OPTIMISATION OF POLICY INTERVENTIONS IN ENVIRONMENTAL QUOTA

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Abstract

The paper analyses the governance choices in production quota with the Flemish nutrient production rights as a case. A static model of quota trade in the short run shows the inefficiency of discrete non-auctioned trade with fixed transaction costs. This model also shows that an obligation to quota sellers to stop their production stimulates structural change. A dynamic model of trade indicates that the measures taken to prevent speculative behaviour causes inefficiencies and stimulates overuse of quota if the penalties are too low. Finally, the dynamic model indicates that a flat rate reduction on traded quota combined with too low penalties for overuse stimulate the total production.

Keywords production rights, quota, dynamic programming, transaction costs

1 INTRODUCTION

Production quota have been an important part of the EU agricultural policy of the past decades. The impact of the rules of quota transfers on structural change have been described by many authors. An important conclusion that has been drawn many times is that limitations on the rules of transfers slow down the structural change in agriculture and lead to a less competitive sector (e.g. Oskam and Speijers, 1992; Boots et al., 1997; Colman, 2000; Van der Straeten et al., 2009a). The old production quota, such as the dairy quota, are about to be abolished but new types of production and emission rights are arising to gradually reduce the production or the emission by policy intervention (e.g, Van der Straeten et al., 2009b).

The contemporary change in policy focus to more environmental concerns leads to the implementation of emission rights or production rights linked to environmental concerns. A well known example is the carbon dioxide emission right. Another example is the implementation of productions rights to limit the animal production in Flanders. The objective of this policy is to put Flanders in line with the EU nitrate directive that requires less animal production in Flanders. Since 2007, the nutrient production rights (NPR) limit the evolution of the total number of animals in Flanders.

The Flemish NPR's have, similar as other types of tradable production rights, inefficiencies in their implementation. Currently, there are more than enough production rights for the animal production but still 2880 farms have to pay fines for overusing of their rights. It remains also an open question whether the system really contributes to the objectives of the EU nitrate directive. Flanders has a detailed manure policy framework wherein manure use on land takes the most prominent role (Van der Straeten et al., 2010). If the system of fertilisation standards on the level of parcels works properly, than NPR's will not have an additional value for obtaining the final goals of the nitrate directive, i.e. avoiding nitrate pollution.

The current paper analyses different elements for fine-tuning the system of the Flemish animal production rights. Two types of models are applied to support policy makers on the following choices of implementation: i) trade of rights between individuals or through a centrally organised auctioning system; ii) forcing farms to stop their activity when selling production rights; iii) how to implement a gradual reduction in the total amount of rights; iv) a system for prevention of speculation.

Each of the choices has an effect on the effectiveness and the efficiency of the policy and the choices might in turn also affect the structural evolution of the sector in question as for instance in the case for milk quota (Bailey, 2002; Alvarez et al. , 2006; Van der Straeten et al., 2009a). The objective of the current paper is to make general recommendations on each of the policy choices based on the generic models applied to the case of the Flemish animal production rights. The Flemish animal production rights is a good case to study these phenomena because of the availability of detailed data and because the implementation differs across agricultural sub sectors making a comparison on actual data possible.

The rest of the paper is organised as follows. The second section describes the system of production rights of our case study and which choices about the institutional setting have been made. The third section introduces a model of trade with transaction costs to compare alternative organisation forms of the trade in production rights. The fourth section introduces a dynamic programming model to analyse the impact of penalties, flat rate reductions in trade and withdrawal of unused production rights. The paper is rounded up by an overall discussion and conclusion.

2 THE NUTRIENT PRODUCTION RIGHT SYSTEM

NPR's are assigned at the farm level in 2007 based on the average number of animals in the period 1995 - 1997. Each type of animal[1] corresponds to an amount of NPR's. This amount is based on the average yearly excretion of nutrients of the corresponding animal type. The higher the joint excretion of phosphorus and nitrogen, the higher the corresponding NPR's. In most cases, the amount of NPR per animal is simply the sum of the average yearly gross excretion of both nutrients of that animal type. Table 1 shows the amount of NPR's per animal for the most important animal types in Flanders. The different types of animals are grouped into four animal categories: cattle, pigs, poultry and other animals. The total quantity

[1] Animal type : combination of species, age and feeding system.

of initially distributed NPR’s is the multiplication of the average present number of animals during 1995-1997 and the corresponding NPR-value.

