.02	1 036.16
Market price differential	USD/tonne	363.51	269.59	429.15	255.80	210.33	330.81	154.81	302.59	345.25	273.78	258.01	182.68	228.40	339.52	233.07	213.43
Three year average	USD/tonne			*354.08*	*318.18*	*298.43*	*265.64*	*231.98*	*262.74*	*267.55*	*307.21*	*292.35*	*238.16*	*223.03*	*250.20*	*266.99*	*262.01*
Excess feed cost	USD/tonne	- 133.32	- 146.22	- 92.98	- 51.78	- 92.18	- 120.16	- 87.67	- 73.24	- 64.20	- 31.33	- 0.85	- 10.60	- 38.39	- 38.46	- 14.98	- 2.94
Producer Nominal Protection Coefficient[1]		1.32	1.21	1.39	1.20	1.14	1.23	1.10	1.25	1.29	1.20	1.16	1.12	1.23	1.43	1.22	1.18
Three year average				1.30	1.26	1.24	1.19	1.16	1.20	1.21	1.25	1.22	1.16	1.17	1.26	1.29	1.28
Volume of Production	000 tonne	27 868	28 637	29 919	29 843	29 774	30 911	31 683	32 258	32 267	32 656	32 798	32 621	35 184	35 952	35 341	36 217
Calculation of Market Price Support																	
Transfer from consumers to producers[2]	USD mn	10 188	3 610	10 151	6 186	3 655	6 648	2 259	7 546	9 387	8 164	8 741	6 398	7 091	11 086	7 947	7 862
less excess feed cost	USD mn	- 3 715	- 20	- 19	- 19	- 17	- 18	- 29	- 39	- 201	- 132	- 155	- 613	- 284	- 116	- 88	- 100
less levies	USD mn	- 3	- 3	- 5	- 5	- 12	- 26	- 41	- 50	- 30	- 13	- 11	- 16	- 18	- 27	- 21	- 9
Market Price Support	USD mn	6 470	3 586	10 126	6 162	3 625	6 604	2 189	7 457	9 156	8 019	8 575	5 769	6 789	10 943	7 839	7 752
Market Price Support	USD/kg	232.17	125.22	338.46	206.48	121.76	213.66	69.08	231.18	283.74	245.57	261.46	176.84	192.97	304.39	221.80	214.05

Notes:
1. The Producer Nominal Protection Coefficient measures the ratio between the producer price and the world reference price.
2. Transfers from consumers to producers are derived by multiplying the market price differential by the volume of production.
Source: OECD PSE/CSE database, 2003.

Annex Table 10. Manure spreading requirements in selected OECD countries

Country	*Regulations controlling the quantity of manure that can be spread*	*Regulations controlling the spreading of manure*
Australia	The Effluent Management Guidelines for Intensive Piggeries gives a general guide of maximum loading rate of 50 to 200 kgN/ha depending on the climate, soil, vegetation land use and effluent management (control of amount and timing of applications) (ARMCANZ, 1999).	Buffer zones, normally about 200 metres, are required between production plant and sensitive areas such as water courses, groundwater, etc. In some states, buffer zones extend up to 5 kms.
Flanders, Belgium	The "decree concerning the protection of the environment against pollution from fertilisation" of January 1991 set maximum fertilisation limits from all kinds of fertiliser for both N (400 kg/ha/year on all agricultural land) and P_2O_5 (200 kg/ha/year on grassland and maize and 150 kg/ha/year on all other arable land) (Hacker and Du, 1993). The first Manure Action Plan (MAP) set maximum fertilisation limits for N and P_2O_5 for the year 2002. From 2002 the maximum annual N application will be 450 kg/ha on grassland and 275 kg/ha on other land, and for P_2O_5 125 kg/ha on grassland and 100 kg/ha on other land. At that point, the maximum annual application of N originating from manure is not permitted to exceed 250 kg/ha on grassland and 200 kg/ha for other crops (van Gijseghem, 1997). Stricter environmental standards are imposed for areas indicated for the production of drinking water, for landscape protection, or where a high level of phosphate leaching is observed.	The decree of 1991 prohibited the spreading of manure between 2 November and 15 February (Hacker and Zu, 1993), or on flooded, snow-covered or deeply frozen soil. The first MAP prohibited farmers from spreading manure between 21 September and 21 January (van Gijseghem, 1997). The second MAP extended the period during which the spreading or manure is forbidden from 21 September to 31 January on grassland and until 15 February on arable land. The period for arable land in the protected zones lasts from 1 September until 15 February (Dobbelaere, 1999).
	As part of the second MAP announced in 2000, farmers are given increased responsibility for their manure practices. Farmers are allowed to use manure beyond this limit if they can prove that the residual nitrate in the upper soil (up to 90 cm deep) is lower than 90 kgN/ha, as measured during the period 1 October to 15 November (van Gijseghem *et al.,* 2002). Furthermore, non-family livestock farmers are required to ensure that an increasing percentage of their surplus is exported out of Flanders, which usually involves being shipped to a manure processing facility (*e.g.* for drying, mineralisation etc) (Dobbelaere, 1999) (van Gijseghem, 1997).	Measures to reduce volatilisation were introduced as part of the first MAP, which included as obligation of manure injection in soils, *i.e.* sod injection or ploughing in within one day after spreading (van Gijseghem, 1997). Under the second MAP, tighter measures have been introduced with the specific purpose of reducing ammonia volatilisation by 40% compared to 1990

