Policy intervention in a concentration permit market: efficiency analysis of obligatory manure processing in Flanders

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1 Introduction

Tradable permits (tradable quota) have become an important tool in managing externalities. Cost efficiency has been seen as the main advantage of these types of policy measures: a predefined environmental target can be reached at lowest costs (Baumol and Oates, 1971). Assuming perfect market conditions (i.e. in absence of transaction costs), those permits will be used by those who attribute it the highest value (Tietenberg, 2003) and this regardless the initial allocation of the permits (Montgomery, 1972).Tradable permits are useful when the concerned emissions have no local impact on environment or population (Lejano and Hirose, 2005) such as greenhouse gases and NO_x. In such cases it doesn't matter where the pollutants are emitted because only the aggregated concentration affects the environment. However, when emissions have an immediate or almost immediate effect on the local environment, emissions trading does not guarantee that initial policy goals are reached for each local receptor. Due to trading of the emissions, hotspots of emissions can occur (Lejano and Hirose, 2005), affecting the local population and environment. Examples are toxins (lead, $SO_{2,...}$) and noise.

Therefore, Stavins (1995) argues that an ambient or concentration permit trading system (CPT) is theoretically to be preferred to regular emission permit trading (EPT). A concentration permit is then defined as a permission to deposit a quantity of pollutants at a specific receptor (Ermoliev et al., 2000). Theoretically, the market will give a cost efficient outcome (Montgomery, 1972) but some authors believe that in practice such systems generate high transaction costs and that cost-effectiveness will not be reached (Tietenberg, 1995). This complexity can be seen as a major reason why, based on literature knowledge, no policies based on CPT have been developed so far. On the other hand, some simulations of well-described problems may show the potential of CPTs and facilitate the analyses of CPT effects. An example of such a well-described problem is the manure problem and manure policy interventions. Basically, the manure policies are attempts to solve problems of surplus production at certain locations by spreading the impact over a larger area while safeguarding the carrying capacity of the environment at each location. The manure problem has been extensively described (Aillery et al., 2009; Aubry et al., 2006; Berentsen, 2003; Berentsen and Tiessink, 2003; Courdier et al., 2002; Feinerman et al., 2004; Feinerman and Komen, 2005; Helming and Reinhard, 2009; Huhtala and Marklund, 2008; Karaczun, 2005; Keplinger and Hauck, 2006; Lauwers, 1993; Lauwers et al., 1998; Le Goffe, 2008; Lewis, 2008; Oenema et al., 2007; Piot-Lepetit and Vermersch, 1998; Sims et al., 2002; Staalduinen et al., 2002; Wossink, 2003; Wossink and Gardebroeck, 2006), making it a good case to enrich our knowledge on CPT based on a spatial modeling system.

The aim of this paper is twofold. First, to compare the EPT system with a CPT system for the Flemish manure policy case. For this case both the private costs for farmers as well as the environmental impact of both the EPT and the CPT are compared. To do so the paper applies a multi actor spatial programming model (earlier described by Van der Straeten et al. (2009a)) to simulate a situation in which either a CPT system or EPT system is used. The paper highlights the specific characteristics of the market of tradable concentration rights and how they can be analysed.

Second objective is to describe and analyse the socio-economic adjustment of a CPT system based on the example of the processing obligation as an abatement strategy for the larger firms in the Flemish manure policy.
The paper is organized as follows. The paper starts with describing the possibility of using the manure-policy case, and in particular the Flemish manure policy as an example of a CPT system. This section also gives a description of the processing obligation as a case for social adjustment of the CPT policy. Section 3 describes the analytical model used for analysing the CPT and EPT systems followed by an elaboration of the spatial aspects of permit prices and how the costs and benefits from trade in permits can be calculated. The result section starts with a comparison between EPT and CPT systems followed by the socio-economic analysis of the obligatory emission processing. Section 5 discusses the results and concludes.

2 The Flemish Manure Policy as a CPT Case

2.1. Fertilization limits as tradable concentration permits

Ambient or concentration permit trading systems are terms which are used in literature for the same thing. In the remainder of the paper we will use the term concentration permit trading (CPT).
Despite the theoretical advantages (Ng and Eheart, 2005), until now CPT systems have not been widely used. Especially for air pollution the system can offer great advantages compared to EPT as it can prevent concentration of pollution (Atkinson and Tietenberg, 1987). As an alternative, problems in which spatial issues of the resource use or emission do matter are often tackled by incorporating spatial limitations in trading of the permits (Atkinson and Tietenberg, 1987; Tietenberg, 2003). The RECLAIM program in the U.S., for example, makes a distinction between two areas (coastal and inland area). Because of the predominant wind going from the coast to the inland, EPTs could only be transferred within the same area or from the coastal to the inland area. EPT transfers from the inland area to the coastal were prohibited (Harrison, 2003). Similar trade rules were introduced in the Dutch Nutrient Quota System. Phosphate production was steered by means of animal based manure production rights. Each farm was allowed to produce 125 kg P_2O_5 per hectare of land. Farmers producing more manure in terms of phosphate need additional manure production rights. These rights are tradable between farmers. Also here distinction is made between two regions: a manure surplus (average phosphate production is higher than 125 kg per hectare) and a manure deficit (with phosphate production below 125 kg/ha) region. Trade of rights is allowed within each region and from the surplus region to the deficit region (Wossink, 2003).
The Dutch Nutrient Quota System was introduced to control the externalities of the intensive livestock production. In Flanders, a region within Belgium and adjacent to the Netherlands, the same type of problem of animal concentration and production and emission of animal manure is found. The Flemish manure policy is, together with the Dutch manure policy, probably the most elaborated policy in controlling the use and production of nutrients originating from agricultural sources.
The Flemish manure policy limits the amount of nutrients (N and P_2O_5) of animal manure emission with fertilization standards. Van der Straeten et al. (Van der Straeten et al., 2009a) describe these standards of organic nitrogen use as Nutrient Allocation Rights