Table 1. The amount of nutrient production rights per animal type

Animal type	Value	Animal type	Value
Dairy cows	127	Sows	38.5
Suckler cows	127	Piglets	4.48
Young cattle (< 1 year)	43	Layers	1.18
Young cattle (1-2 years)	83	Broilers	0.91

Since 2007, each farm with animals is obliged to have sufficient NPR’s for all present animals. The calculation of the needed NPR’s is the same as applied for the initial distribution of the NPR’s.

The initial distribution corresponds with the actual use of the NPR’s except that it ignores 10 years of structural change in the agricultural sector. An initial distribution of emission or production rights based on historic use has the advantage of lower transaction costs than an even or flat distribution where a lot of transactions are needed before reaching an new equilibrium (Stavins, 1995). The main policy discussions on the initial distribution of the NPR’s focussed on specific cases where normal farm management was not possible during the base period. Farms that could prove that they had an exceptional low number of animals during 1995-1997 due to force majeure were also allocated additional NPR’s.

More policy discussion has focussed on the tradability of the production rights. Many authors (see Van de Straeten et al., 2009a) have indicated that limitations on tradability lead to a less efficient distribution of emission or production rights.

The data on the application of NPR’s in Flanders have shown that also in the case of the NPR’s the market is far from perfect. There is at aggregate level no shortage of NPR’s due to a decline in the total number of animals between 1997 and 2008. Despite the surplus at the aggregate level, there are significant shortages at the individual farm level. In total 3 480 532 NPR’s have been used beyond the legal limits of the NPR’s. For the concerning 2 880 farms, this results the first year of detected overuse on a specific farm in a fine of 1 euro per NPR, which is on average 1 209 euro (Table 2). The second and following years the fine would be 2 euro resulting in an average fine of 2 418 euro.

Table 2. The overuse of nutrient production rights in 2008.

	Number of farms with overuse	Number of NPR's overused	Minimal Fine per farm with overuse
Cattle	2 339	2 625 716	1 123
Pigs	477	1 043 900	2 188
Poultry	117	409 792	3 502
Total	2 880	3 480 532	1 209

One limitation that the Flemish policy makers have introduced is the restriction of trade between animal categories. As long as the farmer has only original allocated NPR's, the NPR's can be freely used for every type of animal. When buying NPR's from other farms, these new NPR's and the original NPR's of that category become fixed, i.e. they are exclusively usable for animal types within that category. This type of transferability allows for structural change within an agricultural subsector, but it protects the livestock production subsectors from competition with each other. The motivation of this limitation on trade is the fear that intensive (monogastric) animal production would increase at the expense of cattle production. Earlier studies have shown that differences in profitability together with limitations on trade lead to a difference in price of the traded NPR's depending on the category. The subdivision in animal categories can, however, not explain the over- and underuse at the farm level because there are currently sufficient NPR's in each subsector.

Possible explanations for the inefficient distribution of NPR's can be found in the several other limits on transferability that have been introduced. One limit is that the minimum transferable quantity of NPR's is 200. A second restriction is that the seller of the NPR's must stop the animal activity for the respective animal category except for the cattle-category. Also the fact that trade in NPR's is only possible between individual farms instead of an auctioning system might depress efficient trade. Each of the above limitations on trade is analysed and discussed in section 3 of this paper.

The policy makers have also decided upon a number of interventions in NPR trade to reduce the total number of animals and to prevent speculation on the NPR value. The first objective should be reached by a flat rate reduction on all traded NPR's between farmers without family bonds. Policy makers try to avoid speculation by a mechanism that prevents non-used NPR's to be re-activated. NPR's that are not used during the three preceding years can not be traded anymore but still be used by the owner. Both policy interventions can have a dynamic impact throughout the coming years, because both can gradually change the availability and the trade of NPR's.

Therefore, the paper relies on a model to simulate trade using a dynamic three-agent simulation model. The multi-period description of three firm types with heterogeneous production technologies allows the model to simulate structural change endogenously as a function of the changes in the rules of production right trade. Section 4 of this paper describes the model and the two policy scenarios are evaluated against alternative initial distribution of production rights and different penalties for overproduction.