		levels. Animal manure must be incorporated into the soil within 24 hours if they contain low levels of ammonia, otherwise on arable land they should be injected or incorporated into the soil within 4 hours, and on all other land they should be injected, spread during rain or rained into the soil within 2 hours (Dobbelaere, 1999). Regulations forbid farmers from spreading on Sundays, holidays, and in the evening or night (van Gijseghem, 1997).
Canada		In Quebec, generally manure cannot be spread on farmland between 1 October and 31 March or on frozen or snow covered ground, and within set distances from water courses, wells ditches and wetlands (Fox and Kidon, 2002).
Denmark	The 1987 Action Plan for the Aquatic Environment (APAE I) set a limit on the land application of animal manure. For each type of farm, a maximum quantity of manure was established in terms of livestock units. A livestock unit was approximately the number of animals that in produced 100 kgN in a year. For pig farms, the maximum quantity of manure that could be spread was 1.7 livestock units per hectare on pig farms *i.e.* 170 kgN/ha. In terms of pig numbers, this is equivalent to 30 finishing pigs per ha. Farms with a livestock density exceeding these limits may prove compliance with the standard by presenting a written agreement with neighbouring farms to receive excess manure (Dubgaard, 1991). Under the 1998 Action Plan for the Aquatic Environment (APEA II), the maximum amount of manure that can be spread was reduced to meet the requirements of the Nitrates Directive. The maximum quantity that can be spread on pig farms has been reduced to 1.4 livestock units per hectare *i.e.* 140 kgN/ha (Dirkmose, 1999).	APAE I placed a restriction on the spreading of liquid manure on frozen ground and on unvegetated soil in the period from the autumn harvest until 1 November (Dubgaard, 1991). The 1991 Action Plan for Sustainable Development imposed stronger restrictions. From autumn 1993, the spreading of liquid manure from harvest to 1 February was prohibited except on already established over-wintering grass-land and on winter rape crops in the period from harvest to 1 October. From harvest to 1 October, solid manure can only be spread on ground covered by crops the following winter (Dirkmose, 1999).