(NARs). One NAR gives the farmer the right to emit one kg of organic nitrogen. NARs are allocated to individual firms based on land use; as an example per hectare of arable cropland each farm receives 170 NARs for organic nitrogen. The emitted nutrients must be used on that specific hectare of land, which makes NARs an example of concentration standards. Concentration standards limit the emission per unit of output, per unit of effluent or per receptor (Bruneau, 2005; Ermoliev et al., 2000). NARs have also been categorized as tradable emission rights (Lauwers et al., 2003b) because the policy allows transactions of NARs between farmers. In contrast to other examples of emission permits, the right to emit is locally fixed and the emission right can be traded (Buysse et al., 2008). Therefore, the NARs are close to and can be described as an example of a CPT system.

2.2. Social adjustments

The main theoretical advantage of tradable permits, this is efficiency increase, is at the same time also a considerable social disadvantage. Large differences in efficiency between firms may indeed lead to concentration of permits on the most efficient firms (Tietenberg, 2003). This is e.g, very often the case with ITQs (individual transferable quotas) in fisheries where concentration of permits in larger vessels is very often observed (Branch, 2009) with as a result negative social effects because of the exit of many small fishermen (Palsson, 1998). Different social measures can be imposed to protect small firms or less competitive communities in such cases (Tietenberg, 2003), as e.g. in Alaskan fisheries where quota were allocated to local communities to counteract their competitive disadvantage (Ginter, 1995). The European dairy policy is also based on a system of tradable permits (Van der Straeten et al., 2009b). Spatial concentration of permits in highly efficient regions is avoided by imposing transfer limitations between countries (Alvarez et al., 2006). Some member states even imposed trade limitations within their country (as e.g. Belgium: Jespers et al. (2006)).

Within the Flemish system of NARs, social adjustment measures have been taken as well. Because of the highly intensive livestock production is concentrated in only some regions in Flanders, the introduction of NARs would lead to a large competition for free NARs resulting in high market prices. The Flemish farms are mostly rather small family farms (Calus et al., 2008) with only a small number of larger farms specialized in intensive animal production. The policy maker wanted to mitigate the economic impact of the environmental policy on small family farms. Therefore, the regulation intervenes in the market for NARs by imposing that larger farms in regions with concentrated animal production have to use emission abatement strategies rather than buying additional NARs (Lauwers et al., 2003a) (see also further).

2.3. Making the concept operational

The Flemish manure policy prescribes how individual firms have to deal with their emission (manure). The produced emission per firm is calculated based on the number of animals per animal type, feeding technique and housing type. All produced manure must either be emitted within the available concentration rights (NARs) or the firm has to choose for emission abatement, which is manure processing. The initial allocation of the concentration rights is based on land use but the right to emit an amount of manure can be traded among firms. Therefore, the firms have three allocation choices. First, they can use their produced emission (manure) within their own concentration rights. Second, the firms can transport their emissions to other firms with unused concentration rights, which means permit trading. Third, the firm has the option to engage in emission processing. As a result, the Flemish manure policy has created a demand and supply of concentration rights (Van der Straeten et al., 2009a).

Manure processing or treatment is defined as a comprehensive term for all technologies which remove or recover nutrients out of manure (Flotats et al., 2008). The end products can be used on farmland, home and public gardens etc (Melse and Timmerman, 2008). The decision to opt for manure processing as a result of too high prices for concentration rights is in this paper referred to as market driven processing. Market driven processing happens when the purchase of NARs and the joint manure transport costs are higher than the costs for manure processing. Next to the market driven manure processing, the Flemish manure policy has also created legal obligatory processing imposed on a small number of larger firms[1]. By imposing obligatory manure processing, the government interferes in the NAR market by removing a share of the demand for NARs which should reduce the price of NARs.

Especially in regions with a very high manure production, danger existed that small family livestock farms would not be able to compete for free rights. The initial goal of the policy was to protect these farms against a significant raise in costs and pass on the costs to the more industrial farms. In this paper, we will examine the effectiveness and efficiency of this social policy adjustment.

3 Method

3.1 The NAR market model

Geographically, the concentration rights (NARs) are evenly spread, but the production leading to emissions is regionally concentrated. This spatial difference between demand and supply of NARs can be simulated by a spatial price equilibrium model (SPE). The SPE model computes the supply prices, demand prices and emission trade flows satisfying the equilibrium condition. This condition states that, when trade between two regions occurs, the demand price of a NAR equals the supply price plus the transport cost. Trade doesn't occur when demand price is lower than supply price plus transport costs. Transport costs of the emission or reallocation of the sources of emission are the main characteristic that distinguishes concentration rights from traditional emission rights. Transportation is captured in the SPE model. The demand and supply for NARs of each agent is simulated by a mathematical programming model that assumes cost minimizing behaviour of the allocation of the emission.

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[1] Each firm with a production of more emissions than an equivalent of 10,000 kg phosphate and each firm in a municipality with a production of 100 P_2O_5/ha and a production of more than 7,500 kg phosphate, is obliged to process a given share of the farm manure surplus. This share depends on the total phosphate production at the farm: 30% at farms with a phosphate production between 7,500 and 10,000 kg per year, 50% at farms with a production between 10,000 and 12,500, 75% at farms with a production between 12,500 and 15,000 and 90% for farms with a phosphate production of more than 15,000 kg.