The first policy is a flat rate reduction of all transferred production rights. The results show that policy makers should carefully consider the combination of the level of this flat rate reduction and the penalty of overproduction. A high reduction rate on transferred production rights prevents non-competitive firms from selling their rights. At the same time, the initial distribution of the rights gives these non-competitive firms a cost advantage to continue their production, which they would have stopped otherwise. The competitive firms can not buy additional production rights and are therefore stimulated to produce more than their available production rights allow them while paying penalties for that. A too high flat rate reduction is therefore nor effective, because it stimulates production of non-competitive farms, nor efficient, because it favours non-competitive firms. Lower flat rates are more efficient and effective.

The second policy holds firms from selling rights that have not been used for three consecutive years. It could be expected that this type of policy stimulates firms to hold on to their production to maintain the value of their production rights. The simulations show that this is only the case if the firms have an expectation of increasing prices of the production rights. As the policy is making the rights scarcer in time, the expectation of increasing prices could be stimulated.

3 SHORT-RUN SIMULATION OF TRADE IN PRODUCTION RIGHTS

3.1 Model overview

Transfers of production rights have been organised in auctions or by bilateral trade between farms. The auctioning systems, such as the dairy quota trade in Canada, Denmark and Germany, are organised to promote a more efficient reallocation of productions rights (Bogetoft et al., 2003). Within the auctioning system one can distinguish single bid auctioning such as in dairy quota Denmark and Germany and multiple bid auctioning system of dairy quota in Canada.

In many other cases of production rights, such as in Flanders, the trade is not organised in an auction. This means that the buyer of rights has to make the efforts of finding a seller with a the desired amount of rights. Each bilateral agreement between two farms results in a transaction recorded by the administration, which results in transaction costs. As a consequence, it might be possible that a buyer of rights can only satisfy his demand by making transactions with more than one seller. Likewise, the seller might have to look for several buyers to make sure that all surplus rights are sold. This might not only result in a higher number of transactions than in a system with auctioned trade but it may also lead to the fact that the amount of trade is depressed or that seller can not sell all surplus rights and that buyers can not obtain the desired amount of rights. Both cases are observed in the dataset of traded NPR's in Flanders.

To have an idea about the role of the 'non-auctioned' trade and other restrictions on trade we use a mixed integer programming model with fixed transactions costs. The model minimises the objective function (Eq. 1) that is the sum of penalties (f) multiplied by the deficiency of NPR's for each farm and animal category (μ_{ia}), transaction costs (tc) multiplied by the number of transactions ($\Sigma_{ia}\ \beta_{ija}$) and lost profit from reducing the animal production (ρ_{ia}) multiplied by the gross margin of that activity (gm_{ia}).

The deficiency of NPR's per farm and animal category μ_{ia} is calculated in Eq. 2 as a positive real variable that should be higher than the used NPR's (u_{ia}) minus the available NPR's (a_{ia}) and the net traded NPR's (τ_{ija}) and the reduction of the animal production (ρ_{ia}).

Another constraint (Eq. 3) imposes that the binary variable β_{ija} take the value 1 in case that a transaction takes place between farm i and j for an animal category a.

$$\text{Minimise } Z = \Sigma_{ia}\, f\, \mu_{ia} + \Sigma_{ia}\, \beta_{ija}\ tc + \Sigma_{ia}\, \rho_{ia}\ gm_{ia} \tag{1}$$

s.t.

$$\mu_{ia} \geq u_{ia} - a_{ia} + \Sigma_j\ \tau_{ija} - \Sigma_j\ \tau_{jia} - \rho_{ia} \tag{2}$$

$$a_{ia} * \beta_{ija} \geq \Sigma_j\ \tau_{ija} \tag{3}$$

The model is applied to an administrative dataset of the Flemish Land Agency (Vlaamse Land Maatschappij). The dataset has for each Flemish farm the available NPR's per animal category described in the parameter a_{ia} and the number of present animals resulting in the used NPR's described in the parameter u_{ia}. FADN data are used to assign a gross margin for the different animal production activities. This gross margin is expressed per NPR in the parameter gm_{ia}.

The model is applied to a random subsample of the population to simulate the fact that it is for farmer impossible to search in the entire population for matching packets or rights for their demand. The larger the subsample, the more interactions are possible and the better the market for NPR's is assumed to work.

