Market for tradable pollution permits

Možnosti obchodování s emisemi

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Abstract: Structural changes that were following the transformation from the centrally planed economy to market oriented one brought among other things new perceptions that of the hither to mainly reglected environmental issues. The Czech Republic as one of the few developed countries has achieved a tremendous decline in a emission production by huge investments. Because of the Kyoto protocol ratification by the EU, this issue is getting more important. The practical consequence of this ratification process is the creation of the unified European market for tradable emission permits that should be fully functioning by the year 2005. It is essential to fully understand basic theoretical principles of tradable emission permits market for homogenous and heterogeneous pollutions to achieve maximal benefits out of it.

Key words: Kyoto agreement, air pollution, tradable permits

Abstrakt: Strukturální změny, které provázely přechod z centrálně plánovaného ekonomiky na tržní prostředí, přinesly mimo jiné nové pohledy na do té doby značně opomíjenou problematiku životního prostředí. České republice se jako jedné z mála rozvinutých zemí podařilo významnými investicemi výrazně snížit úroveň produkovaného znečištění. Tím, že se EU přihlásila a ratifikovala Kjótský protokol, nabývá tato skutečnost na významu.Praktickým výsledkem ratifikace této dohody je vznik jednotného evropského trhu pro obchodování s emisemi, jež má být plně funkční od roku 2005. Pro maximální využití tohoto tržního potenciálu je nezbytně nutné porozumět základním teoretickým principům organizace trhu obchodovatelných emisních poukázek pro homogenní či heterogenní formu znečištění.

Klíčová slova: Kjótský protokol, emise, obchodovatelné poukázky

INTRODUCTION

By adoption of the new directive and set of modified amendments of the original document the representatives of the European Parliament have decided that the EU as one of the first among the big regional organizations around the world will implement the Kyoto agreement. As the consequence of this regulation, that will be applied in the EU since the year 2005, the market for tradable pollution permits will be set up. Since the Czech Republic will be a regular member state of the EU at that time, this regulation will be binding for Czech entities. During the past decade, big investments in emission reduction took place in the Czech Republic that gives a great potential to generate additional financial sources by selling emission quotas surplus.

THE OBJECTIVE

The aim of this article is to outline the possible alternatives of environmental policies both on national and international level that so their implementation could lead to accomplishment of the overall optimal stage of environment by abatement or decline of the pollution volume.

For the purpose of this text, the "optimal" stage is the one that reflects mutual political consensus outgoing from scientific records covering the issues of potentional damages and relevant economic studies tackling the areas of pollution disposal cost analysis and the potential control mechanism.

In general, the outline objective can be tackled in 2 different ways. At first, the targeted emission reduction should be put in force. As a good example, there can serve the EU pollution reduction obligation expressed by the Kyoto protocol. The second way rests in improvement of the surrounding environment. Decisions regarding quality water enhancement would belong to this group.

In order to achieve mentioned goals, the responsible bodies have available at there service a whole set of principle political acquisitions, among which the following instruments belong:

– different forms of lectures and persuasions
– qualitative and quantitative limits (called standards)
– taxes imposed on contaminating inputs
– emission taxes
– production taxes
– pollution reduction subsidies
– tradable input permits system
– tradable pollution permits system TPP
– combination of the previous alternatives.

Since the year 2005, the pollution permits market within the EU should start to operate. The relevant directive has been approved by the EU Parliament and will apply to the Czech Republic and the other new member states of the extended EU. Because of the relevancy and importance of this issue, further attention will be paid to this particular group of instruments.

BASIC THEORETICAL ASPECTS

The ecological taxation can be considered as a potential instrument enabling the desired pollution reduction. This concept the popularity of which is increasing among environmental economists was originally proposed by Crocker (1966) and Dales (1968). The aim of this text is to outline basic theoretical aspects of pollution trade for homogenous and heterogeneous contamination and at the same time to point out the set of possible obstacles related to this instrument.

As commonly known, the main economic reason for pollution occurrence is the absence of relevant and clear ownership rights of natural resources constituting environment leading to sustainable development, Tvrdoň (1994). The basic idea underlying TTP is the aspiration to allocate these rights and consequently to trade them. From which the market settlement for pollution rights and their market price should be ensued. Under certain conditions, this price presents a suitable incentive ensuring redistribution of emission activities leading to optimal pollution level.

