THE DUTCH NUTRIENT QUOTA SYSTEM: PAST EXPERIENCE AND LESSONS FOR THE FUTURE

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Paper prepared for the OECD workshop on "The Ex-Post Evaluation of Tradeable Permit Regimes", January 21-22, 2003, Paris.

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1. Introduction

Trading in emission allowances based on an cap-and-trade system is broadly recognised as a cost efficient and environmentally effective instrument for emission reductions in the theoretical literature. However, there is considerable debate about the efficiency and effectiveness of these schemes in practices. Issues of concern are the potential impacts of market imperfections, the organisational efforts of allowance allocation and market establishment, and the position of so-called exposed sectors.

Tradable pollution permits (TPP) do not play a significant role in agri-environmental policy. They are rarely discussed, in contrast to environmental taxes on for example fertiliser, pesticides or nutrient surpluses.[i] To our knowledge there is only one example of a TPP specifically for agriculture, namely the Dutch system of phosphate quota in animal production. The experiences with the Dutch quota system example could be very useful in view of the recent interest of including non-point source pollution from agriculture in trading programmes that traditionally only would cover point source pollution.[ii]

We proceed as follows. Section 2 presents a summary of the environmental problems in Dutch animal agriculture. In section 3 an overview of the phosphate quota regime is given. Section 4 discusses the institutional background and methodology used in the available ex-post studies. Sections 5-7 give an overview of the results, a comparison with ex-ante studies and the policy implications, respectively.

2. Environmental problems in animal agriculture and initial policy regulation

In Western Europe the expansion and intensification process in the pig, poultry and dairy sectors gathered pace during the 1960s and 1970s. In The Netherlands the expansion of animal numbers, specifically pigs and poultry, was particularly evident on the sandy soils in the eastern and southern part of the country. Specialized pork and broiler production was an ideal option to improve the labour productivity and farm incomes on the small farms in these regions. The increase in pork and broiler production was made possible by a growing international demand for animal products and a EU agricultural policy that favoured the import of feed.[iii] As a result, Dutch livestock producers, particularly in the pig (some 10,000 farms) and the poultry sectors (some 2,000 farms), developed intensive livestock operations on farms with small acreages. Between the early 1960s and the mid-1980s, the number of pigs and poultry increased by 10 million (+ 450 percent) and 50 million (+ 125 percent), respectively (Wossink and Benson, 1999).

Consequently, a manure surplus developed, particularly in the east and southern parts of the country. The national surplus of manure was about 16 million metric tons or 19 percent of all manure in 1987 (Tamminga and Wijnands, 1991).[iv] In terms of phosphate the surplus equalled 75 million kg (CPB, 2000). Excess manure leads to over application of manure on crops and consequently emission into groundwater.[v] It was estimated in the mid-1980s that the maximum EU standard of 50 mg nitrate per litre of groundwater was exceeded on 60 % of agricultural land in The Netherlands (Becker, 1992).[vi]

The first warnings about the polluting effects of manure surpluses on the environment were already being voiced in the 1970s.[vii] Growing political concerns in response to the alarming environmental developments in the 1980s, as outlined above, meant that some actions had to be taken (Frouws,

1997). The first policy action was the imposition of a moratorium, the Interim Law for Restriction of Pig and Poultry Farms of November, 1984. This Law prohibited the creation of new livestock farms in the eastern and southeastern regions of the Netherlands and placed restrictions on the expansion of existing intensive livestock farms. However, farmers took full advantage of the expansion opportunities under this Law and further action was needed.[viii] Further action was also needed as the euthropication of surface water and groundwater pollution became issues of international concern.[ix]

The moratorium was followed by a more comprehensive approach with the objective to achieve a balance between production and utilization of the nutrients in manure by the year 2000. This objective was set out in the first National Environmental Policy Plan of 1989, to be implemented stepwise under a Three-Phase Plan covering the periods 1987-1990; 1991-1994 and 1995-2000. The figures in Table 1a identify the *original* targets of the Three-Phase Plan, the figures in Table 1b present the targets as actually implemented. At the outset, the phosphate content in manure was the target nutrient of the regulations.[x] In the first phase (1987-1990), the Manure Law and the Soil Protection Act[xi] (both of 1987) replaced the Interim law. The Manure Law introduced the manure quota system and the manure bookkeeping system. Main aim of the latter system was to ensure that actual phosphate production did not exceed the quota amount and to monitor manure application in view of the admissible rates in Table 1b (see Breembroek *et al.*, 1996).

In the second phase (1991-1994) ammonia was addressed through the Guideline on Ammonia and Cattle Farming under the Nuisance Act (now Environmental Management Act). This Act only allows expansion of livestock farms if acidification is below a threshold of 30 mole acid per hectare annually. Markets for ammonia quota were established in parts of the country through the development of county ammonia reduction plans.

3. Overview of the quota system[xii]

3.1. Initial allocation

Since the enactment of the Manure Law on January 1, 1987 (Amvb, 1986a), Dutch legislation allows a total manure production from all animal sources of up to 125 kg of phosphate (P_2O_5) per hectare of land. Farmers producing more manure in terms of phosphate need additional registered animal based manure production rights. The system of manure production rights was introduced in two steps: in 1987 for the production of manure from cattle, swine and poultry, and in 1992 for the production of manure from sheep, goats, ducks, foxes, nutria and rabbits. Each farm was grandfathered a so-called "reference amount" based on the actual manure production. Actual manure production for each individual farm was estimated by an inventory of animals and standards for the manure production for each specific animal category measured in kilograms of P_2O_5 per year[xiii]. These animal specific standards were calculated as the difference between phosphate supply (in feed, animals, fertilizer etc.) and phosphate removal (in meat, milk, eggs, animals, etc.). The residual is assumed to represent the phosphate content in manure of the specific animal category. For example, the phosphate standard for finishing pigs is 7.4, meaning that one finishing pig will produce 7.4 kg of P_2O_5 per year.

Assessment were made of all land either owned or long term leased (minimal 6 years and officially registered) used for agricultural purposes in December of 1986 and again in December of 1991. The difference between the reference amount and the assessed acreage based phosphate rights was used to establish a distinction between manure surplus farms (with manure production in excess of 125 kg of P_2O_5 per hectare) and manure deficit farms (with phosphate production below 125 kg/ha). A deficit farm could still increase animal production on the basis of unused land based manure production rights. For a manure surplus farm such an increase in production capacity was possible only with an increase in the reference quantity of manure production rights through land acquisition.

Table 1a. The *original* targets of the Three-Phase Plan: maximum admissible application rates of animal manure in kg P_2O_5/ hectare/year.

	Phase 1 1987-1991	Phase 2 1991-1995	Phase 3 1995-2000	From 2000
Grassland	250	200	175	125 [1]
Silage corn	350	250	175	125 [1]
Arable land	125	125	125	125 [1]

[1] These figure later to be adjusted for crop nutrient uptake.