3.2 Short-run simulations of trade in NPR's

In the simulations we analyse the effect of the presence of transaction costs by doing a sensitivity analysis on the parameter tc. The analysis gives us also an idea of the impact of minimum transferable quantity of NPR's of 200 NPR's. A second restriction is that the seller of the NPR's must stop the animal activity for the respective animal category except for the cattle-category. Also the fact that trade in NPR's is only possible between individual farms instead of an auctioning system might depress efficient trade.

3.2.1 Impact of fixed transaction costs on trade of NPR's

The model (Eq. 1) - (Eq. 3) is applied to a random sample of 500 Flemish farms. The size of the sample implies that each farm is able to acquire the information of other farms about the use and the availability of NPR's. We are convinced that 500 is a very optimistic estimate because this implies that each farmer has the full information of each farm in its own municipality and four surrounding municipalities.

The simulations with model (Eq. 1) - (Eq. 3) starts with a sensitivity analysis on the fixed transaction costs 'f' because there exists no information about these costs in the administrative dataset or in the FADN. The results in Table 3 indicate that the presence of fixed transaction costs can partly explain why farmers do not trade sufficient NPR's to avoid penalties or having to reduce their animal production. The comparison of the results of the model with the real short run behaviour indicates that the model overestimates for all simulated transaction costs the intention of farms to reduces their production resulting in an underestimated overuse of the NPR's.

Despite the fact that the current information is insufficient to derive an exact value of the transaction cost, the comparison of the information of Table 2 with the simulation results of Table 3 might give an idea that the order of magnitude of the transaction cost. Using the population average of overusing NPR's after one year of trade the total amount of overuse in the sample should correspond to 31 744, which is much higher than the sum of the simulated overuse and production reduction at even a transaction cost of 900 euro.

Table 3. The impact of increasing transaction costs on trade and production

Cost per transaction tc (in euro)	Total penalty (in euro) Σ_{ia} f μ_{ia}	Number of transactions Σ_{ia} β_{ija}	Trade Σ_j τ_{ija} (in NPR's)				Production reduction Σ_{ia} ρ_{ia}(in NPR's)			
			other	bovine	pig	Total	other	bovine	pig	Total
100	71	91	16 226	65 232	4 636	86 094	1 753	318	0	2 071
200	228	79	15 141	59 778	4 733	79 652	2 352	4 421	0	6 773
400	582	73	14 809	53 255	4 733	72 797	2 494	4 902	0	7 396
600	2602	57	12 318	53 795	4 183	70 297	3 971	5 739	550	10 260
800	4676	47	11 858	53 828	2 882	68 568	3 971	6 922	1 495	12 388
900	5115	44	9 673	52 020	2 725	64 418	4 988	6 922	1 495	13 405

3.2.2 Impact of prevention of sales of NPR's from active farms

Besides the fact that the trade of the NPR's happens from farm to farm, the policy has further restricted the trade by imposing for all animal categories, except 'bovine', that the selling farm has to sell all his NPR's from that activity. The idea of this policy intervention is to stimulate the structural change by making the production factors quicker available for the remaining farms.

The comparison of the results in Table 3 and Table 4 shows that the at least in the short run the policy rather reduces the production and stimulates the traded amount of NPR's compared to the scenario without the policy. The policy also leads to the fact that the buyers of the NPR's have to buy more NPR's than needed in the short run leading to a surplus at their farm. The surplus gives them, however, again the opportunity to expand production in the long run. The conclusion is that this policy intervention indeed stimulates the structural change in the agricultural sector because the amount of the traded NPR's increases, even though the total number of transactions slightly decreases.

Table 4. The impact of increasing transaction costs on trade and production in the scenario where the selling farms have to stop their production

Cost per transaction tc (in euro)	Total penalty (in euro) Σ_{ia} f μ_{ia}	Number of transactions Σ_{ia} β_{ija}	Trade Σ_j τ_{ija} (in NPR's)				Production reduction Σ_{ia} ρ_{ia}(in NPR's)			
			Other	bovine	pig	Total	other	bovine	pig	Total
200	131	85	106 659	190 334	14 942	311 936	4 148	15 278	0	19 426
400	822	71	103 421	149 707	13 336	266 463	5 142	25 326	0	30 468
600	2691	57	26 735	126 706	12 771	166 212	20 328	22 145	550	43 023
800	4408	46	19 786	124 448	7 104	151 338	16 263	18 832	1 495	36 590

The model described in this section only simulates short run adaptations to the limits introduced by the NPR's. The model simulates only the possibility of buying extra rights or reducing the production. The model does not simulate farm growth or a multi-period planning to optimise the moment of selling or buying the production rights. The next section introduces a model that tackles these shortcomings to simulate the effect of a flat rate reduction of trade and the removal of unused NPR's.