	In between these two APAEs, the 1991 Action Plan for Sustainable Agriculture (APSA) introduced measures to promote a more efficient use of manure. Since crop year 1994/95 farms over a certain size have been required to prepare annual fertiliser accounts.[1] Each year, the Ministry of Agriculture informs farmers about standard permissible use of N for all individual crops, the standard N content in manure and slurry from different types of livestock (calculated on the basis of the stable system they inhabit) and the required minimum manure utilisation rates. On the basis of this information the farmer calculates the maximum, permissible amount of N that can be used on the farm, also termed the N-quota, and the quantity of N in manure and slurry that is utilised. In order to tighten the requirements even further, the APEA II reduced the standard N application rates for all crops to 10% below the economic optimum. It also increased over time the minimum manure utilisation rates. For pig farms, this increased from 50% to 70% by 2003 (Ambus *et al.*, 2001).	In 1987, the Danish APEA I set a maximum time limit of 12 hours for working in liquid manure after spreading to reduce ammonia emissions (Dubgaard, 1991). The 2001 Action Plan for Reducing Ammonia Volatilisation from Agriculture will place a ban on the surface spreading of liquid animal manure from 1 August 2002.
France	In NVZs, farmers are obliged to spread a maximum of 170 kgN/ha from animal manure as from 1999 (Vermersch, 2001). Some more stringent limitations are placed on application rates around water wells and along rivers. In the Vendée *département,* there is an additional limit of 100 kgP_2O_5/ha. The quantity of N and phosphorus in the slurry is calculated on the basis of the number of reproductive sows present in the herd and the number of growing pigs produced per year. Allowable limits may be calculated in one of three ways: (a) standard values which are used on farms where no improvement of the feeding strategy has been made; (b) the "two-phase" feeding values which are used in farms where different diets are used for different classes of pigs; or (c) a balance based on the actual intakes of protein and phosphorus (Dourmad *et al*., 1999).	Manure can only be spread up to 10 metres of neighbouring property on the condition that it is immediately incorporated.
Germany	The whole country is designated a NVZ. The "Fertiliser Act" (Duengeverordnung) 1996 obliges all farmers to limit the average amount of N applied in manure fertiliser over the whole farm 170 kg/ha on arable land and 210 kg/ha on grassland (Zeitjs, 1999). In calculating their	Manure may not be applied between 15 November and 15 January or if conditions are unsuitable (Hannen, 2000).

	N application rate farmers are allowed to adjust for 10% losses during storage and 20% loses during spreading (Eichler and Schulz, 1998). Regional authorities are able to designate and protect water collection areas, and in these areas impose greater restrictions on land use including handling of manure (Zeitjs, 1999). For example, in the state of Baden-Wuertteemberg, farmers can be restricted to applying 45 kgN/ha (van der Bijl *et al.*, 1999).	The Fertiliser Act 1996 provides only loose requirements affecting ammonia release relating to the spreading of manure. It specifies that the spreading of manure should be performed close to the ground, that the manure should be ploughed in "immediately after spreading" and that the equipment used be in accordance with the "generally accepted rules of technology" (Eichler and Schultz, 1998).
Ireland	Pig farmers in part of Cork County are limited to spreading no more than 210 kgN/ha in catchments where groundwater nitrate levels exceed 20 mg/l, and no more 250 kgN/ha on all other land (Lara *et al.*, 2001).[2]	In County Cork manure produced during the period when animals are housed must be land spread by 31 October, and no manure shall be spread in January/February on land that receives chemical fertiliser containing N (Lara *et al.*, 2001).
Italy	At the national level, the maximum amount of manure that can be applied to land is the annual production of 4 tonnes of live weight per hectare. However, some regions have introduced their own regulations for manure management. These are strictest in the four Northern regions in the Po Valley: Piemonte, Lombardia, Emilia-Romagna and Veneto. For example, in the Emilia-Romagna and Lombardia regions the maximum annual application rates are 170 kgN/ha in vulnerable zones and 340 kgN/ha in non-vulnerable zones. In Veneto, four zones have been identified with application rates for each set at: 0, 170, 250 and 340 kgN/ha, while in Piemonte the range varies between 250 and 500 kgN/ha depending on soil type (Cortellini *et al.*, 1999) (Massarutto, 1999).	The four regions of the Po valley impose varying restrictions on when manure can be spread. For example, Lombardia and Emilia-Romagna impose bans between 1 November and 28 February, and 15 December and 28 February respectively, while no such time bans are placed in Piemonte or Veneto. All four regions prohibit the spreading of manure in other circumstances such as the presence of snow or frost, flooded areas, steepness of the land, in quarry areas etc (Massarutto, 1999).