Table 1b. Maximum admissible application rates of animal manure in kg P_2O_5/ hectare/year as *actually* implemented.

	Phase 1	Phase 2			Phase 3	
	1987-1991	1991-1992	1993	1994	1995	1996-1997
Grassland	250	200	200	200	150	135
Silage corn	350	250	200	150	110	110
Arable land	125	125	125	125	110	110

Source: Jongbloed and Lenis (1998).

3.2. Period 1987-1993: Trading in land related manure production rights only

From 1987 until 1993 the transfer of the manure production rights was severely restricted to prohibit a further exacerbation of the manure problem. The conditions are specified in the "Relocation Decision" document enacted on May 1, 1987 (Amvb, 1987). It states that the reference quantity is only transferable: (a) as part of the transfer of a whole farm,[xiv] (b) with marriage and heritage, (c) with annulment of a lease contract for a farm, in which case the lessor was entitled to transfer the reference amount to another farm in his possession.

The limited possibilities for increasing the manure production rights of the farm and hence its production capacity, meant that expansion could have been only realized by means of land acquisitions. However, buying an additional hectare of land would result in a net increase in aggregate (animals plus land) manure production rights only for a deficit farm. For a surplus farm, buying additional land could cause a proportional amount of the existing reference (animals based) quota to "sink" into the land-based quota with no net increase in aggregate manure production rights.[xv] So in fact, more animal production was possible only by starting a new animal farm or by starting an animal enterprise on completely non-used land quota, that is by relocating animal production to crop farming regions. Expansion of the existing livestock farms in the Netherlands came to a standstill in the regions where animal production has been traditionally concentrated, *i.e.*, in the South and East of the country. The regulation indirectly caused a freeze of the agricultural structure in those regions hampering the adaptation and investment processes required for solving the national manure problem. To counteract these limitations, a new law regulating transfer of manure production rights was enacted on January 1, 1994 (Haerkens and Walda, 1994).

3.3 Period 1994-1997: Relaxed trading in manure production rights

The main element of the new law regulating transfer of manure production rights was that the production rights became tradable. For each farm the reference amount was converted into "manure production rights" (manure quota) to indicate the change in policy. In contrast to the homogeneous

reference amount, manure production rights became highly differentiated with the goal to restrict the trading. This was done in three steps.

First, a farm's total manure quota was officially divided into two parts: a land based part and a non-land-based part. The first part amounts to 125 kg of P_2O_5 times the number of hectares of land on the farm, whereas the non-land based part is calculated as the difference between a farm's reference amount and the land-based quota.

Second, a farm's non-land based quota was allocated to specific animal categories reflecting the situation on an individual farm. Using the inventory figures on animals from earlier assessments of the reference amount, each farm's total manure quota was partitioned into animal categories. This was accomplished by using a ranking scheme reflecting the extent to which keeping various categories of animals is truly land related. Three classes were established: (1) cattle and turkeys, (2) sheep, goats, foxes, nutria and ducks, and (3) pigs and chickens or broilers. In the Netherlands, hog, broiler and other small animal farms are confined animal husbandry operations, whereas a cattle farming is more directly land related. The ranking scheme was used to determine which animal category is associated with the non-land (tradable) quota.

As seen in the upper portion of Table 2, the available land quota (125 kg of P_2O_5 per hectare) will first cover the manure production from cattle and turkeys and then, if there is some land quota left, it will be assigned to the other two animal categories until the entire land quota is exhausted. The remaining difference between the farm's reference amount and the land-based quota becomes non-land based and hence tradable. As the result of this regulation, most of the tradable quota ended up being allocated to the third animal category (pigs and chickens). The denomination of the tradable quota is important because trading was restricted across animal species. The quota was made upward compatible in the sense that the third animal category quota can be used for the production of the second and the first category of animals. On the other hand, pigs and chickens can be produced only with the third category quota since using phosphate quota from any other animal category for pigs and chickens is not permissible. The rationale behind this rule was to prevent farmers from using other animal category quota to further increase swine production, which was perceived to be the source of the most serious environmental problems.

Third, the non land-based quota allocated to cattle, turkeys, pigs and chickens (broilers) was differentiated further to account for the improvements in feed conversion in these sectors. For each of these animal categories the "dormant quota", i.e., the difference between the original reference amount and the actual phosphate production was assessed.[xvi] This was done for each farm individually. As seen in the lower portion of Table 2, the dormant part of the quota became non-tradable. There were other restrictions that inhibited the trading of the production rights. For example, with each transaction 25% of the quota was retired. This reduction applied to all animal categories. In addition, the farmer who acquired additional quota had to certify that he had either sufficient land on his own farm to dispose off the total manure for the next two years or had a manure disposal contract with another farm.

Manure quota could still change hands through land transactions (lease or sale) with no reduction in the available quota. However, just as in the earlier period, if additional land was acquired by a surplus farm, the land-based quota that goes with it automatically 'sunk' into the animals based quota (see note xv). So, for a surplus farm, the acquisition of more land reduced the tradable part of the quota by increasing the land-related share and reducing the non land-related share.

Table 2. Example of the assessment of the tradable animal based quota

Farm description:

- 9 hectares of land
- Reference amount 2800 kg P_2O_5, of which 800 due to cattle/turkeys and 2000 due to pigs/chickens/broilers
- Highest actual manure production in 1988-1990: 2200 kg P_2O_5, of which 500 due to cattle/turkeys and 1700 due to pigs/chickens/broilers

Calculation	Total		cattle/turkeys	pigs/chickens/broilers	
Reference amount	2800		800	2000	
Land related quota (9×125)	1125	Allocation	800	325	(1125-800)
Non land related	1675		0	1675	
Actual manure production	2200		500	1700	
Land related 9 × 125	1125	Allocation	500	625	(1125 -500)
Non-land related (tradable)	1075		0	1075	
Dormant (non tradable)	600			600	(1675-1075)

3.4 Regional differences and geographical restrictions on trading

Based on the concentration of animals per unit of agricultural land, The Netherlands is divided into two regions. The manure-surplus region has an average manure production of more than 125 kg of P_2O_5/ha and encompasses parts of four provinces: Gelderland and Overijssel in the East and Noord-Brabant and Limburg in the South (see Figure 1). In the past, farms in the surplus region were typically small with a mixture of enterprises. Given the farm size, the lack of better alternatives forced farmers in the region to specialize predominantly in confined livestock production with off-farm purchases of virtually all feedstuffs. The manure deficit region covers the rest of the country (Groningen, Flevoland, Friesland, Drenthe, Utrecht, Noord-Holland, Zuid-Holland and Zeeland), for which the average manure production is below the 125 kg of P_2O_5/ha threshold. Until recently, this region had a very limited experience with confined livestock production. Historically, it was characterized by larger farms specialized in dairy, crop farming and horticulture.