The combination of mathematical programming models for each agent and the SPE model creates an overall Mathematical Programming Multi-Agent Simulation model (MP-MAS), which is used in this paper and more in detail described in Van der Straeten et al. (2009a). The data needed for the model contain information of each individual firm about its location, production and NARs. Based on this information, a firm-specific supply or demand of NARs is calculated (Van der Straeten et al., 2009a). The MP-MAS allocation model is able to simulate the different costs related to each allocation option at firm level and is able to simulate endogenously market prices of the NARs. The model distinguishes between the disposal costs, the transport and the treatment cost and the concentration right costs, i.e. the costs for obtaining NARs from other firms. The transport, disposal and treatment costs are extra costs at sector level while the concentration right costs are the result of a redistribution within the sector.
We start from the equation in Stavins (Stavins, 1995) where the quantity of traded permits (t_i) by farmer i is defined as:

$$t_i = |u_i - r_i - q_{0i}| \qquad (1)$$

with u_i the unconstrained emission, r_i the emission reduction or abatement and q_{0i} the initial allocated permits. Translated to our manure case, this equation becomes:

$$TP_i = |NP_i - NT_i - NAR_{0i}| \qquad (2)$$

where TP_i is the traded permits by farmer i, NP_i the nitrogen production per farmer, NT_i the volume of treated (processed) nitrogen and NAR_{0i} the initial NAR allocation per farmer. To explicit the manure problem as an analogue of the CPT issue, the correspondence of terms is given in table I.

Table I: correspondence of terms between CPT – manure problem analogue

CPT - system		Manure problem	
description	symbol	description	symbol
Unconstrained emission	U	Nitrogen production	NP
Emission reduction / abatement	R	Nitrogen treatment	NT
Initial allocated permits	Q_0	Initial allocated NARs	NAR_0
Traded permits	T	Traded permits	TP
Constrained emission cost[(1)]		Disposal cost	C_d

(1) mostly the cost to emit a pollutant is zero. For example there is no cost to emit CO2 in the air

Each farmer tries to minimize his total costs (TC):

$$TC_i = [C_t * NT_i + C_d * (TP_i + NAR_{0i}) + P_{NAR} * (NP_i - NT_i - NAR_{0i}) + T(TP_i)] \qquad (3)$$

$$with\ T(TP_i) = C_{trans} * tr_i * d_i \qquad (4)$$

in which C_t is the treatment costs, C_d the disposal costs, P_{NAR} the price per traded NAR and $T(TP_i)$ the transport costs which are function of the distance of farmer i to the NAR-location (d_i), the transport cost per unit of distance (C_{trans}) and the quantity of obtained NARs between both farms (tr_i).
When the production exceeds the available permits, the farmer has the choice to buy additional permits or to abate the surplus (nitrogen treatment, NT). The optimal level of treatment is where total costs are minimized:

$$\frac{\partial\, AC_i(NT_i)}{\partial\, NT_i} = 0 \quad (5)$$

Substituting equation (2) into equation (3) gives:

$$P_{NAR} = C_t - C_d - C_{trans} * d_i \quad (6)$$

where the price the farmer wants to pay (P_{NAR}) equals the difference between the treatment cost and the disposal cost minus the transport costs. The higher the transport costs, the lower the price the farmer wants to pay for the permit.

However, trade in NARs generates benefits for the supplier of NARs. Therefore the revenues generated from trade must be taken into account as well, resulting in the net costs of farmer *i* (NC_i).

For a demander of NARs, which generates no profits from sale, the net costs are equal to the total costs (equation 7):

$$NC_i = TC_i \quad (7)$$

with TC_i implying costs for purchased NARs

For a supplier of NARs, the revenues from trade are:

$$R_i = P_{NAR} * NAR\_sold_i \quad (8)$$

Net costs, as it will be modelled for each farm i will then be modelled as revenues to be subtracted from the total costs to arrive at the net costs (equation 9):

$$NC_i = [TC_i - P_{NAR} * NAR\_sold_i] \quad (9)$$

with NAR_sold_i the NARs sold on the NAR market.

At sector level, the benefits equal the cost of trading NARs, so that the sum of the net costs at sector level equals the total amount of money going out the sector.

The calculation of the price of the NARs and the resulting redistribution over location and among farmers is explained in next subsection.

3.2 Price of NARs

Under perfect market conditions, and EPT assumptions, a uniform market price can be found (Baumol and Oates, 1971). In CPT, however, the unequal distribution of emissions and NARs and the distance between suppliers and demanders becomes important in price-settings. Stavins (1994, 1995) imputes transport costs the same characteristics as other transaction costs because of the similar influence on the market equilibrium. In the case of the NAR market, the purchaser of rights bears the transportation costs. This results in a downward shift of the demand curve (Figure 1). Similar to transaction costs (Stavins, 1995), transportation costs lead to a difference in the price a seller of rights receives (P_S) and the price paid by the purchaser (P_D). The traded volume decreases from Q_m to Q_T. However, the shift of the demand curve (figure 1) is not the same for the whole range of exchanged NARs because the cost reallocation of emission varies. Reallocation of emission can be achieved by reallocating the production or by transporting the emission. In the case of manure, the transport of the emission is the cheapest and easiest and, therefore, in this paper the reallocation costs are transport costs. The case of manure is, however, complicated by the heterogeneous manure transport cost, which depends on the quantity of emitted nitrogen.