Nether-lands	Under MINAS farmers must record their N and P_2O_5 inputs (in manure, fertiliser and feed) and output (in animal and plant products) on a nutrient declaration form. Surpluses per hectare are calculated as input per hectare minus output per hectare. Maximum surplus levels are allowed with a levy charged on surpluses above these levels (LNV, 2001). In addition, maximum limits on the application of nitrogen from livestock manure have been set. These vary according to the type of cultivation carried out on the land. These have been reducing over time and from 2003 were 250 kgN/ha on grassland and 170 kgN/ha on all other land (LNV, 2001).	Farmers are not allowed to spread manure between 1 to 15 September (depending on the soil type) and 1 February, and on soils that are water-saturated, frozen or snow-covered. Since 1990, low ammonia emission manure spreading techniques such as shallow or deep injection, or spreading harrow have been obligatory.
New Zealand	The discharge of manure to land (spray irrigation or irrigation from ponds) is a "permitted activity" (*i.e.* no individual permit is required) provided than certain conditions are adhered to. In terms of the quantity of manure that can be spread, these vary between Regional Councils but limits in the range of 150-200 kgN/ha are common (Meister, 2002).	When discharging manure to the land livestock farmers are required to take into consideration factors such as the distance to the neighbours' property, proximity of discharges to watercourses, the application interval and the local area guideline (Meister, 2002).
Norway	Farmers are required to achieve a balance between the input of fertiliser and uptake by plants based on phosphorus. The maximum application rates are connected with the amount of phosphorus that plants can take up (Morken, 1999).	It is forbidden to apply manure on frozen soil and between 1 November and 15 February. Furthermore, manure can only be applied after 1 September if it is ploughed in or injected, and must be incorporated at all times when used on arable land. Farmers must spread using a technique that minimises volatilisation (*e.g.* by adding water to the waste or using injection techniques) and incorporation is required within 18 hours of spreading. Farmers must use a low spreading technique when applying manure within a certain distance of housing (Morken, 1999).

Sweden	Since 1999, fertiliser may not be spread in amounts that exceed the crop N requirements for the growing season in NVZs. The amount of fertiliser applied should be based on the balance between the crops foreseeable N requirements and the N supply from all external potential N sources, and take into account: soil conditions, type and slope; climatic conditions; and land use and agricultural practises including crop rotations. For other parts of the country national guidelines are published (Swedish Ministry of Agriculture, 2000*a*).	Since 1989, the application of manure has been banned between 1 December and 28 February on all farms unless it is incorporated into the soil on the same day. Since 1995, the spreading of manure between 1 August and 30 November in NVZs can only take place on a growing crop or before sowing. In 1999, a complete ban on the application of manure from 1 January to 15 February in NVZs was imposed, together with a ban on the application of all fertilisers on snow covered, frosted or water-saturated ground in these regions. Since 1998, in the Southernmost parts of Sweden, manure must be incorporated within 4 hours when applied to bare soil. On growing crops, a suitable technique (either band spreading, injectors or dilution) must be used (Swedish Ministry of Agriculture, Food and Fisheries, 2000*a*).
United States	Animal feeding operations are regulated at the state level through restrictions and requirements imposed on field application techniques. The stringency of these regulations varies from state to state but most states regulate some aspect of the manure management system construction and manure field application (Metcalfe, 2000) (Carpentier and Erwin, 2002).	

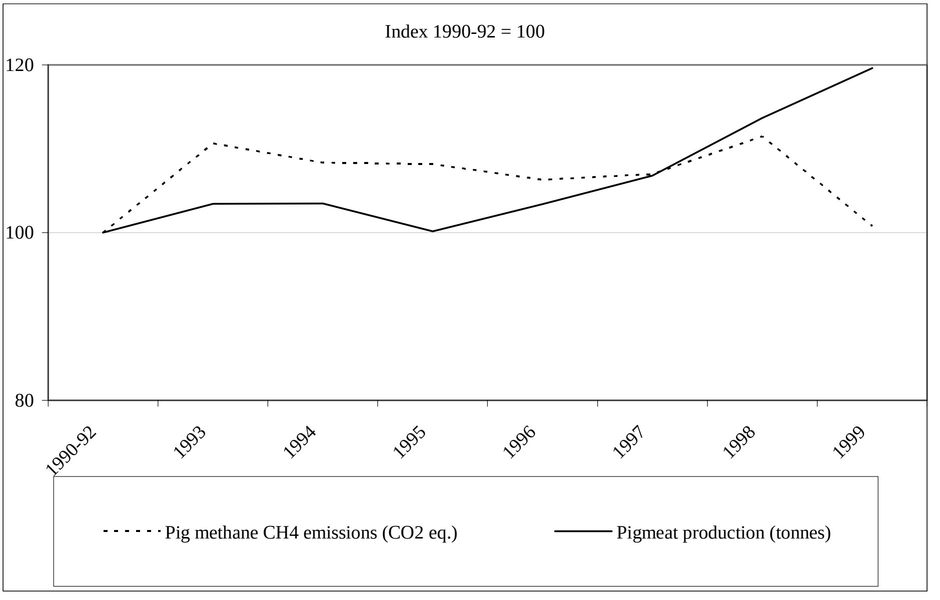
For Notes, see following page.

