CICERO Working Paper 2004:01

Market power with interdependent demand

Sale of emission permits and natural gas from the Former Soviet Union

Cathrine Hagem (Dept. of Economics, University of Oslo)

Steffen Kallbekken (CICERO)

Ottar Mæstad (Institute for Research in Economics and Business Administration, SNF)

Hege Westskog (CICERO)

January 2004

CICERO
Center for International Climate
and Environmental Research
P.O. Box 1129 Blindern
N-0318 Oslo, Norway
Phone: +47 22 85 87 50
Fax: +47 22 85 87 51
E-mail: admin@cicero.uio.no
Web: www.cicero.uio.no

CICERO Senter for klimaforskning
P.B. 1129 Blindern, 0318 Oslo
Telefon: 22 85 87 50
Faks: 22 85 87 51
E-post: admin@cicero.uio.no
Nett: www.cicero.uio.no

Tittel: Market power with interdependent demand: sale of emission permits and natural gas from the Former Soviet Union

Forfatter(e): Cathrine Hagem, Steffen Kallbekken, Ottar Mæstad, and Hege Westskog
CICERO Working Paper 2004:01
11 sider
Finansieringskilde: Stiftelsen for samfunns- og næringslivsforskning (SNF)
Prosjekt: Statoil prosjeketet
Prosjektleder: Cathrine Hagem
Kvalitetsansvarlig: Gunnar Eskeland
Nøkkelord: klimapolitikk, naturgass, markedsmakt, kvoter

Sammendrag:. En del land i Øst-Europa og tidligere Sovjetunionen vil sannsynligvis få muligheter til å utøve markedsmakt i kvotemarkedet dersom Kyoto Protokollen gjennomføres. Dette gjelder i særlig grad Russland. Imidlertid kan det innvendes at siden disse landene også er store eksportører av fossil energi, vil de ikke ha interesse av å bidra til en økt kvotepris gjennom å utnytte markedmakten sin i kvotemarkedet.

I denne artikkelen argumenterer vi for at effekten på kvoteprisen av deres eksport av fossil energi ikke er entydig. En betydelig andel av Russlands eksport av fossil energi er naturgass. En høy kvotepris kan øke etterspørselen etter naturgass ved substitusjon fra mer forurensende fossile energibærere (olje og kull), og dermed øke profitten til naturgasseksportørene. En eksportør av naturgass vil dermed kunne ha økte insentiver til å utnytte markedmakten sin i kvotemarkedet. Videre, vil en stor eksportør av fossil energi kunne bruke sin markedsposisjon til å påvirke etterspørselen etter kvoter og dermed kvoteprisen. Relasjonen mellom inntekt av kvotesalg og fossil energieksport kan dermed gå i begge retninger.

I vår artikkel analyserer vi sammenhengen mellom inntekten fra kvotesalg og fossil energieksport både teoretisk og empirisk. Vi studerer virkningen av en koordinert utøvelse av markedsmakt i de to markedene. Ved bruk av en generell likevektsmodell viser vi at det faktum at det tidligere Sovjetunionen er en stor gasseksportør har liten innvirkning på incentivene til å utøve markedsmakt i kvotemarkedet. Derimot påvirkes det optimale nivået av gasseksport betydelig av en slik koordinering.

Språk: Engelsk

Title: Market power with interdependent demand: sale of emission permits and natural gas from the Former Soviet Union

Author(s): Cathrine Hagem, Steffen Kallbekken, Ottar Mæstad, and Hege Westskog
CICERO Working Paper 2004:01
11 pages
Financed by: Institute for Research in Economics and Business Administration, SNF
Project: The Statoil project
Project manager: Cathrine Hagem
Quality manager: Gunnar Eskeland
Keywords: Climate policy, natural gas, market power, emission permits

Abstract: With implementation of the Kyoto Protocol, the Former Soviet Union countries, and Russia in particular, will most likely be able to exert market power in the emission permit market. However, since these countries are also big exporters of fossil fuels, their incentives to boost the permit price may be weak. However, a significant share of Russia's fossil fuel exports is natural gas. A high permit price may boost the demand for natural gas through substitution from more polluting fuels and thus increase gas profits. Therefore, being a natural gas exporter may increase the incentives to exert monopoly power in the permit market. Moreover, a large fossil fuel exporter may use its market position to influence the effective demand for permits. Hence, the relationship between permit income and fossil fuels exports runs in both directions. We explore the interdependence between the revenues from permit and fossil fuel exports both theoretically and empirically. A numerical general equilibrium model finds that the fact that the Former Soviet Union is a big gas exporter has a negligible effect on the incentives to exert monopoly power in the permit market. However, there are significant impacts on the optimal level of gas exports.