4 MULTI-PERIOD SIMULATION OF TRADE IN PRODUCTION RIGHTS

4.1 Model overview

The model simulates three farm types with different quadratic cost functions representing the differences in production technology in the Flemish farm population. The model simulates production changes and trade of NPR's of a period of 7 year by maximising the expected profit from production and the selling of NPR's. Unlike the model of previous section, the dynamic model assumes that the long run market operates according to the assumptions of a perfect market.

The objective function (Eq. 4) maximises the depreciated revenues at interest rate r for all years t, farms i and animal activities a. The economic revenue is the price (op) minus the marginal cost multiplied by the activity level (χ). The cost function is quadratic with a linear (lc) parameter and a quadratic parameter (qc). Also the acquisition (Σ_j τ_{tija}) and the sales (Σ_j τ_{tjia}) of NPR's is accounted for in the revenue. The price of NPR's (np) is exogenous to the model. The received price for NPR's is multiplied by 0.84 to account for the flat rate tax of 16% that has to be paid on the income of the sales of the rights. The buyer of the rights has to take into account the average reduction rate (ω) of the number of rights as speculation prevention. Finally, the total income is reduced by the penalties (f) of overuse of the available NPR's.

Eq. 5 determines the NPR balance. Eq. 6 prevents farms from selling more NPR's than available. Eq. 7 applies a reduction rate ψ to the traded NPR's. This reduction rate is set minimum to the flat rate (rr) of 25% (Eq. 8) or higher than the unused NPR's calculated in Eq. 9. Eq. 9 uses the average unused NPR's (φ) of the last three years. φ is assigned in Eq. 11 as a function of the available NPR's and the level of each animal activity. Eq. 13 calculates the average reduction rate (ω). This average reduction rate is used in the objective function to measure the impact on the price change as result of the reduction in the total available NPR's.

Maximise

$$Z = \sum_{t=1}^{T} \left(\begin{array}{c} \sum_{i} \sum_{a} (op_{tia} - lc_{tia} - qc_{tia} * \chi_{tia}) * \chi_{tia} \\ + np_{ta} * \Sigma j \, \tau_{tjia} * 0.84 \\ - \dfrac{(np_{ta} * \Sigma j \, \tau_{tija})}{1 - \omega_{ta}} \\ - f \mu_{tia} \end{array} \right) / (1+r)^{t} \qquad (4)$$

s.t.

$$a_{tia} = a_{t-1\,ia} + \Sigma_j \tau_{tija} - \Sigma_j \tau_{tjia} \qquad (5)$$

$$a_{tia} \geq \Sigma_j \tau_{tjia} \qquad (6)$$

$$\Sigma_j \tau_{tija} \psi_{tia} \geq \Sigma_j \tau_{tjia} \qquad (7)$$

$$\psi_{tia} \geq rr \qquad (8)$$

$$\psi_{tia} \geq (\varphi_{tia} + \varphi_{t-1ia} + \varphi_{t-2ia}) / 3 \qquad (9)$$

$$\varphi_{tia} \geq 0 \tag{10}$$

$$\varphi_{tia} \geq a_{tia} - \chi_{tia} / a_{tia} \tag{11}$$

$$\omega_{ta} \geq 0 \tag{12}$$

$$\omega_{ta} \geq \Sigma_i\ a_{tia} - \Sigma_i\ \chi_{tia} / \Sigma_i\ a_{tia} \tag{13}$$

$$\mu_{tia} \geq \chi_{tia} - a_{tia} + \Sigma_j\ \tau_{tija} - \Sigma_j\ \tau_{tjia} \tag{14}$$

$$\mu_{tia} \geq 0 \tag{15}$$

4.2 Multiperiod simulations

For reasons of transparency of the results, the generic model of the previous sub-section is applied to only three farm types with 1 animal activity with hypothetical cost function parameters. The results of the simulations should therefore be interpreted as illustration of the mechanisms of the policy impact on trade and production rather than as actual predictions of production or trade shifts that will occur.