Since the government's main objective was to keep the animal population from increasing in the surplus region, an important element of the system of manure production rights is a set of geographical restrictions on trading. The transfer of quota was allowed within regions and from a surplus region into a deficit region, but prohibited from a deficit region into a surplus region. In addition to phosphate quota, farmers willing to expand animal production in the surplus region had to acquire ammonia rights (MANMF, 1995). Trade in ammonia rights was only allowed within a county and hence was even more spatially restricted than trading in phosphate quota. There was no such ammonia regulation in the manure-deficit region.[xvii] Despite the fact that the new regulations significantly eroded the positive agglomeration effect that the hog industry in the surplus region had historically experienced, hog farmers did not leave the surplus region *en masse.*[xviii]

Figure 1. Livestock concentration areas in the Netherlands

3.5 Policy uncertainty

The future of the quota system was uncertain from the beginning because of expected changes in policy. In 1993 the central agreement between the Ministries of Agriculture and the Environment and the farmers' union (Landbouwschap) was that by 1998 the quota system would become obsolete[xix] with the introduction of a nutrient accounting scheme at the farm level. The short time period during which the quota system would be in effect raised the raised the question whether this system had to be introduced at all (Haerkens and Walda, 1994).

The nutrient accounting scheme mentioned above scheme included strict nutrient application standards not only for phosphate but also nitrogen per hectare plus a *prohibitive* tax on any surpluses. With such a scheme a farm's legal production capacity would not be determined by the amount of quota but by its capacity of manure disposal, either by land application on the own farm or by hauling it to a crop farm in the deficit region. The scenario was met by massive protest from farmers, forcing union leaders to distance themselves publicly from the plan (Frouws, 1997). Besides, the plan was met with serious doubts on the part of the environmental organisations and drinking water suppliers.[xx] In addition each of the stakeholder groups had concerns about the objectives for ammonia reduction.[xxi]

In 1995 the definitive governmental proposal regarding nutrient accounting was launched (MANMF, 1995). Nutrient accounting would become obligatory for both phosphate and for nitrogen. Nutrient surpluses above the waste standard would be subject to a high tax to ensure manure disposal to the deficit regions. In addition additional requirements for new buildings were announced in order to

reduce ammonia emissions. Also in 1995, the existing animal-based quota for pig and poultry farmers was cut by 30 % in response to the development of low-nutrient feed.[xxii] Added to the political agenda by mid July 1997 was an additional 25 percent reduction in quota specifically for the swine sector.[xxiii] Competing farmer action groups (including a radical union of pig farmers, Nederlandse Vakbond Varkenshouders or NVV) voiced their protest and attacked with renewed vigour eager to gain time. Eventually, on January 1, 1998 the nutrient accounting scheme and building requirements were enacted but *without* abolishing the quota system. The 30 % reduction of 1995 was revoked and the quota system was further detailed by separating the swine quota from those for chickens and broilers and by further detailing the swine quota. On September 1, 1998, quota for finishing and farrowing pigs were allocated on the basis of 90 % of the actual number of these animals on each farm in 1996 or 1995. New housing requirements aimed at the improvement of animal welfare became imperative with the purchase of extra quota for pork production. A quota buy-out programme was initiated specifically for the swine sector.

The 10 % reduction of September 1998 was part of the Pig Farming Restructuring Act (Wet Herstructurering Varkenshouderij), aimed at reducing the generated manure and the pig herd by 25% by the year 2000 (with 1995/1996 as base year). The act also included stricter health and veterinary requirements for the pig production industry. Originally the Act passed the legislative hurdle. However, it became subject to litigation between the NVV and the Dutch government and, therefore, halted until January 2000. On January 20, 2000, the Court in The Hague ruled in favour of the government and declared the 10% reduction in the size of the pig herd as enacted on September 1, 1998 to be legitimate. However, the court decision exempted the second generic reduction by 15% that was announced for 2000.

A survey in 1997 showed that Dutch livestock farmers in general perceive policy uncertainty as very relevant and of the same importance as the uncertainty from production and markets (Meuwissen et al., 2001). The respondents in this survey associated regulatory risks with environmental policy, animal welfare policy and the value of production rights, in particularly.

In summary: In the context of the Dutch phosphate quota system, regulatory uncertainties arise for two main reasons: (1) the uncertainty of the continuance of the quota system, and (2) the uncertainty of the introduction of future constraints on quota use. The impact of constraints on quota use or of a quota phase-out is obvious: quota values would always be affected negatively. The impact of a cut in quota is less clear. The Dutch phosphate quota system does not allow leasing, so users of quota are all owners of quota. In that situation users of quota would all suffer a loss in asset values with a cut in quota. On the other hand, a generic cut would lead to an increase in the marginal value per unit quota, which would lead to higher quota prices. Hassett and Metcalf (1999) argue that the net directional impact of the overall effect of potential policy changes that follow a discrete jump process, such as those that might affect the quota program, is uncertain. Barichello (1996; p. 295) concludes that specifically for quota the perception is that the policy risks are highly asymmetric. Some options may exist for policy changes that would increase quota rents, but these are largely outweighed by possible changes that would reduce rents, consistent with the results of the above mentioned survey study (Meuwissen et al., 2001).

4. Evaluation

There is only a limited number of *ex-post* studies that evaluate the Dutch efforts to control the manure problem or parts of these efforts. In the overview presented here specific attention is given to reports written in Dutch in order to make them accessible to an international audience. Section 4.1 highlights the institutional background, motivations for evaluation and data use of the *ex-post* studies and section 4.2 discusses the methods used in these studies. The results of the evaluation studies are presented in sections 5.1-5.5.

4.1 Institutional framework, motivations for evaluation and data use

The most specific evaluation study of the quota system is a 15-page report by the Dutch Ministry of Agriculture (MANMF, 1996) which covers the period January 1994-June 1996. It discusses the number of trades and trade volume, whether total farms where traded or parts thereof, price development, the impact of the quota system on structural change and on the development of nature and environmental policy, problems encountered with monitoring and control and other bottlenecks. Data used for this study are from Bureau Heffingen and from IKC [Information and Knowledge Center, mainly renamed Expertise Center-LNV], both of which are agencies of the Dutch Ministry of Agriculture. Bureau Heffingen is responsible for the implementation of the regulations on manure and nutrients and records and monitors information on number of animals, quota and quota trade and manure application by farm[xxiv]. The agency does not record quota prices. The price information reported in the study was collected by IKC by means of expert elicitation.

In 2000, the Netherlands Bureau for Economic Policy Analysis (CPB, 2000) published a substantial ex-post evaluation study of the total mix of manure regulations covering the period 1983-1999. This study was part of a wider project covering four prominent and persistent environmental problems in Dutch society and was commissioned to support the development of the Fourth National Environmental Policy Plan.[xxv] The study presents a detailed description of the policy changes since 1983 and of the development of the viewpoints of the various stakeholders. This evaluation however is for the *total mix* of regulations of which the quota system is only one element (see section 2). The study uses commonly available sources and there seems not to have been any preferential access to data or this was not used. An important source of data is the series of the Agricultural Economics Research Institute in the Hague (LEI-DLO) on the environmental performance of Dutch agriculture (LEI-DLO, various years). The series provides data on the development of animal numbers, waste volume and the cost of the regulation at the farm level. This information is gathered through annual farm surveys (CBS, various years) and the records of a panel of 1,500 farms maintained by LEI-DLO.