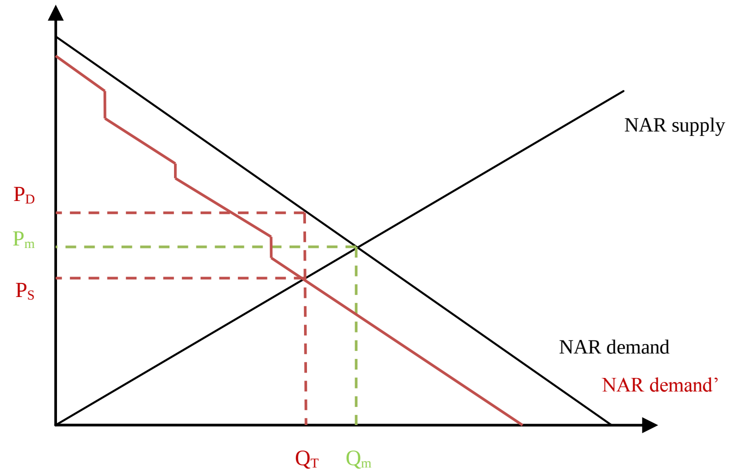

Figure 1: graphical representation of the market of concentration rights and the effect of transport costs on the market equilibrium

The shift in the demand curve depends also depends on the location of the market for NARs. NARs located far from the emission source bear higher transport costs. The resulting demand curve shifts more to the left and the observed price of the NARs is lower at a lower traded volume. In regions with high emission concentration, competition for concentration rights is high. Firms in regions with highly concentrated sources of emission have to choose to buy expensive local NARs or reallocate their emission to a region with lower prices for the rights but they have to bear the reallocation costs. This specific characteristic of the NARs results in spatial differences in market prices, which has also been shown for the manure emission rights (Van der Straeten and Buysse, 2009; Van der Straeten et al., 2009a).

3.3 Specification of costs and benefits from trade of NARs

The price of the NARs (P_{NAR}) generates a reallocation of revenues within a sector if the actual use is different from the initial allocation, i.e. when $\sum_i |TP_i| \neq 0$. In our case of manure emission rights in Flanders, the distribution of the rights is based on land use while the emission is based on animal production. There is a strong correlation between land use and animal production for cattle farms. However, the correlation is much smaller for specialist animal production and specialist arable production. The former have a significant shortage of NARs while the latter have a significant surplus.

The second objective of the paper is to assess shifts in revenue among agents caused by socially inspired policy interventions in the trade of NARs and needs an in-detail description of the cost and benefits from trade of NARs. The concentration emission from manure can be expressed homogeneously as kg N/ha. The source of the emission, manure, on the other hand is rather heterogeneous. Each animal type, as a combination of species, age and feeding system, produces manure with own characteristics (e.g. nutrient content and dry matter content). The model in the current paper considers four different manure types with each a fixed nutrient content.

All four types have a specific nitrogen content resulting in different transport cost per kg of nitrogen. This results in a discontinuous demand curve for NARs. A firm first transports the cheapest type of manure, resulting in a small downwards shift of the curve, then with increasing manure transport, the expensive manure types are considered. Higher transport costs lead to a larger downward shift of the demand curve.

The costs for the buyer of the NARs are the sum of the price to be paid for the right plus the transport costs. The cost of obtaining the concentration right is $P_S * Q_T$. The costs of reallocation of the emission is not equal to $(P_D - P_S) * Q_T$ because our calculation uses the marginal transport cost as the transport cost for each right. The marginal transport cost is generally higher if the reallocation costs are not homogeneous for all the emission. Graphically, only the shaded part in Figure 2 is the actual reallocation cost and not the full area a, b, P_s, P_d.

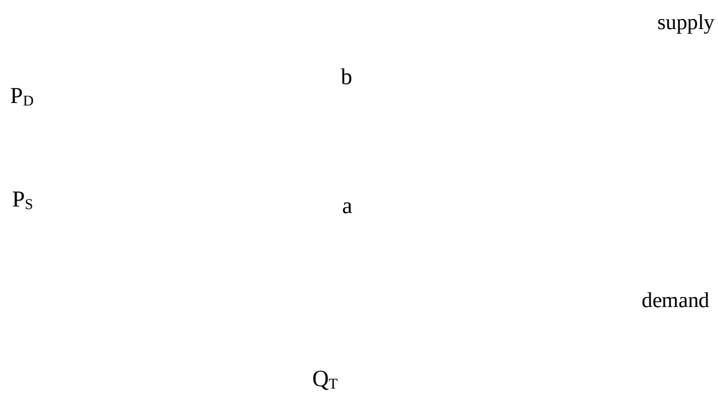

Figure 2: transportation costs in the manure market

3.4 Data

For our simulations, we used data from the Flemish Land Agency (Vlaamse Landmaatschappij, VLM) for 2006, which is a public body controlling manure exchange between farmers. The dataset contains the total farm population and offers data about the crops, manure production [illegible] ARs and the manure allocation behaviour for each Flemish farm. In total 38,777 farms are included in the model. These farms have a total acreage of 677,000 hectares [illegible] nland. 26,555 farms holding animals is resulting in a total nitrogen production of [illegible] million kg and a phosphate production of 57 million kg. More than half of the nitrogen is produced by cattle and more than one third by pigs. Poultry is the third most important nitrogen producer (almost 10% of total nitrogen production). One fourth of the Flemish farms are surplus farr[illegible] produce more manure than they can spread on their own land (with respect to NARs).