The profit function parameters of the three farm types are described in Table 5. Given the parameters in Table 5, the unconstrained maximum profit would be reached at a production of 10 for farm 1, 2.5 for farm 2 and 5 for farm 3.

Table 5. The parameters for the three farm types in the model

Farm /	Output price 'op'	Linear cost parameter 'lc'	Quadratic cost parameter 'qc'
1	20	10	0.5
2	20	10	2
3	20	10	1

These parameters are used in combination with changes of all other parameters in the model such as the penalty level 'f', the initial distribution of NPR's 'a', the reduction rate 'rr', and the presence of the Eq. (8).

Some simulations confirm what could have been expected and what has been described already by other authors. We will not discuss these simulations in detail such as the fact that the level of the penalty 'f' has indeed an impact on the traded quantities. At lower levels of 'f' it becomes more profitable to oversupply and pay the penalty instead of reducing the production or buying additional rights. This finding could also be confirmed by the model of section 3 with actual penalty levels and realistic data on gross margins.

The simulations also confirm the findings of, e.g. Hahn and Noll (1982), Hahn (1984) and Stavins (1995) that the initial distribution 'a' of the rights does play a role in the final distribution of the production rights because of the presence of transaction costs.

We will focus on the simulations of changes of parameters that have not been discussed yet in the literature. The simulations performed with focus on changes in the Eq. (8) and Eq. (9) yield less obvious results. In the Eq. (8), the reduction rate 'rr' can be increased to see the impact on the transactions and the activity levels. The flat rate reduction 'rr' is applied to all NPR's traded between two farm without any family bond or without the combined trade of dairy quota. The more NPR's are traded the less total NPR's are available. The reduction rate 'rr' has been introduced to obtain a gradual decline in the number of rights and therefore in a decline of the total animal production. The decline in animal production would help to bring Flanders in line with the objectives of the Nitrate directive.

Eq. (9) simulates the policy measure that should prevent speculation because only the active farms can sell their NPR's. The policy stops non active farms from holding on to their NPR's and speculating on NPR price increases because after three years the unused NPR's can not be sold anymore. During the simulations, the Eq. (9) can be removed from the model to analyse the impact of this type of policy.

4.2.1 Flat rate reduction on traded NPR's

The results of simulations of changes in the reduction rate 'rr' are performed with an initial distribution of NPR's over the three farm types of 10, 5 and 0 for the farm 1, 2 and 3 respectively. The penalty is set at 2 euro per unit of overuse of NPR's. A multiperiod simulation is chosen for this scenario because the reduction is cumulative in time. The multiperiod results show in each case trade in the first year where trade is possible and for the remaining years a constant level of production. The results in Table 6 show the impact of changes in the reduction rate of traded NPR's on the production and the distribution of the NPR's over the three farm types. The results indicate that the objective of having a long term reducing effect on the production is only reached with small reductions on the traded NPR's. Without policy intervention on the trade of NPR's, 4 NPR's are sold to the farm type 3. The introduction of a reduction of the traded NPR's leads to the fact that 0.25 NPR's are more sold to be able to satisfy the demand of the farm type 3. Yet, the net bought NPR's decline with 0.2 NPR's because the reduction rate of 10% reduces the total number of NPR's obtained by the buyer. The net effect of the limited increase of the reduction rate is a decline in the total number of NPR's and the total production. The striking result is that a further increase of the reduction rate from 0.1 to 0.2 or more leads to an increase of the production. The increase of the production can be explained by the fact that the reduction rate introduces a transaction cost leading to less trade in NPR's. The farm types 1 and 2, with sufficient initially distributed NPR's, sell less NPR's and hold on to their production. Farm type 3 can not buy sufficient NPR's to satisfy his demand and decides to produce beyond the NPR-limit and pay penalties for the overuse.

The policy of having high transaction costs and penalties lower than the gross margin results therefore not in the expected reduction of the total production. The only positive element for policy makers is the increase in the government revenue by the higher penalties that have to be paid.