Let us suppose that the surrounding is encumbered by a homogenous contamination such as sulphur oxide. Homogenous pollutions are assumed to have equal marginal abatement cost *MAC*[1], Bergman (1991).

Next, competent institutions are concerned about certain reduction of the total pollution at the given area, state or region. For this purpose, a fixed amount of pollution permits that enables producers to foul environment is issued. To exceed this limit framework is obviously forbidden.

Tradable emission permits can be issued and released on market in two ways (1) they are simply transformed by administrative act to the producers for example on the pro rata base with respect to the existing current pollution level of these producers or (2) sold to them directly in the market. The assumption of general merchantability of these permits is applied. The subjects with relatively higher *MAC* will be probably considered as buyers, on the other hand firms with relatively lower *MAC* will be constituted as potential sellers. All these deductions are holding, if the original pollution permits redistribution was not realized according to the attained minimal cost (i.e. emission permits are allocated to those firms achieving the lowest *MAC*).

The situation of individual firms is depicted in the Figure 1, where the horizontal axis represents both emission level e, and the volume of disposal tradable permits at the firm level. Without any appropriate actions taken by the responsible civil bodies targeting the emission reduction, the firm position will be corresponding with e_f.

After the implementation of freely tradable pollution permits, the market price p^* is settled. Every firm would keep in its tenure exactly e^* number of pollution permits. If the capitalization of the possessed permission drops bellow this value, in that case *MAC* are higher than own price of these permits. Which denotes that it is cheaper to buy additional rights to pollute than to introduce new pollution reduction investments. In the case that firm holds more than e^* pollution permits, it would decide to sell out its surplus on the market since the price p^*, which can receive, exceeds the *MAC* firm level. On the contrary, an enterprise attaining a higher cost of pollution control would need (demand) more tradable pollution permits counter to the situation responding to the price p^*.

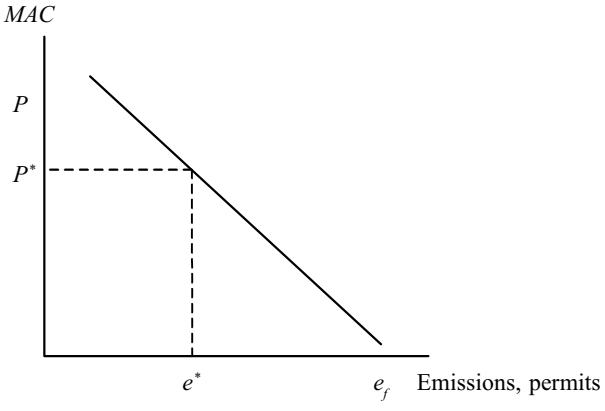

Figure1. Firm response to emission approval

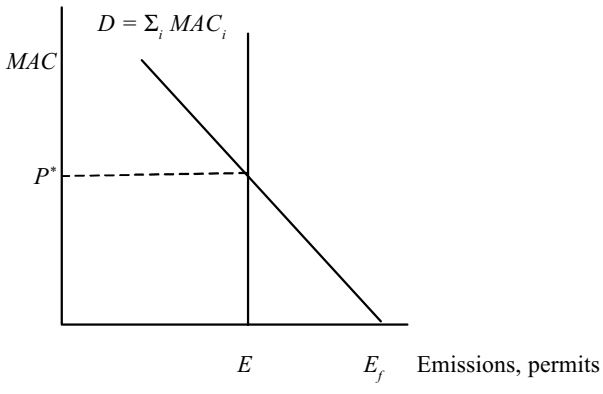

Figure 2. Emission permits supply and demand

[1]Abatement cost function is describing cost related to the emission reduction. Then marginal abatement cost *MAC* are defined as a minimum possible cost related to emission reduction. Both economic theory and empirical results are confirming that *MAC* is growing function of emission reduction level.