De Walle and Sevenster (1998) present an overview of agricultural policies on manure and nutrients in six EU member states, the U.S. and Canada. This study was commissioned by the Technical Soil Protection Committee, which advises the Netherlands Ministries of the Environment and Agriculture. The analysis of the Dutch legislation includes a very short discussion of the environmental effects for the period 1985-1992 (De Walle and Sevenster, 1998, p. 41-43), but no evaluation of any other criteria. The evaluation of the environmental effects is based solely on OSPAR data (OSPAR, 1995).[xxvi]

Finally, there are two academic studies that address single aspects of the phosphate quota program. Vukina and Wossink (2000) analyse the regional differences in the impact of the policy regime specifically for land prices. Two hypotheses are tested at the level of provinces for the 1987-1996 period. First, the existence of the quota with regional restriction on trading should have caused a disproportional increase in price of agricultural land in the surplus region where the quota is binding relative to the deficit region where the quota is not binding. Second, the increase in cost of environmental compliance from other policy restrictions[xxvii] that became considerable more stringent in the 1990s should have generated an eroding effect on the existing gap in land rents and consequently land prices between regions. Data used in this analysis all came from LEI-DLO and Statistics Netherlands.

The other academic study is Wossink (2000) and addresses the effect of policy uncertainty on the performance of the quota programme. It is hypothesised that policy uncertainty leads to a wait-and see attitude that impedes the efficient functioning of the quota market. Uncertainty arises for two main reasons in the setting of the Dutch quota system: (1) the uncertainty of future constraints on quota use, and (2) the uncertainty of the continuance of the quota system. Stricter rules on waste disposal or the

introduction of a pollution tax would lower returns to quota and thereby reduce the volume of trade. The phasing out of the program would make the quota valueless and would lead to complete inaction on the quota market. The only data used in the analysis are quota prices, earning of quota use and the interest rate. Data for quota prices[xxviii] comprised a series of 166 and 103 individual transactions in quota for swine in the region south and east period in April 1996-May 1998, respectively. The Dutch Association of Realtors provided the latter data.[xxix]

4.2. Methodology for evaluation

We will discuss here the evaluation criteria as used in each of the studies indicated above.

The evaluation by the Dutch Ministry of Agriculture (MANMF, 1996) focuses on the main objectives of the law that introduced trade of phosphate quota: (a) structural development in animal agriculture by way of reallocation of non-land base phosphate quota, (b) to solve the bottlenecks encountered in the period of limited trading (1987-1993), and (c) to relocate farms away from nature reserves and forests. After the enactment of the Guideline on Ammonia and Cattle Farming a fourth objective was added: (d) to facilitate trade in ammonia quota. The MANMF report is organised according to eight evaluation questions: (1) the number of trades, (2) trade volume by region, (3) trades of whole farms as part of the total number of trades[xxx], (4) price development, (5) whether quota trade enhanced structural adjustment, (6) prevention of increase in total manure production and prevention of further concentration of farms close to nature reserves, (7) monitoring and reporting, and (8) bottlenecks in the trade rules. It was not the intention of this study to perform an economic evaluation of the efficiency and effectiveness of the quota system in comparison with other policy instruments. The focus is on the dynamic effects of quota trade on the structure of the agricultural sector. The baseline used in the study is the situation before the quota became tradable.

The evaluation by the Bureau for Economic Policy Analysis (CPB, 2000) addresses each of the seven key criteria listed by the OECD for the evaluation of environmental policy instruments (OECD, 1997). Environmental effectiveness and cost efficiency are evaluated as well as administrative costs, dynamic effects, wider economic effects and the role of attitude and awareness. The study includes an extensive discussion of the counterfactual, i.e. what would have happened in Dutch animal agriculture in 1983-1999 in the absence of the manure policy. A separate baseline is distinguished for the dairy sector, for pork production and for poultry. The remaining animal categories are not discussed. A comparison with ex-ante studies is also included.

De Walle and Sevenster (1998) only discuss the environmental effectiveness. These authors compare the average application rates of manure and fertiliser (in terms of N and P in kg per ha) in 1985 and 1993. They also discuss nitrogen surpluses in 1994 and 1995. The counterfactual is the situation without the policy efforts to reduce the manure problem.

Vukina and Wossink (2000) address the impact of the quota regime on land prices. The econometric analysis for 9 regions and 10 years enables detailed attention to be given to the counterfactual. The pooled cross-section time-series data include variables that represent the changes in land acreage, farm income, total manure output, cost of environmental compliance (manure storage and disposal) and the cost of capital. Remaining systematic differences in the change in land prices between the two concentration areas and the rest of the country are attributed to the quota system.

Wossink (2000) argues that the value of quota as policy-created assets reflects market participants' assessment of the level, variability and duration of future returns to policy. The possibility of future change in policy regime leads to risks for the market participants. The stream of future incomes from quota use could be reduced or stopped by a change in policy. The paper asks to what extent policy risk affects quota prices and quota market efficiency. It is generally acknowledged that the price of

production quota in agriculture (*e.g*., dairy, eggs, tobacco, and peanuts) is well below the expected capitalized value, indicating high risk-premiums for policy uncertainty[xxxi]. However, a simple comparison of quota prices and discounted returns does not include transaction cost which may also affect quota values and trade and does not address the impact of policy changes over time. Wossink uses the option value theory to forge a natural connection between political uncertainty and quota price volatility. Based on the option value theory, an econometric model is developed for investing and disinvesting in quota. The econometric estimation enables the impact of policy risk on transaction costs to be distinguished from that of other, conventional, sources of transaction costs (*e.g.*, cost for services by an estate agent and a notary). The evaluation baseline is the situation without policy uncertainty.

5. Overview of main results

Sections 5.1-5.5 section follow the guidelines for *ex-post* evaluation of tradable permit programmes as set out by the OECD Working Party on Environmental Policy (OECD, 2001). The following criteria are discussed: economic efficiency, environmental effectiveness, administrative costs, dynamic effects and innovation, and "soft" effects.

Before we do so, we need to point out a distinct characteristic of the phosphate quota system that has general implications for the assessment of results and their interpretation. The Dutch permit system to control animal waste is in fact a quota on livestock numbers that is used as a proxy for the environmental impacts from animal waste. Such a system obviously only caps livestock and can only be environmentally effective and efficient if combined with other policy measures that directly aim at (the emissions from) waste handling and disposal and animal housing. In the Netherlands a series of such additional measures were introduced after 1987 and they became gradually more stringent with time. As a consequently, an evaluation of the quota system is complicated as it is difficult to disentangle the effects of the nutrient quota system from that of the other measures.