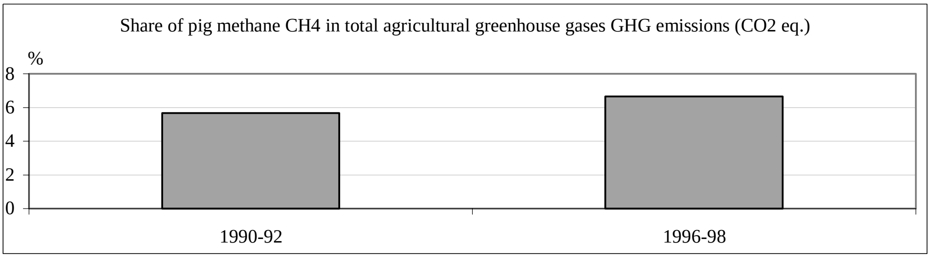
Notes to Annex Table 10:

1. A farm must prepare fertiliser accounts if they have: an income of more than USD 2 300 from agriculture; or more than 10 livestock units; or more than 1 livestock unit per hectare; or more than 25 tonnes of manure. By participating in the scheme farmers are exempt from tax on commercial fertiliser.

2. Ireland is the only EU member state to have not designated NVZs although the voluntary code of good practice required by the Nitrates Directive has been established. The Local Government (Water Pollution) Amendment Act 1990 gave local authorities the power to enact by-laws for the regulation and control of polluting activities. County Cork was the first to impose by-law regulations on livestock farmers in the catchments of the Lee, Gradogue and Funshion rivers (Lara *et al.*, 2001). By-laws were established during 2001 in Cavan, Tipperary and Westmeath and other counties are expected to follow suit soon.

Annex Figure 1. Contribution of pigs to greenhouse gas emissions: Austria

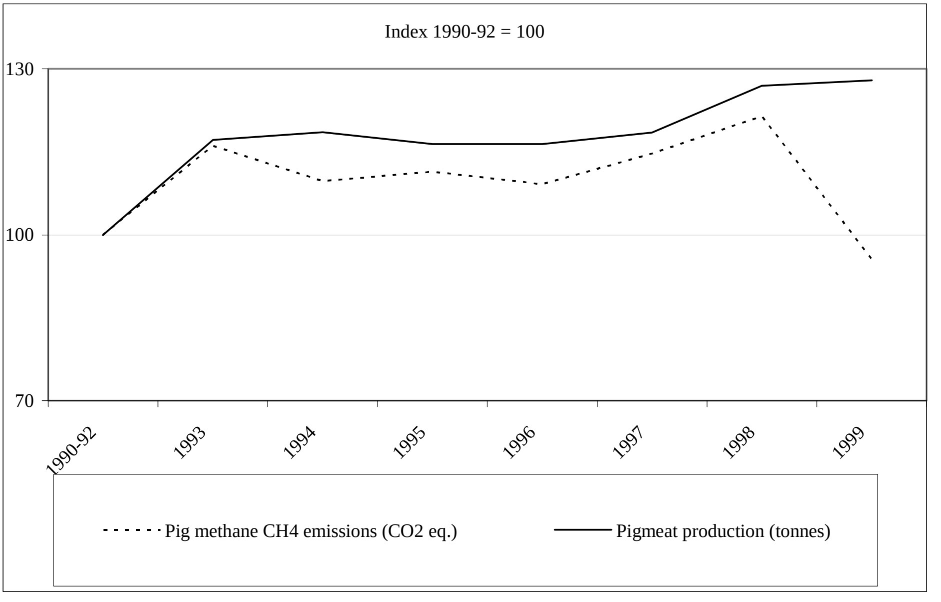


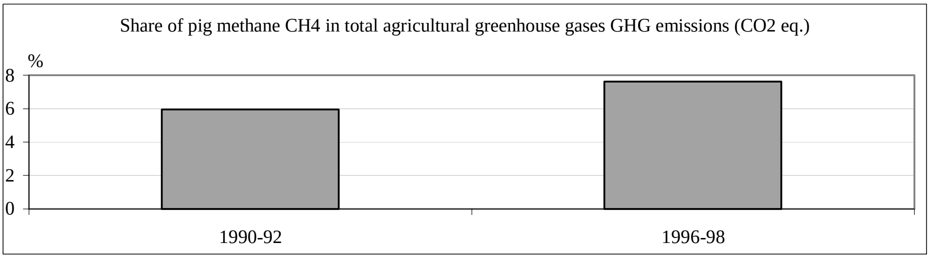


eq: Equivalent.