4 Results

4.1 Comparing CPT and EPT

The NAR system, as an example of a CPT policy, is compared with a simpler tradable emission permit (EPT) system. In the CTP system, the firm's emissions are spatially limited by the imposed maximum of concentration rights. The simpler system of tradable permits gives the firms more degrees of freedom because they can emit the same amount of emissions without fully facing the problem of concentrated emission. In fact, firms are facing limits at considerably higher concentration levels. In the manure case, the amount of manure per ha will then be determined by the agronomical maximum, beyond which production, or utility, would be reduced. For the sake of our simulations, this agronomical maximum is set at 500 kg N on grassland, 400 kg N/ha on most other crops and 200 kg N /ha for the crops accepting only a limited amount of nitrogen such as onions, peas and beans.

The net costs for all manure emission in Flanders, with the EPT system, is estimated to be 106 million euro (on annual basis). The more complex EPT system results in a higher net cost of 118 million euro for all manure emission. The difference of 12 million euro can be seen as a consequence of the reallocation costs of the emission in the case of the concentration rights (NARs). These results confirm the statement of Stavins (1995) that the control of the emission closer to the source with concentration rights might increase the transaction costs. The estimate of the transaction costs in our case is still a lower limit because we have only taken the transport costs as proxies for transaction costs into account and not the costs for information, negotiation or control. Also the public control costs are not considered. This manure emission is controlled by soil samples and sometimes even by helicopter. The emission reallocation by long distance transport is controlled by GPS. This cost of the GPS markers is imposed on the private firms and is included in the 12 million euro. The cost of control by helicopter is public and is not included.

A larger difference between both systems can be found in the total costs, i.e. when the benefits from trading are not taken into account. The total costs under EPT were almost equal to the net costs (106 million euro), because almost no permit trading occurred. Under CTP the total costs increase to 180 million euro, meaning that the trade of rights leads to an extra cost of 62 million euro.

Making distinction between suppliers of NARs (i.e. farms producing less nitrogen than their available NARs) and demanders of NARs (i.e. farms producing more nitrogen than the available NARs) we see that the increment in total costs is mainly at the expense of the demanders of NARs (from 79 to 140 million euro or + 82%). The suppliers experience an augmentation in total costs of almost 40% (from 27 to 37 million euro).

The environmental consequences of the CPT system and the simpler EPT system is also quite different. The CPT system imposes a limit to manure emission to prevent that excessive nitrogen leaching would occur. The FLA administrative database shows that the CPT type of policy has successfully induced a reallocation of the manure emission. Figure 3 gives the average municipal nitrogen use per hectare of farmland under a EPT system.

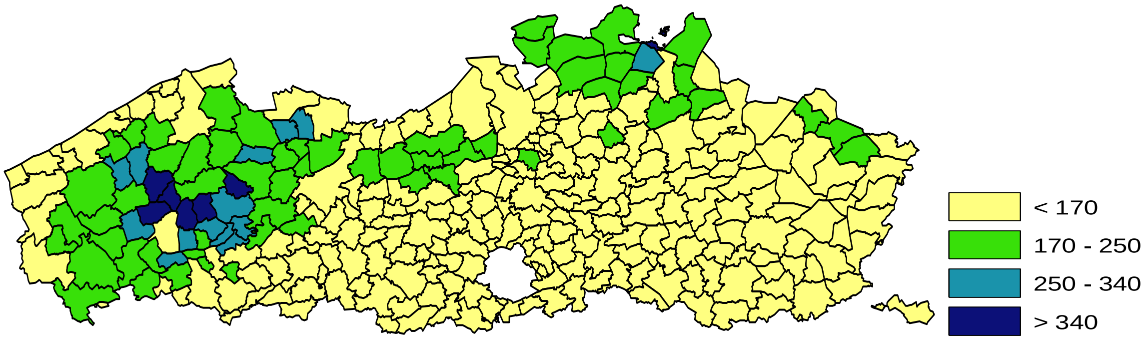

Figure 3: average nitrogen use per hectare of land per municipality under EPT in 2006 (kg N/ha)

The CPT system prevent concentration of emission and forces the firms to reallocate the emissions (Figure 4).

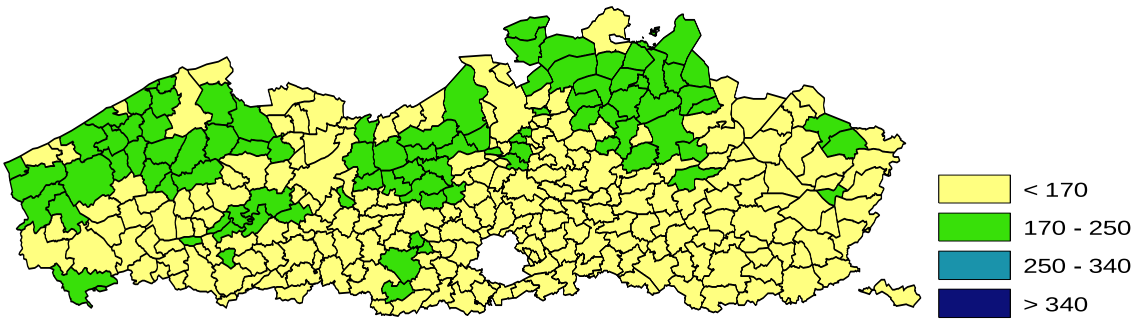

Figure 4: average nitrogen use per hectare of land per municipality under CTP in 2006 (kg N/ha)

The simulation of our MAS model shows that, from the 677,000 ha, 502,000 ha (74.2%) would receive a lower or equal manure emission while 175,000 ha (25.8%) would receive a higher manure emission. On 83,000 ha (12.3%) the maximum EU nitrogen concentration for vulnerable areas (170 kg N from manure / ha) is exceeded more than twice (more than 340 kg N from manure). The environmental comparison of the tradable concentration right system and the tradable emission right system for the Flemish manure policy thus also confirms that from an environmental perspective a control closer to the source is preferable.