5.1 Economic efficiency

Relevant indicators of the functioning of the permit market are price dispersion between trades, the volume of trade, the number of buyers and sellers, geographical patterns of trade and transaction costs (OECD, 2001). For each of these aspects the main findings of the evaluation studies are given.

Price of quota

Considerable variation in quota prices was observed, both between regions and over time. The MANMF report discusses average quota prices for the two surplus regions and the rest of the country in 1994 and 1995. Prices for pig/poultry quota ranged from 25 to 60 guilders[xxxii] per kg in the south, between 20 to 50 guilders per kg in the east and between 12 to 30 guilders in the rest of the country. Prices for cattle/turkey quota were 15 to 40 guilders per kg in both the south and east. Later on quota prices were higher. For the period April 1996-May 1998, prices for pig and poultry quota ranged between 29 and 100 guilders in the south and 20 and 80 guilders per kg in the east, respectively (Wossink, 2000).

Volume of trade

Quota became tradable on January 1, 1994. By December of 1994, about 2,200 transactions had taken place with a total trade volume of 1.8 million kg phosphate (MANMF, 1996). This was however only 1.5 % of the total volume of quota available for trade (T.P.M. den Teuling, personal communication,

Bureau Heffingen Assen, 2000). Further data from Bureau Heffingen shows that by December 1997 in the concentration areas 8.1 % and in the non-concentration areas 9.5 % of all non-land based quota had been traded.

Several causes for the slow development of trade can be identified. Firstly, administrative approval of the trade was required -- farmers acquiring additional quota had to certify that they had a manure disposal plan in place for the next two years. In 1994, no less than 37 % of the trade applications had to be resubmitted because of shortages in the manure disposal plan (MANMF, 1996). Secondly, farmers might have been allocated the optimal amount of quota and hence did not need to buy or sell to satisfy their production requirements. The initial allocation was based on information on animal numbers provided by the farmers themselves. The Dec 1986 survey organised for this purpose had been announced and likely led farmers to mention the maximal stable capacity instead of the average occupation. It is estimated that initial quota was over-allocated by 10 to 25 % (CPB, 2000) and this likely affected trade volume. Thirdly, the restriction of quota transfer within region and by animal category limited the tradability and thereby reduced the efficiency of the system. The even more limiting spatial restrictions (within counties) on the trade of ammonia quota further reduced the efficiency of the phosphate quota system.

Geographic pattern of trade

Vukina and Wossink (2000) conclude that in the earlier stages of implementation, the program served as a barrier to entry into the swine industry in the manure surplus region. Later, an upward shift in environmental costs acted as a stimulus for producers in the surplus region to move their production to the deficit region. Due to the higher quota prices in the surplus regions, it was more profitable to leave (sell) the quota in the surplus regions and to buy land in the rest of the country. The manure production rights needed to expand production in the rest of the country were almost entirely land-based as is confirmed by data from Bureau Heffingen (T.P.M. den Teuling, personal communication, Bureau Heffingen Assen, 2000). The rents formerly created by the phosphate quota program gradually dissipated as new environmental policy constraints on manure storage and land application took effect. Searching for less limiting environmental policies, a number of pork producers left the surplus regions and relocated to the rest of the country (or migrated).

Transaction costs

Wossink (2000) estimates the conventional transaction costs incurred by the markets participants for swine and finds significant estimates as high as 17 % of the average quota price. Many other studies indicate the prevalence of significant transaction costs in tradable permit markets (Stavins, 1995, p. 135). Recall that in the specific case addressed here, formal approval of the trade was required for which buyers had to certify that they had a manure disposal plan in place. The cost of arranging such a plan and the administrative cost associated with obtaining approval can be assumed to be important particularly because as these costs are invariant to the size of the transaction. Besides, the trading system as such was very complicated, the brochure explaining the system to farmers contains no less than 66 pages (MANF, 1993). This complexity likely led to pecuniary and also non-pecuniary transactions costs for farmers.

Wossink (2000) also estimates the impact of uncertainty in terms of transaction costs and market efficiency. Uncertainty drastically increased the transaction costs and market equilibrium was virtually absent. The probability of a wait and see attitude due to uncertainty was found to be considerably higher for the eastern region where the additional transaction cost was also much higher. The latter increase was estimated to be 71.31 guilder per kg of quota in the southern surplus region and 152.57 guilders in the eastern surplus region, respectively. In comparison, the average quota

prices paid were 66.11 guilder and 48.69 guilder per kg in the south and east, respectively. The announcement in July 1997 of a future cut in quota led to significant further increases in transaction costs and less efficient markets. The policy announcement particularly affected the quota market in the south. The differences between the estimated option values in the regions South and East and the estimated increase in option values after July 1997 correspond well with anecdotal evidence for the quota market.

5.2 Environmental effectiveness

As described in section 3.1, the Dutch permit system to control animal waste is a quota on livestock numbers which is used as a proxy (by fixed emission coefficients by animal type and age category) for damages arising from phosphate and indirectly also nitrate.[xxxiii] Optimal control would require continuous monitoring of nonpoint-source emissions but is prohibited by the intermittent nature of the discharges and the fact that pollutants are widespread. In such a situation a useful alternative for regulatory bodies is to grant political legitimacy to environmental indicators such as a fixed phosphorus coefficient per animal. Such an indirect approach of input-output oriented environmental indicators is acceptable for policy design whenever there are no indications that the suspected polluters possess better information about the ultimate pollutant release than the regulatory agency (Dosi and Moretto, 1993). This reasoning was definitely applicable at the time the phosphate quota system was first introduced.[xxxiv] Furthermore it is argued that generally, the indirect approach of environmental indicators should be preferred whenever it is believed that the cost for regulatory agencies of acquiring information about ultimate environmental implications of productive decisions in terms of ambient pollutants levels are prohibitively high (Dosi and Moretto, 1993). This point of view is particularly applicable to agriculture, which involves many producers, many pollutants and many production situations.

The Dutch phosphate quota system imposed a ceiling on the maximum phosphate output and a cut by 25 percent in the case of trade. This 25 % retirement rule was imposed for environmental reasons. Phosphate quota is differentiated by animal category and the phosphate standard per animal category directly links quota volume to animal numbers. With these trade rules, animal numbers and total phosphate output will at least be stabilised and could be reduced by as much as 25 percent. Notice however that the retirement rule is a disincentive to trade. It reduces gains from trade by more than 25 %, since buyers will discount the resale value as well. Secondly, it makes the cap completely uncertain since it is dependent on trade volumes. None of the evaluation studies analysed pays attention to this issue.