The remaining question is the assessment of price p^*. This price p^* constitutes equilibrium price on the pollution permits market, as showed in Figure 2. Responsible bodies of civil service issue the limited volume of permits E. All participating firms based on comparison of their own MAC and designated permission price take decision about how many of these permits they would keep. If the price drops down, then the firm owns more permits and at the same time controls less amount of pollution. It can be derived that the firm MAC curve represents permits demand function. Than aggregation of MAC curves of all firms $i = 1 \ldots\ldots n$ operating in given region

$$(\sum_{i=1}^{n} MAC_i)$$

characterizes regional permits demand function. If the permits supply increases or declines as a consequence of administrative actions, than the given demand function equilibrium price drops or growths.

The explanation and understanding of cost minimization principle for tradable permits should be now clear. As depicted in Figure 1, firms are adjusting their own MAC structures to the permits price then e.g. for the firm 1 holds $MAC = p^*$. Remaining entities in sector would undergo the same adjustment processes that would eventually lead to the equality of their emission level and equilibrium price p^*.

Under the assumption of existence of n firms in the sector, the following equation holds:

$$MAC_1 = \mathrm{MAC}_2 = \ldots\ldots\ MAC_n = p^*$$

which is the necessary condition for homogenous pollution ensuring cost minimization principle fulfilling for all emission activities. Based on these reactions and interactions, firms are moving towards cost minimization point. In the other words, the tradable pollution permits can be viewed as a possible way of maximum emission reduction at the given abatement cost level.

Total financial encumbrance of individual entities arising out of the pollution market regulation consists of resource costs (set bellow MAC level) and transfer payments. The Figure 3 depict 3 different possible scenarios of company's financial burden. In the Figure 3a the situation, where the firm has to pay for all requested and consequently granted tradable permits the equilibrium price p^*, is outlined. In the Figure 3b, the second alternative is showed, where the firm has in its hand a lower number of permits than the cost minimization principle would require. Therefore, it has to go to the market and to buy the missing permits from others. The last alternative described in the Figure 3c captures the situation, where the individual firm is facing surplus of tradable permits contrary to its real needs and has to sell it out in the market to potential buyers.

It is evident that the volume of transfer payments from one individual firms point of view depends on the permits price regardless of becoming eventually a net seller or buyer. While resource cost (i.e. control cost) remains the same for all three alternatives as showed in Figure 3a.

From the sector overall perspective, the value of transfer payment is equal to zero because the earning flows are fully compensated by aggregated expenditures assuming that there are no taxes nor administrative charges imposed. In the case of homogenous pollution, it is obvious that emission permits are traded at 1 : 1 rate. It means that the firm A by selling its quota surplus in the existing market has to reduce its own emissions by exactly the same amount. On the other hand firm B, a potential buyer, can increase own emission by the same volume. To describe the mutual reciprocity is possible only because of the existence of relevant control mecha-