Table 6. The changes in steady state production for the three farm types as function of changing the reduction rate of traded NPR's

'rr'	farm type 1		farm type 2		farm type 3		Total	
	production	NPR	production	NPR	production	NPR	production	NPR
0	8.6	8.6	2.2	2.2	4.2	4.2	**15.0**	15.0
0.1	8.4	8.4	2.1	2.1	4.0	4.0	**14.5**	14.5
0.2	8.6	8.6	2.1	2.1	4.0	3.4	**14.7**	14.1
0.3	8.8	8.8	2.2	2.2	4.0	2.8	**15.0**	13.8
0.4	9.1	9.1	2.3	2.3	4.0	2.2	**15.3**	13.5
0.5	9.4	9.4	2.4	2.4	4.0	1.6	**15.8**	13.4

The question now raises whether the theoretical situation would also occur in reality in the Flemish case with the current penalties for overuse of 2 euro per NPR, a reduction rate of 25% and the observed gross margins. The answer to this question has two sub questions. Is animal production in Flanders profitable enough to survive with paying penalties for overuse of the NPR's? Are there farms that would hold on to their NPR's because the transaction cost of selling them is too high?

The first question can be answered by comparing the gross margins per NPR with the penalty of overuse per NPR. The average gross margin for pig farms in the FADN is estimated at 4 euro per NPR in 2006 with a standard deviation of 2.2 and 1.8 euro per NPR in 2007 with a standard deviation of 1.6. The administrative dataset confirms that a significant number of farms overuse their NPR's. We can therefore conclude that it is very likely that some farms can overuse their NPR's and can still survive by paying the penalties.

The second question is also affirmed because it is very likely that farms exist using their NPR’s without selling them because their gross margin is between 75% and 100% of the penalty level of the overuse of NPR’s (2 euro).

4.2.2 Prevention to trade unused NPR’s

To illustrate the impact of the Eq. (9) the model simulates the same situation in one scenario with Eq. (9) included in the model and a second scenario without Eq. (9). The impact of the production and the division of the NPR’s of these two scenario’s are illustrated in Table 7 and Table 8 respectively. Notice that the trade in NPR’s in the model is only allowed after three years to have a base period calculation of how many NPR’s should be removed because they were not activated by corresponding production.

The results of farm type 1 in Table 7 and Table 8 of the two scenarios give the same outcome because the reduction of unused NPR’s does not affect this farm type, nor in the selling of the NPR’s nor in the buying of NPR’s. As long as less than 25% of the NPR’s remain unused, the flat rate reduction is the limiting factor on the traded NPR’s.

The situation of farm type 2 is different because the unconstrained production is 2.5, which is only 50% of the available NPR’s. The results in Table 7 show that the speculation prevention of Eq. (9) gives farm type 2 an incentive to produce more than otherwise economically optimal. Farm type 2 holds also longer on to the production to be able to sell more of its NPR’s as an attempt to avoid the impact of the speculation prevention. The selling of the NPR’s happens in two steps to further avoid the reduction of the unused traded NPR’s. From income point of view, the situation of farm type 2 is worse in the scenario with the speculation prevention of Eq. (9) because farm type 2 can sell less NPR’s and it has to maintain unprofitable production to be able to sell some more NPR’s.

The fact that farm type 2 sells later its NPR’s and more of the NPR’s are withdrawn by the speculation prevention, implies that farm type 3 has to pay more penalties. This is especially true for the years 4 and 5 because of the postponed trade of the NPR’s. The production of farm type 3 is not affected because the optimal level of production is in both scenario’s determined by the level of the penalty.

The overall effect of the policy intervention in Eq. (9) is negative from almost all perspectives. Eq. (9) reduces the income of two of the three farm types. The policy reduces the overall efficiency because the production of the non competitive farm type is stimulated.

The production is increased in the short run, which is contradictory to the policy objective of environmental quota. The only positive element in the short and long run is the increase of government revenue from the higher penalties that have to be paid by farm type 3.

Table 7. Changes of production and NPR's during six years in the case the farms can not sell unused NPR's beyond the flat rate reduction of 25% on traded NPR's

Year	farm type 1		farm type 2		farm type 3		Total	
	production	NPR	production	NPR	production	NPR	production	NPR
1	10.0	10.0	2.5	5.0	4.0	0.0	16.5	15.0
2	10.0	10.0	3.0	5.0	4.0	0.0	17.0	15.0
3	10.0	10.0	3.1	5.0	4.0	0.0	17.1	15.0
4	8.7	8.7	3.1	5.0	4.0	1.0	15.8	14.7
5	8.7	8.7	2.6	2.6	4.0	2.4	15.3	13.7
6	8.7	8.7	2.2	2.2	4.0	2.7	14.9	13.6