4.2 Market description

Under an EPT system, farmers are only bounded in their nutrient use because of agronomical limits. Simulation results show that under EPT practically all manure could be spread on own land. A CPT system leads to a distinction between farmers within the sector. One part of the sector has an emission which exceeds their NAR, while for the other part of the farmers NAR's are (partly) left unused. Both exceeders and under-users of CPTs can benefit from interaction between them, and thus start trading permits. Simulation results (Table II) show that permits indeed are traded between individual farmers.

Table II: simulated manure allocation behaviour under CTP (million kg N), 2006

	On-land disposal	Own-land disposal	transport	Processing	Production
Cattle	67.69	59.62	8.07	0.00	67.69

Pig	32.81	12.07	20.74	12.85	45.66
Poultry	1.03	0.03	1.00	11.68	12.71
Other animals	2.44	1.85	0.59	0.00	2.44
Total	103.97	73.57	30.40	24.53	128.50

In 2006, almost 104 million NARs were used in Flanders. This allows to dispose more than 80% of the total produced emissions (128 million kg N). From this total nitrogen use of 104 million kg, almost 30% is spread on traded NARs. The NAR market is thus frequently used by the farmers and is an important tool for the farmer to manage manure emission conform the legal prescriptions. However, the supply of NARs is not enough to use all manure on land. Therefore still 24 million kg N had to be transported or exported to other countries.

The results show a clear distinction in allocation behaviour for the four types of manure which is the result of the heterogeneous nitrogen content in manure. A higher nitrogen content results in lower allocation costs per unit of nitrogen. The highest concentrated manure type will be chosen for the most expensive allocation option. This explains why poultry and pork manure are the preferable manure types to process. Another implication of the difference between types of manure is that the traded NARs are mostly used for the disposition of pig manure (72% of the totally traded concentration rights). Cattle manure is mostly used under own NARs because of the higher reallocation costs in case of NARs exchange (12% of the total production) and the fact that cattle farmers usually do possess more land per livestock unit than pig or poultry farmers.

Most of the Flemish farms are involved in the manure market, from specialist arable farms, over mixed farms to specialist livestock farms. In the remainder of the paper we make a distinction between four types of farmers: big livestock farms (with a manure production with an equivalent of phosphate of more than 10.000 kg), intermediate livestock farms (5000 – 10000 kg P_2O_5), small livestock farms (300 – 5000 kg P_2O_5) and non-livestock farms (<300 kg P_2O_5). This subdivision is based on manure production. Within each group, there can be suppliers and demanders of NARs.

4.3 Market intervention in a tradable concentration permit system

The high emission treatment cost and reallocation costs resulting from the NAR system, caused many actors to oppose to the manure policy. Increasing political pressure incited policy makers to develop a number of accompanying measures trying to reduce the burden for many small family-based businesses. One of these accompanying measures is the manure processing obligation for large firms. The objective of this subsection is to analyse this introduction of the manure processing obligation and the distributional effects of the market intervention in the market of tradable concentration rights.

Net effects of the introduction of obligatory manure processing

The obligatory manure processing regulation forces some firms, mainly the larger ones, to process more than half of the amount that has to be processed (13 million kg N). The remainder of the emission treatment remains driven by market impulses. We call it therefore market-driven processing. The processing obligation imposes farms, with a production higher than 10,000 kg phosphate or 7,500 kg phosphate in municipalities with high manure concentration, to process a part of their manure surplus. Table III shows the

aggregated manure allocation behaviour of the Flemish farmers confronted with the processing obligation.
Simulation results show that under processing obligation other manure types have to be processed as well. This results from the reduction in degrees of freedom of the farmer. The differences in manure allocation behaviour (as well as in the scenario without processing obligation (NPMO) as well as in the scenario with processing obligation (WPMO)) have led to differences in the costs and benefits structure of individual farms and the farm sector as a whole.

Table III: simulated manure allocation behaviour under scenarios with obligatory manure processing (million kg N), 2006

	On-land disposal	Own-land disposal	transport	Processing	Production
Cattle	67.16	59.58	7.58	0.53	67.69
Pig	32.11	11.94	20.17	13.55	45.66
Poultry	2.27	0.08	2.19	10.80	12.71
Other animals	2.43	1.84	0.59	0.01	2.44
Total	103.97	73.44	30.53	24.49	128.46

The aggregated costs and benefits related to manure allocation are given in table IV.

Table IV: money flows related to the manure allocation under both scenarios, 2006

	Net costs		NAR costs		Total costs	
	Total (million €)	Average (€/kg N)	Total (million €)	Average (€/NAR)	Total (million €)	Average (€/kg N)
NPMO(1)	117.68	0.92	62.61	2.06	180.29	1.40
WPMO(2)	120.57	0.94	56.20	1.84	176.77	1.38
difference (%)	2.46	2.46	-10.25	-10.65	-1.95	-1.95

(1) NPMO: scenario with no processing obligation

(2) WPMO: scenario with processing obligation

The introduction of the manure processing obligation has led to various effects. On the one side, the manure processing obligation increases the net costs by almost 2.5%. In other words, the farm sector faces a rise of the net costs of almost 2.5% for allocating the manure emission, resulting in a net outflow of cash from the agricultural sector.
Another important implication of the manure processing obligation is the strong decline in the prices of NARs of more than 10%. The result of the rise in allocation costs and the decline in NAR prices can be found in the total costs which decrease with almost 2%. This means that at aggregated level the livestock farms benefit from the introduction. On the other hand, the farms with an excess of NARs (e.g. firms with land but without manure production: arable farms) face an important decline in revenues from selling concentration rights. These differences in effects between individual farms are analysed into detail in the next section.