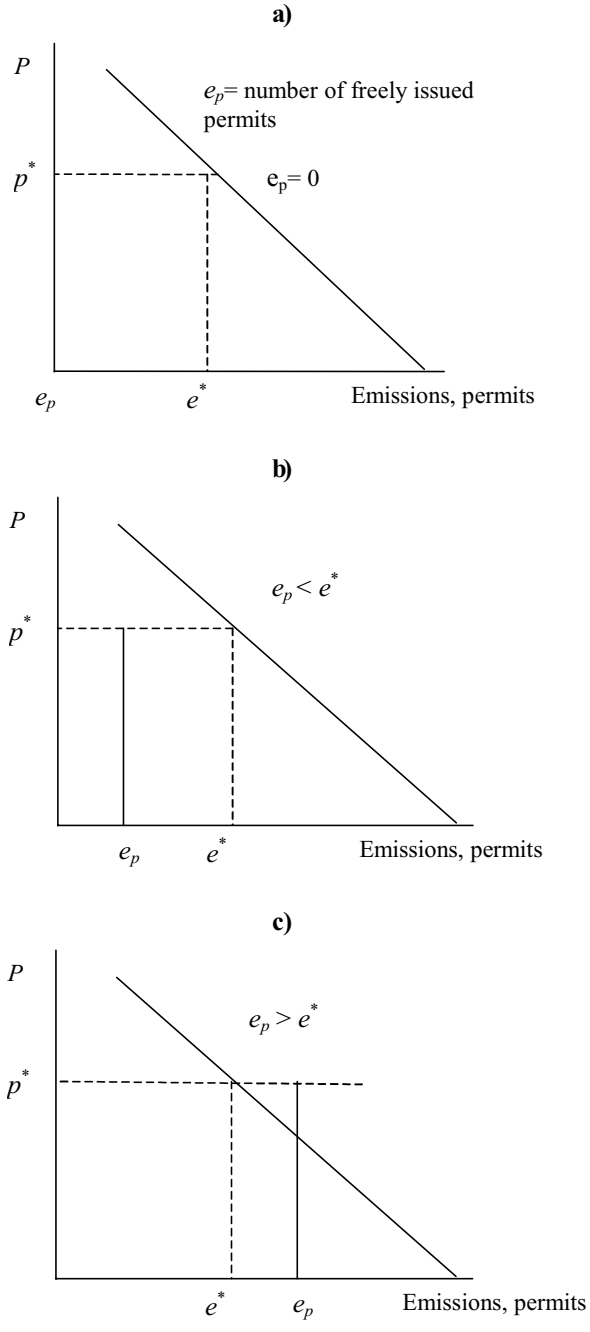

Figure 3. Emission permit impacts on firm revenues and expenditures

nism which aim is to reduced overall encumbrance of environment, however, without spatial settlement.

Now, the above-mentioned conclusions will be elaborated in a more formal way. The principles of cost minimization in the context of tradable pollution permits were originally developed by Montgomer (1972) and further extended by the work of Tietenberg (1984). Let us assume that A represents initial pollution level of sulphur oxide (homogenous contamination) produced in certain region under the control. Then this amount can be derived as follows:

$$A = \alpha + \sum\left(e_{fi} - x_i \right) \tag{1}$$

where α represents emission activity of the remaining sources including natural resources, $e_{f,i}$ determinates uncontrolled emissions $i = 1 \ldots n$ firms generating contamination and x_i characterizes pollution reduction.

Firms are displayed to the cost connected with control mechanism C_i, that depends only on the level of pollution reduction:

$$C_i = C_i(x_i) \tag{2}$$

where $C_i(x_i)$ is continuous, twice differentiated function with $C' > 0$ a $C' < 0$. The responsible civil bodies demand pollution level at/or bellow a certain pollution volume A, that is obviously lower than the sum of the currently produced pollution. Then the following problem has to be solved:

$$\underset{x}{Min} \sum_i C_i\left(x_i\right) \tag{3}$$

under the following conditions:

$$\alpha + \sum\left(e_{fi} - x_i \right) \leq A \tag{4}$$

and

$$x_i \geq 0 \tag{5}$$

The constraint (4) means that the sum of total emissions background and firm emissions reduced by the proposed amount may not exceed the maximum limit. This problem can be solved by using the Kuhn-Tucker method[2] deriving Lagrang equation:

$$L = \sum C_i\left(x_i\right) + \lambda\left(A - \alpha - \sum\left(e_{fi} - x_i \right)\right) = 0$$

By the first order derivation with respect to x_i. the Kuhn-Tucker optimization conditions are derived:

$$\partial C_i\left(x_i\right)/\partial x_i - \lambda \geq 0 \qquad i = 1 \ldots n$$

or simply rewritten

$$C_i'\left(X_i\right) - \lambda \geq 0 \tag{6}$$

and

$$x_i\left[C_i'\left(x_i\right) - \lambda \right] = 0 \qquad i = 1 \ldots n \tag{7}$$

$$\alpha + \sum\left(e_{fi} - x_i \right) \leq A \tag{8}$$

$$\lambda\left[\alpha + \sum\left(e_{fi} - x_i\right) - A\right] = 0 \tag{9}$$

$$x_i \geq 0, \quad \lambda \geq 0 \qquad i = 1 \ldots n \tag{10}$$

From the above, it can be derived that λ represents shadow price of pollution reduction that can only acquire positive values, if this constraint is compulsory. The *MAC* value for all firms has to be equal to this constraint. Too high control cost can prohibit some subjects from participation in the cost minimization solution, in this case the value is $x = 0$.