Table 8. Changes of production and NPR's during six years with only a flat rate reduction of traded NPR's

Year	farm type 1		farm type 2		farm type 3		Total	
	production	NPR	production	NPR	production	NPR	production	NPR
1	10	10	2.5	5	4	0	16.5	15.0
2	10	10	2.5	5	4	0	16.5	15.0
3	10	10	2.5	5	4	0	16.5	15.0
4	8.7	8.7	2.2	2.2	4	3.1	14.9	14.0
5	8.7	8.7	2.2	2.2	4	3.1	14.9	14.0
6	8.7	8.7	2.2	2.2	4	3.1	14.9	14.0

5 Discussion and conclusion

The paper illustrates how the details of the implementation of different types of rules of production right transfers has an impact on production, efficiency, structural change and the effectiveness of the policy interventions. The paper confirms the earlier findings (Oskam and Speijers, 1992; Boots et al., 1997; Colman, 2000; Van der Straeten et al., 2009a) that limitations on the rules of transfers lead to inefficiency.

The current paper continues at the path paved by previous authors to use models to analyse different elements of the implementation of tradable production rights on the effectiveness and the efficiency of the policy. The paper uses a mixed integer programming model to simulate the short run reactions of trade taking into account that the discrete nature of trade leads to fixed transaction costs. The possible dynamic effects of policy interventions are simulated with a multi-period simulation model. The Flemish Nutrient Production Right (NPR) is used as case in both models.

We accept that the simplified models are not able to simulate all elements that influence the trade in production rights but the simplified illustrative models are still useful to identify potential weaknesses in the policy design of tradable production right and their impact on production and structural evolution. In the case of the NPR's in Flanders several possibilities for improvement could be suggested.

The model of the short-run adaptation to the production rights has illustrated that the system of bilateral trade with fixed transaction costs depresses the trade of production rights leading to a less efficient distribution. The simulations confirm that the absence of an organised auction can partly explain why so many farms have to pay penalties for a shortage of production rights while at aggregate level there are more than enough production rights. This conclusion can be extrapolated to other cases where discrete trade between farms increases the fixed transaction costs.

The same model could also illustrate that the fact that only completely stopping farms can participate in trade stimulates them to stop which might accelerate the structural change in the short run. The model has shown that the impact on the number of transactions in limited.

The multiperiod simulation model with simplified synthetic data could further illustrate that policy measures that intervene in trade with the objective of reducing the amount of production rights do not always reach the objective. Besides the fact that the policy intervention in the trade of production rights leads to a lower efficiency, the increase of transaction costs combined with a relatively low penalty for overuse can make the policy intervention also very ineffective. The results indicate that the flat rate reduction on traded NPR's in Flanders might even have a production stimulating effect, which is really an undesired outcome against the background of the environmental concerns that has motivated the introduction of the production rights. The only advantage of the flat rate reduction on traded NPR's is the increase in government revenue from the penalties of overuse. The general lessons drawn from the paper is that a gradual reduction of production rights should not be reached by interventions in trade of the rights. The trade interventions increase the transaction costs, which, in turn, decrease the efficiency and even the effectiveness in the case of a wrong combination with the penalties for overuse of the production rights. A better alternative is to reduce the amount of NPR's irrespective of the trade of the NPR's.

Also the final evaluated policy intervention shows that the current implementation in the case of the Flemish NPR’s is far from optimal. The policy makers want to avoid speculation by preventing farms from selling production rights that have not been used for three successive years. The multiperiod simulation model could also illustrate with synthetic data that the speculation prevention stimulates individual farms to increase their production the three years before selling the production rights. The overall result is again that the intervention in the trade of production rights decreases efficiency and is, furthermore, not effective because the production is stimulated. This final result can not be confirmed with actual data but anecdotic evidence exists that farms are stimulated to produce in order to make sure that as much as possible production rights remain valid.

The overall conclusion is that the added policy value of the system NPR’s is not at all clear. In Flanders there also exists a detailed manure policy framework that regulates the manure use on land. This complementary policy has been described as a system of tradable concentration rights (Van der Straeten et al., 2010) and has the theoretical properties to become the efficient and effective policy to minimise the impact of the concentration of the pollution of animal production.

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