Sources: The Convention on Long-Range Transboundary Air Pollution, the United Nations Framework Convention on Climate Change and FAO databases, March 2002.

Annex Figure 2. Contribution of pigs to greenhouse gas emissions: Denmark

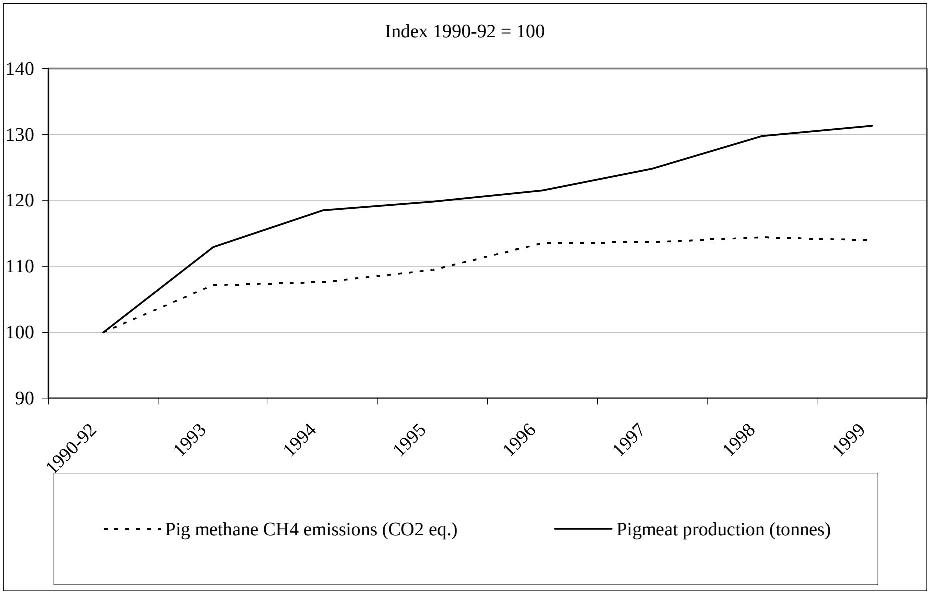


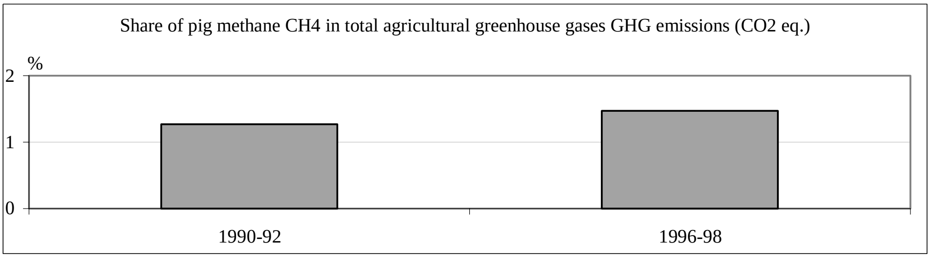


eq: Equivalent.

Sources: The Convention on Long-Range Transboundary Air Pollution, the United Nations Framework Convention on Climate Change and FAO databases, March 2002.