On the supply side, it is necessary to take decision about the acceptable level of pollution that is corresponding to the pollution permits volume

$$E = \sum\left(e_{f,i} - x_i \right).$$

The assumption of mutual reciprocal rate 1 : 1 among market actors remains at the place. This system is called pollution permits system, Tietenberg (1990). Then at the

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[2] Kuhn-Tucker (K-T) condition can be summarized by the following equations:

$$L_{x_1} = f'\left(x_1\right) - \lambda_1 \leq 0 \qquad x_1 > 0 \qquad x_1 L_{x1} = 0$$

$$L_{\lambda_1} = x_1 \geq 0 \qquad \lambda_1 \geq 0 \qquad \lambda_1 L_{\lambda_1 1} = 0$$

Then, in general for n variables and m constraints, Lagrange optimization function can be written:

$$L = f\left(x_1, x_2, \ldots\ldots, x_n\right) + \sum_{i=1}^{m} \lambda\left[b_i - g^i\left(x_1, x_2, \ldots\ldots, x_n\right)\right]$$

and corresponding K-T constraints are:

$$L_{xj_1} \leq 0 \qquad x_j \geq 0 \qquad \text{and} \qquad x_j L_{xj} = 0 \qquad (j = 1, 2, \ldots\ldots\ldots, n)$$

$$L_{\lambda i} \geq 0 \qquad \lambda_i \geq 0 \qquad \text{and} \qquad \lambda_i L_{\lambda_1 i} = 0 \qquad (i = 1, 2, \ldots\ldots\ldots, m)$$

beginning every firm receives the initial amount of pollution permits e_i^0 then $\sum e_i^0 = E$ and price P is set up. Afterwards, the firm optimization problem can be transformed into:

$$Min C_i\left(x_i\right) + p\left(e_{f,i} - x_i - e_i^0\right) \tag{11}$$

and consequently the solution derived:

$$C_i'\left(X_i\right) - p \geq 0 \tag{12}$$

$$x_i\left[C_i'\left(x_i\right) - p\right] = 0 \tag{13}$$

$$x_i \geq 0 \tag{14}$$

Based on the comparison of these equations with the initial ones (6) to (10), it is obvious that the solution fulfilling cost minimization condition would be achieved, if the price p will be equal to λ. This equality will be fulfilled under the existence of pure competitive markets, Montgomery (1972).

In the previous text the general assumption regarding homogenous contamination were implemented. However, in the reality many of these pollutions cannot be considered as homogenous ones e.g. organic refuse drained into the watercourse. In this case, the civil agency is concerned in both volume of soiling and also its spatial allocation, because both these factors jointly determinate the final pollution level of ambient air and water in the selected territories. The transformation coefficient indicates the amount of contamination produced at the point i and transformed to the point j. Afterwards, conditions describing pollution concentration at any point j can be reformulated for heterogeneous contamination as follows:

$$A_j = \alpha_j + \sum d_{i,j}\left(e_{f,i} - x_i\right) \tag{15}$$

where α_j are emissions coming from other pollution sources to the place j, $d_{i,j}$ represents individual coefficients of transformation. The optimization task can be rearranged in the following way:

$$Min \sum C_i\left(x_i\right) \tag{16}$$

under condition

$$\alpha_j + \sum d_{i,j}\left(e_{f,i} - x_i\right) \leq A_j \tag{17}$$

where A_j is maximum allowed concentration of pollution at every point j. For simplification, let us suppose the existence of some minimal control (i.e. $x_i > 0$ for every i), then the Kuhn-Tucker condition is following:

$$C_i'\left(x_i\right) - \sum d_{i,j}\lambda_j = 0 \tag{18}$$

Then *MACs* of every resource are equal to weighted average of shadow cost related to the required pollution reduction. In other words, for each point j shadow prices λ_j exists.

CONCLUSION

The aim of this text lays in outlining basic theoretical underpinnings of a very actual issue of tradable pollution permits, which is necessary to gain maximum positive effects by Czech subjects.

In order to ensure broader and deeper understanding of basic theoretical starting points, it is suitable to pay further attention to the two following aspects dealing with market operations and basic pollution permits market model extension. In the case of market acquisitions, the issue of market rules development, tradable permits system implementation, imperfect market competition, secondarily pollution permits trading and so on should be tackled. Possibilities of original model extension are linked for instance to the alternative TTP innovation, the problem of multi polluters etc.

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