MANMF (1996) reports that in 1994, 1995 and the first six months of 1996 a total of 6.7 million kg phosphate was traded of which 1.6 million was cut. The trade covered 6.6 % of the total quota volume in the concentration areas. Outside the concentration areas this was 7.4 %.[xxxv] Trade in quota for pig and chicken and broilers made up 85 % of the trade volume and trade in cattle and turkey quota was responsible for 11 %. The report highlights that *additionally* there had been 2,200 trades of in total 6.6 million kg animal-based quota that were not cut because the quota trade was part of the sale of a complete farm. The MANMF report discusses that the change in the volume of animal-based quota is not directly indicative for the change in environmental pressure from animal production. The start of new farms on land-based quota in the non-concentration areas and additional production based on previous "dormant" quota (see section 3.3.) could actually have increased total manure production. The report refers to statistics based on a sample of the manure records of farms in animal production that showed that the actual production of phosphate in Dutch agriculture decreased from 163 million in 1993 to 134 million in 1995. The MANMF reports implicitly attributes this reduction of 17.8 % of the total phosphate production in 2.5 years to the quota programme.[xxxvi]

The Bureau for Economic Policy Analysis (CPB, 2000) emphasises that it is incorrect to ascribe to policy the observed reduction in quota volume and in actual manure production. In cattle and dairy farming there were only minimal impacts of the mix of manure regulations, and of the quota programme for that matter. The reduction in animal numbers and in actual waste production in the cattle and dairy sector (Table 3) can be completely ascribed to the EU's Common Agricultural Policy. The introduction of milk quota in the early 1980's and the reduction in price support for beef were the main determinants of the changes in this sector. In contrast, the regulation on manure did have an impact in pork production. The quota system prohibited a further increase in animal numbers and the compliance cost of the regulations on manure application and storage increased the cost of production considerably. Without the policy on manure the number of pigs would have been 10 to 20 % higher based on the counterfactual for the swine sector in Folmer *et al.* (1995). For the poultry sector the same conclusion is reached in analogy with the analysis for the swine sector. The CPB study concludes that without the policy, total manure production from livestock production in the Netherlands would have been 5 to 10 % higher[xxxvii]. The specific contribution of the quota program is not addressed.

Table 3. Trends in animal numbers and total animal waste production, The Netherlands, 1980-96

	ANIMAL NUMBERS			ACTUAL ANIMAL WASTE PRODUCTION							
	Pigs	Cattle	Poultry	Pigs		Cattle		Poultry		All livestock	
	1000 head			Manure MMT	P_2O_5 Mil. kg	Manure MMT	P_2O_5 Mil. kg	Manure MMT	P_2O_5 Mil. kg	Manure MMT	P_2O_5 Mil. kg
1980	10,138	5,226	82,035	14.6	..	68.5	..	1.7	..	85.7	230
1990	13,915	4,926	92,765	16.4	69.6	65.4	133.3	2.3	32.7	86.0	226
1993	14,964	4,797	98,086	17.0	72.0	65.5	126.1	2.5	34.8	86.0	235
1994	14,565	4,716	93,953	16.4	65.3	63.6	119.6	2.3	33.0	81.2	219
1995	14,565	4,716	93,953	16.2	60.1	63.7	118.4	2.1	30.7	80.9	209
1996	14,419	4,551	93,552	16.9	56.9	61.7	103.6	2.4	30.5	80.4	207
1997 *	15,189	4,411	95,295	15.5	57.2	59.7	101.0	2.4	32.1	77.3	186

* Affected by outbreak of classical swine fever.

Source: CBS/LEI-DLO, various years, and www.minlnv.nl/infomart.feiten/1997/feitlandb6.htm

5.3 Administrative costs

The only study to discuss the cost of enforcing activities is the report by the Bureau of Policy Analysis (CPB, 2000). The total annual costs are estimated to be about 44 million Euro (110 million guilders).[xxxviii] This figure covers the administrative cost associated with all the elements of the manure policy. Especially the enforcement and control cost of the manure bookkeeping system can be assumed to be considerable. On the other hand, this figure does not include the research expenditures of governmental and semi-governmental and private organisations or the cost of the additional staff requirement at the Ministry of Agriculture and its agencies.

5.4 Dynamic Effects and Innovation

The MANMF report of 1996 mentions that 95 % of those farms that sold their entire quota amount quit animal production completely. The report (pg 5.) concludes that the quota system enhanced structural changes, i.e. it encouraged exit. This insight was based on survey information and was not statistically confirmed in terms of quota volume and actual phosphate production.

There is significant evidence that the policy mix on manure provided a continuing incentive for animal producers to search for innovative approaches to reduce emissions (CPB, 2000; Wossink and Wefering, 2002). These reductions have to be ascribed to the measures on manure storage and application and cannot be attributed to the quota system. The emission reductions were made possible by nutritional measures particularly in the swine industry, which was most seriously affected by the regulations on manure. Aside from improvements in nutrition efficiency using existing diets, significant improvements were achieved by the development of modified feeding regimes for pigs. The modified diets reduced the N and P intake and thereby the N and P surplus while maintaining or even enhancing daily weight gains. With storage of additional feed types accounted for, total costs per farm were assessed to be negative for finishing pig farms and very limited for farrowing pig farms (Leneman et al., 1993).

5.5 Soft effects

A psychologically important point was that many farmers were not convinced of the environmental benefits of the policy (Katteler and van den Tillaart, 1989). To some extent these benefits are also still disputed in academic circles (CPB, 2000). The fierce response of the swine producers, in particular, has to be viewed in this context. Besides the swine sector was severely affected by the regulations on manure storage and land application that were later added to the policy. The compliance cost of these regulations had to be borne mainly by the swine producers and these predictably did not embrace the policy.

The CPB report emphasises that there were far too high expectations in policy circles of the possibilities of technical development and the export of processed manure (CPB, 2000). Consequently the position of the swine industry as an 'exposed sector' was not recognised in time and this became a big bottleneck. The Dutch swine sector dominated the policy debate but in fact is relatively small in macro economic terms.[xxxix] A quota buy-out in the early nineties for swine production could have prevented a lot of environmental damage and human grief (CPB, 2000).

6. Comparison with ex-ante studies

There are several *ex-ante* studies that address the expected economic impact of the manure regulations. None however looks specifically at the phosphate system.

Tamminga and Wijnands (1991, p.130-135) present an *ex-ante* analysis of the costs to achieve a balance between production and utilisation of the nutrients in manure by the year 2000. Stolwijk (1989) assesses the direct economic effects of three policy scenarios for animal agriculture by 1986. Both studies address the cost of changes in environmental management at the individual farm and indicate that for the majority of the swine producers, compliance cost would amount to 40-50 % of their average income. The poultry sector would also be severely affected.

7. Implications for policy reform

The Dutch experience with the phosphate quota programme provides considerable experience and data to draw on. The implications for policy reform can be summarised as follows:

Baseline data and permit allocation:
There must be accurate data on the baseline for permit allocation together with a reliable and accurate system of monitoring and accounting. Theoretical studies commonly state that "regulators influence the success of tradable permits systems by permit allocation mechanisms". The evaluation of the Dutch phosphate quota programme shows that initial quota was over-allocated 10 to 25 %. Allocation

was based on a farm survey in which many farmers mentioned the maximal stable capacity instead of the average occupation. Consequently there was less incentive for Dutch livestock farmers to buy quota.