Annex Figure 3. Contribution of pigs to greenhouse gas emissions: France

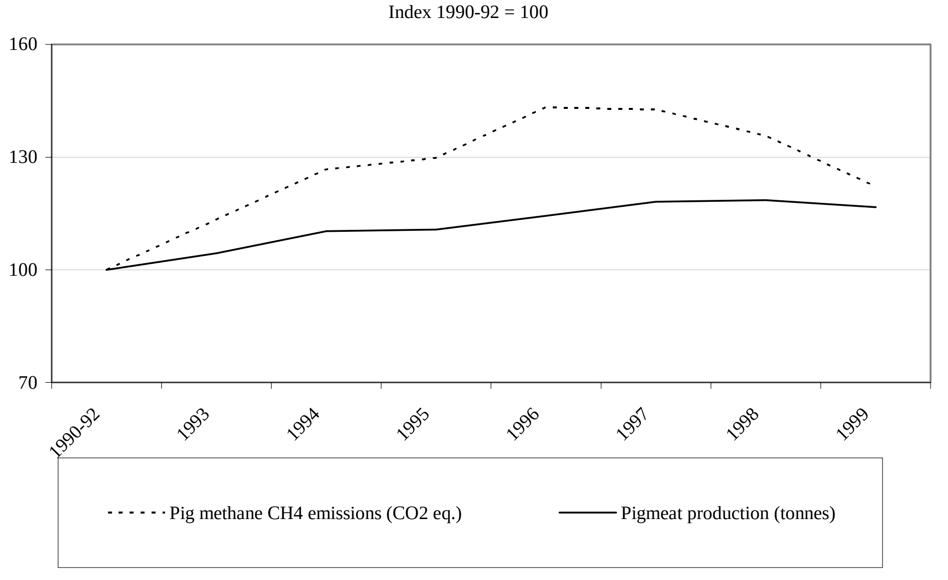


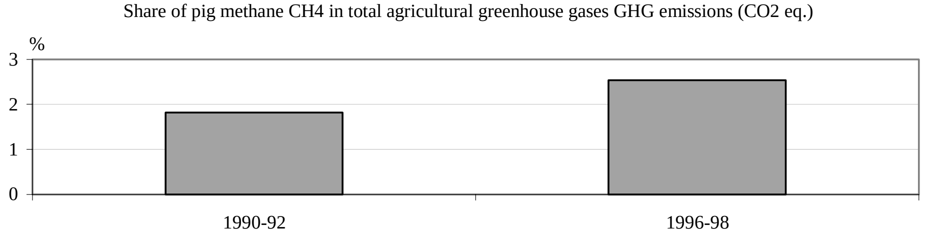


eq: Equivalent.

Sources: The Convention on Long-Range Transboundary Air Pollution, the United Nations Framework Convention on Climate Change and EUROSTAT databases, March 2002.