Distributional effects of the introduction of obligatory manure processing

The initial aim of the manure processing obligation was to protect the small family livestock farms from the increased costs from the system of tradable concentration rights. Table V summarizes the impact of the policy on different firm sizes.

Table V: Percentages of the manure surplus falling under manure processing obligation

Percentage of manure surplus per farm size				N under processing obligation	
7,500 ≤ P_2O_5 <10,000	10,000≤ P_2O_5 <12,500	12,500≤ P_2O_5 <15,000	15,000≤ P_2O_5	(million kg N)	% against total N surplus
0	0	0	0	0	0.00
7.5	12.5	18.75	22.5	3.14	12.80
15	25	37.5	45	6.29	25.63
22.5	37.5	56.25	67.5	9.44	38.47
30	50	75	90	12.59 (current)	51.30
37.5	62.5	93.75	100	14.82	60.39
45	75	100	100	16.07	65.48
75	90	100	100	19.29	78,61
90	100	100	100	20.99	85,53
100	100	100	100	21.88	89,16

The results of table 4 show that the processing obligation affects the different groups in a totally different way. The non-livestock farms experience a decline of the average total costs per farm (-3 %) but at the same time their average net costs per farm increase (+12.5%). This is the result of the decline in NAR market prices, which leads to less benefits for these farmers. On the other hand, big livestock farms experience a serious increase in total costs because of the manure processing obligation. The average total costs per produced kilogram nitrogen increase with 8% and the average total costs per farm even with 9.5%. The net costs per kg N and per farm increase as well with 8.2 and 9.6%, respectively. The largest benefits can be found in the class of small livestock farms. The total costs per kg produced N decrease with 4.4% for the very small livestock farms and 3.2% for the intermediate livestock farms. The change in net costs is less pronounced, but still decreasing (-1.4% for small livestock farms and -3% for intermediate livestock farms). These farms face a decline in total costs as well as in net costs. The effect in net costs is less distinct because also the benefits generated by selling NARs is taken into account and these benefits would decrease because of the processing obligation.

4.4 Efficiency and effectiveness of the introduction of obligatory manure processing

The distinction between total and net costs is important in the determination of the efficiency and effectiveness of the policy adaptation. Effectiveness can de defined as to what extent the desired effect is reached while efficiency indicates whether this is done in the most economic way. Mentzer & Konrad (1991) define efficiency as the invert of the ratio between the normal level of inputs and the actual level of inputs. Effectiveness can be measured as the real set of outputs and the desired set of outputs (Van der Meulen and Spijkerman, 1985).

Translated to the manure problem, the real level of inputs is the net cost for the entire farm sector. Efficiency can be calculated by following equation (10):

$$efficiency = 1 - \frac{net\ costs\ WPMO - net\ costs\ NPMO}{net\ costs\ NMPO} \qquad (10)$$

The initial policy goal was to decrease the costs for the small livestock farms. The effectiveness of the policy can be seen as the extent to which these small livestock farms experience a cost reduction and is given by equation (11):

$$effectiveness = \frac{total\ costs\ NMPO - total\ costs\ WPMO}{total\ costs\ NMPO} \qquad (11)$$

The current policy has an efficiency score of 97.54% and an effectiveness of 4.11%. To achieve an average cost reduction of 4.11% for small livestock farms, the total allocation costs of the sector had to lose almost 2.50% in cost efficiency. Both figures depend strongly on the initial rules for obliged processing. Therefore, not only the absolute value of both parameters is important but also the sensitivity of both parameters to changing levels of obliged processing. To asses this effect the percentages of the manure surplus that falls under obligatory manure processing per group of farms is experimentally changed for ten simulation runs (Table 6). In 2006 24.54 million kg N was in surplus, meaning this amount of nitrogen had to be processed. Under the current regulation 12.59 million kg N must be processed under obligatory processing. By changing the percentages of the manure surplus that has to be processed, the total amount of nitrogen that has to be processed changes (table VI).

Table VI: Aggregated results per farm size class, 2006

	Non-livestock farms	Small livestock farms	Intermediate livestock farms	Big livestock farms
Number of farms	18781	17020	2543	433
Net cost NPMO (€/farm)	-1258	3365	24518	50059
Net cost WPMO (€/farm)	-1096	3319	23954	54860
Total cost NPMO (€/farm)	394	5037	25504	51502
Total cost WPMO (€/farm)	382	4817	24870	56277
Net cost NPMO (€/kg N)	-6.80	0.5245	1.69	1.80
Net cost WPMO (€/kg N)	-6.07	0.52	1.64	1.94
Total cost NPMO (€/kg N)	2.50	1.07	1.76	1.85
Total cost WPMO (€/kg N)	2.39	1.02	1.70	2.00

The results of this sensitivity analysis are given in figure 5 where the efficiency and effectiveness are given per percentage of surplus manure that falls under obligatory manure processing.

The higher the percentage of the aggregated manure surplus that falls under the obligatory manure processing policy, the more effective the policy will be. A higher percentage under processing obligation, means that large farms are required to process more, and more NARs become available for small farms. Moreover, because of the declining demand for NARs, NAR-prices will decrease which again lowers the costs. The drawback of this, is the decreasing efficiency. The rise in effectiveness of the social correction is coupled with a decline in total costs efficiency. Since more and more allocation choices are determined by government policies, the market situation departs more and more from the most efficient allocation. If 90% of the aggregated manure surplus would fall under the processing obligation, the total costs for small farms would decrease with almost 12%. The cost the sector has to pay for this, is an increase of the net costs with almost 6%.