Consistency:
Ambiguous property rights complicate any environmental regulation but can cripple a regulation around trading of the rights. In the context of permit systems regulatory uncertainties arise for two main reasons: (1) the uncertainty of the continuance of the system, and (2) the uncertainty of the introduction of future constraints on permit use. There must be confidence in the stability of the policy system for a reasonable period of time. Without this participants will not trade. Consequently, policy uncertainty incurs aggregate welfare losses because of misallocation of resources to produce the permitted output. The process of a decision on alternative policies can generate uncertainty. It can also be created through the *prospects* of policy changes and even by uncertainty about the implementation of programmes to enhance trade. Because these factors are likely to be present to some extent in future trading programmes, it is important to understand their implications on market performance in order to judge and evaluate such programs accordingly.

Permit unit:
Specifically for the control of non-point source pollution it is common to use a proxy for the environmental impacts. The Dutch permit system uses livestock numbers as an indicator of the environmental impacts from animal waste. For a permit system based on such a proxy to be environmentally effective it has to be combined with other policy measures that directly aim at the emissions. However, such measures will undermine the effectiveness of the permit system (Tietenberg, 1980). Besides the discussion about additional policy measures leads to policy uncertainty.

Autonomous developments:
Environmental pollution is not influenced by governmental policy only. Autonomous developments, such as technological, structural and market developments also affect pollution levels and their impact can be positive or negative. Policy makers in general appear to be far too optimistic with respect to the effects of both regulations and autonomous developments. It should be prerequisite to use *ex-ante* studies in policy design to prevent policies being developed based on pertinently unrealistic assumptions.

Timing:
The Dutch example shows that a tradable permit system as the single policy instrument to achieve policy targets might only work when actual pollution and policy targets are reasonable close. Therefore it is important to act in a timely fashion. If the quota system had been introduced in the late 70s the manure problem would probably long have been solved.

Commitment:
A strong policy commitment to the system and its objectives is crucial. The constituency of political support should include the affected parties and the implementing agency. Specifically in agriculture where there are many relatively small enterprises, support should include agencies providing administrative assistance. Otherwise conventional transaction costs can be very high.

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Endnotes

[i] In Europe, both Sweden and Denmark have a fertiliser tax and the Netherlands has a tax on unallowable nitrogen and phosphate surpluses. Finland and Austria had fertiliser taxes before they entered the European Union. Outside the EU, there is a fertiliser tax in Norway.

[ii] Woodward and Kaiser (2002) give an overview of water quality trading programmes in the US that include both point source and non-point source pollution. Fifteen cases are discussed in which trading is either in place or under development. Of the 11 existing programmes only 2 existed prior to 1989 and 7 have been started since 1996.

[iii] Due to price support for cereals in the EU and the absence of import levies on imported feed stuffs, import of, for example tapioca, soy, citrus pulp and maize gluten became attractive for Dutch farmers, who exploited their proximity to the port of Rotterdam.

[iv] Notice that the surplus calculation refers to the farm level. When manure surpluses at the aggregated level are discussed three aspects are to be considered: farms with surpluses, farms with deficits and different crops, and the willingness of farmers with deficits to accept manure. The value of manure will depend on the nutrient content, organic matter, cost of transportation, tolerance of crops, risks of spreading of diseases, etc.

[v] Over application was most evident for silage corn, which was mainly grown as a waste disposal crop. In 1985, for example, the application rate for phosphorus exceeded the requirement of this crop, which is 200 kg P_2O_5 per ha, by a factor of four, on average. Furthermore, it was estimated that 300,000 hectares or 50 % if the cultivated land on sandy soils was saturated with phosphorus. Phosphorus saturation of the soil receives little attention in the EU, except in The Netherlands. The same applies for ammonia emission.

[vi] See de Walle and Sevenster (1998) for details on the extent of the problem, on regional differences and on how the Dutch situation compares with the rest of the E.U.

[vii] The early signals came from agronomists who pointed at the risks of euthrophication due to nitrate leaching, in particular (*e.g.*, Henkens, 1975). Their findings were rebuffed, however, because of the economic importance and political clout of the livestock sector. In particular, the Ministry of Agriculture and the farmers' lobby resisted and succeeded in postponing measures to address these issues (Frouws, 1997). Up until 1984 animal waste problems were mentioned in political discussions but no measured were taken (Tamminga and Wijnands, 1991).

[viii] A total growth of stock of 10% was justified on existing farms. Despite this restriction, the number of pigs actually increased *annually* by 7.5 % between 1983 and 1987 (Tamminga and Wijnands, 1991). This increase was mainly possible because of the large number of building requests filed just before the moratorium (*cf*. CPN, 2002, p. 25).

[ix] Important in this respect were (de Walle and Sevenster, 1998, p. 11-13, 30): (a) the statement of the second International North Sea Conference (1987) to reduce the nutrient supply to the North Sea by 50 %, and (b) the Paris Convention of 1988 which requested the 50 % reduction by 1995 in comparison with 1985 levels.

[x] The reasons for focusing on phosphate related mainly to soil physics. The groundwater table in the Netherlands is rather high, being on average less than 1 meter below the soil surface. Saturation of soils with phosphate, with leaching into groundwater and euthrophication of surface waters was thought to be likely. Furthermore, it was assumed that a decrease in nitrogen problems would follow naturally from imposing limits on phosphate application. N application was calculated indirectly by assuming a fixed N: P ratio of 2:1 (Frederiksen, 1997). However, experience showed that this assumption was invalid and, starting in 1998, explicit standards for nitrogen application were established as well.

[xi] The Soil Protection Act sets restrictions on: (1) on the application of manure with the aim to gradually reduce these admissible application rates, see Table 2, and (b) the period of the year the waste could be land applied (for details see Tamminga and Wijnands, 1991; de Walle and Sevenster, 1998).

[xii] The larger part of this section is from Vukina and Wossink (2000).

[xiii] For the assessment of the number of animals different dates were used: December 31, 1986 for pigs, poultry and cattle, and December 1991 for sheep, goats, rabbits, ducks, foxes and nutria. (Amvb, 1986b).

[xiv] Under two important restrictions: the amount could only be bought and sold in its totality and the farm had to be continued as an autonomous enterprise at the same location as before.

[xv] As an example, consider a 3-hectare farm with 1,000 fattening pigs. As mentioned before, the animal specific transfer coefficient for pigs is 7.4 kg of P_2O_5 per animal per year. Therefore, this farm's total reference amount is 7,400 kg of phosphate per year. Given that the land based phosphate allowance is 125 kg of P_2O_5 per hectare, the total reference amount is composed of $3 \times 125 = 375$ kg of land based quota and $7{,}400 - 375 = 7{,}025$ kg of animals based quota. Buying 1 additional hectare of land would increase the land based quota to 500 kg but would at the same time decrease the animal based quota to 6,900 kg without changing the total available quota. Consequently, this farm would have to buy additional 55.2 acres ($55.2 \times 125 = 6{,}900$) of land before its total quota available for production would go up.