Annex Figure 4. Contribution of pigs to greenhouse gas emissions: Sweden

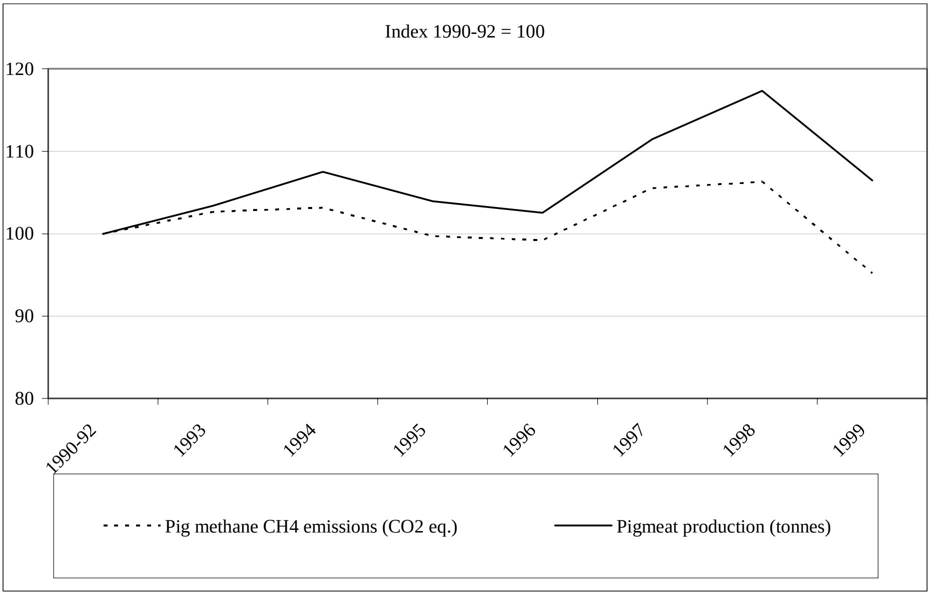


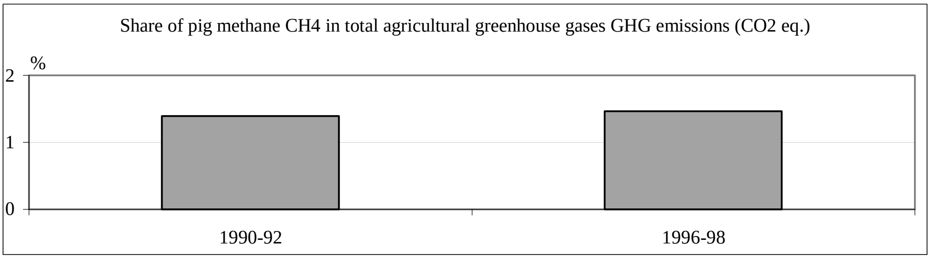


eq: Equivalent.

Sources: The Convention on Long-Range Transboundary Air Pollution, the United Nations Framework Convention on Climate Change and FAO databases, March 2002.

Annex Figure 5. Contribution of pigs to greenhouse gas emissions: United Kingdom





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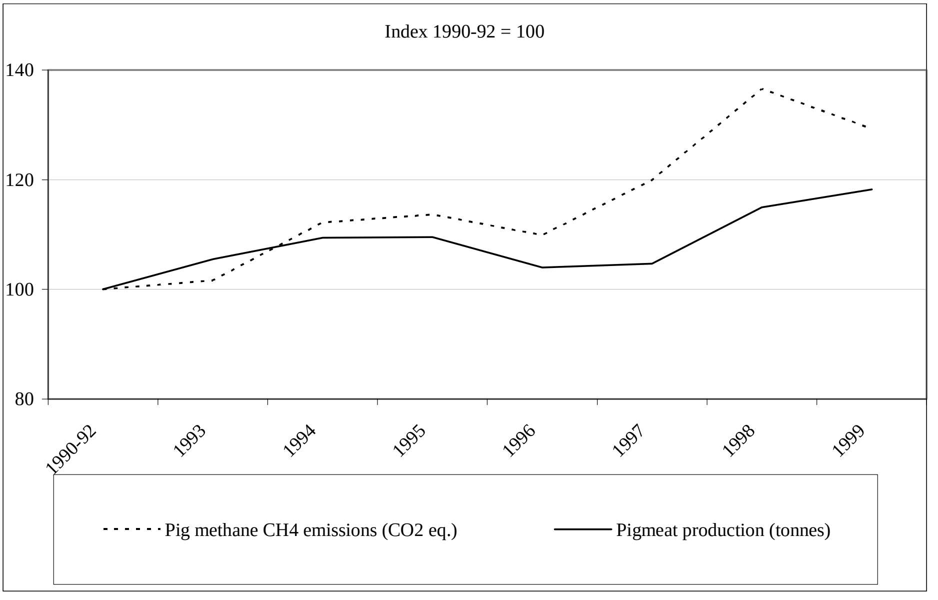
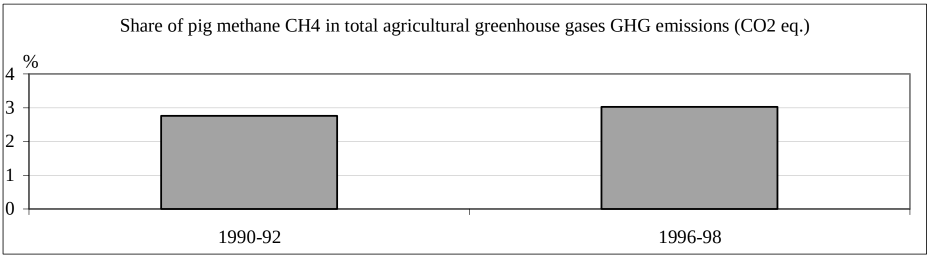
Sources: The Convention on Long-Range Transboundary Air Pollution, the United Nations Framework Convention on Climate Change and EUROSTAT databases, March 2002.

Annex Figure 6. Contribution of pigs to greenhouse gas emissions: United States





eq: Equivalent.

Sources: The Convention on Long-Range Transboundary Air Pollution, the United Nations Framework Convention on Climate Change and OECD Agricultural Commodities Outlook databases, March 2002.

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