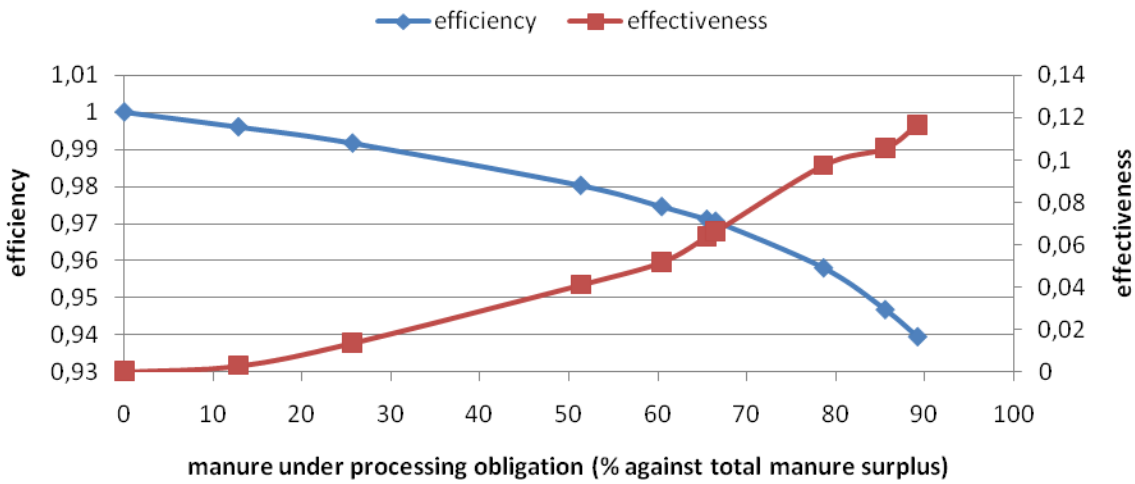

Figure 5: Efficiency and effectiveness under different degrees of manure processing obligations

5 Discussion and Conclusion

Montgomery (1972) has already shown theoretically that a competitive market of a tradable concentration rights system ensures the minimization of total emission control costs subject to the constraint of attaining the predetermined environmental standard at each receptor. Stavins (Stavins, 1995) refined the statement by considering the fact that transaction costs shift the market equilibrium also in the case of emission permits. Stavins (Stavins, 1995) suggested that transaction costs impede the implementation of tradable concentration permit systems despite the theoretical advantages in pollution control.

The research described in this paper use the well-known manure problem as an analogue to these tradable concentration permits and allows to describes transportation costs in the pricing. The case is token from the Flemish manure policy. The paper uses a multi agent simulation model on the administrative database of 36,000 firms active in the trade of manure concentration rights to simulate the cost and the effectiveness of emission policy alternatives. The model is a combination of mathematical programming models simulating the least cost disposition of the emissions of individual firms and a spatial equilibrium model to simulate the spatial price formation of the concentration rights. The reallocation costs of the emissions are also simulated as an important part of the transaction costs that the firms face in the context of tradable concentration rights.

The simulations show that the CPT system outperforms the traditional tradable emission permit system in terms of reaching maximum environmental standards in the different locations in Flanders. This environmentally better performance comes at an emission reallocation cost for the emission producing firms. In Flemish manure case this accounts for 56 million euro which is about 5,828 Euro per firm with excess emissions. The conclusion is that a tradable concentration permits system is an adequate policy alternative for a case with following features: a low reallocation cost of the emission, a transparent distribution of the concentration rights and a market for concentration rights with many participants.

In the case of manure, the emission is transportable to the location of the concentration rights. This gives the opportunity to more firms to participate in the market for the concentration rights resulting in a more competitive market. The regional submarkets face different prices but they are still linked by the emission reallocation costs. These findings allows for generalisation to concentration permit trading. The reallocation cost of the emission is an important reason why the system is not often used as a pollution control option. In the case of air or water toxins, where reallocation costs are very high, this means that rights can only be transferred to firms within a certain area and several small markets would exist (Atkinson and Tietenberg, 1987).

The distribution of the concentration rights in the Flemish manure case is based on the usage of agricultural land. A number of concentration rights is assigned to each plot based on its size, its location and vulnerability to nitrate leaching. The cost of administration of these concentration rights is currently limited, because the agricultural land area per farmer has to be administered anyway for the common agricultural policy direct payments. The main extra cost is the administration of the exchange of NARs between firms.

An important topic for controversy are the different possibilities of transferability of the concentration rights (Tietenberg, 2003). Those who are in favour of free exchange of the permits argue that any restriction reduces the efficiency of the system (Tietenberg, 2003). Yet, others argue that intervention in the free market of rights is justifiable to prevent socially unacceptable outcomes such as destruction of community interest, degradation of the environment and concentration of rights. The last argument was the motivation of the Flemish government to intervene in the system of tradable concentration rights of manure. The policy has introduced an obligation to the largest firms to process a part of their emission to prevent them from dominating the concentration right market. Our analysis of the policy intervention confirms what has already been revealed in other studies: intervention increases overall emission abatement costs (Tietenberg, 2003; Van der Straeten et al., 2009a).

The more the government intervenes, the higher the loss in efficiency is. Our model results also confirm that imposing obligatory manure processing on the larger farms protects the small family livestock farms against the competition for concentration rights from the large firms. Results show that the obligation to process has indeed a positive effect on the total costs of the small family livestock farms. A stronger intervention leads to a higher effectiveness of this policy be it at a certain overall cost for the sector. It is the task of policy makers to make a trade-off between efficiency and effectiveness. The stronger the intervention, the more the costs to meet the prescriptions are passed on from the small family livestock farms to the large livestock farms.

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