[xvi] Information on the actual manure production for each surplus farm is available from the annual manure bookkeeping accounts. To assess dormant manure production rights for cattle, poultry and pigs, the highest manure production figures are selected from the three-year period: 1988-1990.

[xvii] The combined costs of phosphate and ammonia production rights increased the start-up costs of a new animal production unit in the surplus region by about 20% relative to the deficit region. The investment costs for a new swine finishing facility in 1995 required about NLFL 1,155 per pig place (Gibo, 1996). In addition, starting a new operation in the surplus region would require purchasing 7.4 kg of phosphate quota and 2.5 kg of ammonia quota per pig place. Using 1995 quota prices of 25 guilders per kg of phosphate quota and 25 guilders per kg of ammonia quota translates into an additional expense of about NLFL 250 per pig space. 1 NLFL ≅ 0.5 US$.

[xviii] Social and cultural factors (family ties, differences in religion and dialects) are known to limit the mobility of the farming population in the Netherlands considerably, despite the country's small size. Research on this topic has particularly focused on glasshouse horticulture, see for example Voskuilen and Van Elk (1990).

[xix] Art. 22-3 of the "Law regulating transfer of manure production rights" (Amvb, 1987) states that the quota system will be terminated on January 1, 1997.

[xx] This was due to a debate whether the nutrient accounting/prohibitive tax system indeed would be capable of reducing the national manure surplus. Also additional research on the auditability of the scheme was requested as it was expected to be susceptible to fraud.

[xxi] The objective for 2000 was a reduction of 50 % compared with 1980 and 70 % compared with 1970. A recent evaluation showed that these targets were not met (CPB, 2000, p. 28).

[xxii] This cut was in response to the development of modified feed for pigs, which resulted in a reduction in the phosphate content of the manure of about 20-25 percent. There has not been a comparable innovation in poultry. However, only 80 to 90 per cent of the quota was actually being used on most farms in this sector, which meant that the cut did not have a big impact.

[xxiii] The serious outbreak of swine fever in spring 1997 in the south of the Netherlands is seen as the incentive for this reduction in quota. Due to this outbreak pork production received even more media coverage. The large concentration of pigs was now associated with a whole complex of problem (animal health, animal welfare and surplus manure) and the public perception was that a reduction in animal numbers was the only solution.

[xxiv]The detailed records of Bureau Heffingen are not readily accessible but summary information is available (T.P.M. den Teuling, personal communication, Bureau Heffingen Assen, 2000). This summary information covers the period January 1994-Sept 1998 and includes the volume of trade and the total transferable (animal based) amount of quota in kg phosphate. The data is organised by 6 months periods and irregular shorter periods of mostly 2 months (*e.g.*, Aug 17-1996; Nov 4-1996; Feb 1-1997). Trade is distinguished in three categories: trade in the concentration areas, in the rest of the country and from the concentration area to the rest of the country. No distinction is made in the three classes of quota (cattle & turkeys; pigs, chickens & broilers; sheep, goats, foxes, nutria and ducks). The number of trades is not reported.

[xxv] These four problems include manure; CO_2 and the greenhouse effect; SO_x and NO_x of traffic and transportation, and aircraft nuisance of Amsterdam airport. The research of these four persistent problems was commissioned as background research for the preparation of the Fourth National Environmental Policy Plan (NMP-4) that sets the national environmental objectives for the period 2010-2030. The Plan was issued in 2001.

[xxvi] OSPAR is the combination of the Paris and Oslo Conventions, PARCOM and OSCOM respectively. PARCOM aims at the nutrient pollution of the (North) sea from sources on land and in the air. More or less parallel to PARCOM, OSCOM has focused on nutrient pollution from sources at sea. OSPAR has two objectives: monitoring and assessment and taking measures for protection. Members of OSPAR are: Belgium, Denmark. Germany, France, Netherlands, Norway, Sweden, UK, Ireland, Spain, Portugal, Iceland, Finland and the EU (de Walle and Sevenster, 1998, p. 13-14.

[xxvii] The additional costs were mainly those of waste disposal because of the land application standards and costs of extra animal waste storage capacity.

[xxviii] The data on individual transactions used in the analysis covers 12.5 % of the total volume of trade in the regions East and South over April 1996-May 1998 (T.P.M. den Teuling, personal communication, Bureau Heffingen Assen, 2000). For a revision of the paper (Wossink and

Gardebroek, in preparation) panel data are used from LEI-DLO on quota prices and farm level earnings. The panel data covers 78 transactions in 1994-1997. The results of the revised paper are very similar to that in Wossink (2000). The panel data are not publicly available.

[xxix] For a revision of the paper (Wossink and Gardebroek, in preparation) panel data are used from LEI-DLO on quota prices and farm level earnings. These panel data are not publicly available.

[xxx] This distinction is important for the total quota volume after trade. In the case of the sale of a whole farm the farm's quota is not cut by 25 % as with other quota trades.

[xxxi] The rate of discount usually is 20 to 30 % in real terms and reveals that buyers recognize that they are taking a sizeable risk and price the asset (quota) accordingly (Barichello, 1996). This assessment does not correct for transaction costs.

[xxxii] One Dutch guilder ≅ 0.5 ECU≅ 0.5 US$.

[xxxiii] It was assumed that a decrease in nitrogen problems would follow naturally from imposing limits on phosphate application and a fixed ratio was assumed for N: P of 2:1 (Frederiksen, 1997).

[xxxiv] After the introduction of the detailed nutrient bookkeeping system in 1992 farmers gained an understanding of the environmental impacts of animal production and how to reduce emissions through changes in management. Nutrient bookkeeping was developed by CLM (Centre for Agriculture and Environment) and different groups of farmers and was originally designed to provide management support. The environmental data provided by this management information system were particularly insightful in combination with farm economic data, i.e. to provide empirical evidence of significant variations in environmental and economic inefficiencies. From 1998 onwards the management information system was used as a policy instrument to tax farm level surpluses of both N and P (see Breembroek et al., 1996 for details).

[xxxv] Data from Bureau Heffingen (see note xxiv) shows that by December 1997 in the concentration areas 8.1 % and in the non-concentration areas 9.5 % of all animal-based quota had been traded. The total tradable quota volume was 97.5 million kg phosphate by the end of 1994 and 96.1 million by the end of 1997.

[xxxvi] The only caveat mentioned in the report is that 95 % of those farms that sold their entire quota amount quit animal production completely and that these farms likely would have stopped anyway also without the quota programme. This insight was based on survey information from IKC and was not statistically confirmed in terms of quota volume and actual phosphate production.

[xxxvii] The CPB study emphasises as additional positive effects the improved distribution of the manure over total agricultural land and the improvements in (swine) animal nutrition that reduced the phosphate content of manure. These two effects are completely attributable to the regulations on manure application and cannot be ascribed to the quota system.

[xxxviii] This figure is based on the estimate given in MANMF (1995).

[xxxix] In 1997 there were 6,304 pig farmers (full-time).