JEL classification: Q4, D58, L12, Q28, Q48.

Language of report: English

Rapporten kan bestilles fra:
CICERO Senter for klimaforskning
P.B. 1129 Blindern
0318 Oslo

Eller lastes ned fra:
http://www.cicero.uio.no

The report may be ordered from:
CICERO
PO Box 1129 Blindern
0318 Oslo, NORWAY

Or be downloaded from:
http://www.cicero.uio.no

Contents

1 Introduction 1
2 A simple theoretical model 2
2.1 COMPETITIVE PERMIT MARKET 4
2.2 UNCOORDINATED MARKET POWER 5
2.3 COORDINATED MARKET POWER 5
3 A numerical general equilibrium model 6
4 Results and discussion 7
4.1 COMPETITIVE PERMIT MARKET 8
4.2 UNCOORDINATED MARKET POWER 8
4.3 COORDINATED MARKET POWER 9
5 Concluding remarks 10

1 Introduction

The Kyoto Protocol requires that the average annual emissions of a basket of six greenhouse gases in the industrialized countries do not exceed 95 per cent of 1990 emissions in the period 2008-2012[1]. The Kyoto Protocol allows for emission permit trading among the Annex B countries. Some countries may become large sellers and buyers and thus be in a position to exercise market power in the permit market. As pointed out by Hahn (1984), the degree of market power in the permit market depends on the initial allocation of permits. The literature suggests that Russia and other Eastern European countries will become large exporters of permits (see e.g. Weyant and Hill (1999) and Weyant (1999)). It is therefore likely that the FSU countries will be able to exercise some market power in the emission permits market. Several studies show that the FSU can significantly increase its benefit of the agreement by restricting its supply of permits (e.g., Böhringer (2002), Bernstein *et al.* (1999)).

One issue that has received little attention in the discussion about monopoly power in the permit market is the fact that FSU is also a large exporter of fossil fuels. According to IEA (2001a, 2001b), the FSU annually exports 9.9 TJ natural gas and 165 Mt crude oil. Measured in CO_2 equivalents, the oil and gas exports each amounts to some 500 $MtCO_2$. This is the same order of magnitude as the expected permit exports from the FSU (e.g. Holtsmark, 2003). To the extent that high permit prices reduce the demand for fossil fuels, the incentives for the FSU to sustain high permit prices may be rather weak (Bernard *et al.* (2003)). On the other hand, as pointed out by Hagem and Mæstad (2002) and Holtsmark (2003), high permit prices may induce substitution from coal and oil towards gas, making the effect of permit prices on the effective gas demand more ambiguous.

A second issue that has been neglected in previous literature is that the relationship between permit income and income from fossil fuel exports goes in both directions. It is not only the case that the price of permits affects the effective demand for fossil fuels. The price of fossil fuels will also affect the demand for emission permits; low fuel prices and high fuel demand will increase the demand for permits and thus increase the potential income from permit exports. This relationship between fuel exports and permit prices can of course only be profitably utilised by countries with market power in the fossil fuel markets. The FSU enjoys such market power in the natural gas market; Russia's share of the European gas market is 42% (IEA, 2001a). Moreover, Hagem and Mæstad (2002) calculate that the combustion of gas in the European gas market will cause around 20% of total greenhouse gas emissions in all industrialised countries in 2010 (excluding the USA). The effect of gas market policies on permit prices may therefore be significant.

This paper explores the incentives of the FSU to exert monopoly power in the permit market while taking into account the fact that the demand for permits and the demand for natural gas are interdependent. Not only does the permit price affect the demand for natural gas, the price of gas also affects the demand for emission permits.

With interdependent demands, there is an externality between the profit of the permit exporter and the profit of the gas exporter as long as they are organised as separate economic units. There are several ways of internalising this externality. Moe and Tangen (2000) pointed out that it is not unlikely that the Russian authorities will allocate a substantial share of the country's emission permits to various commercial agents. They also argue that the dominating

[1] USA and Australia have chosen not to ratify the Protocol, and the entering into force of the Protocol hinges on Russian ratification. The agreement will not enter into force until it has been ratified by at least 55 countries which together contribute at least 55 percent of the industrialized world's greenhouse emissions in 1990.

Russian gas producer, Gazprom, may be left in control of a large share of Russia's permits. Such allocation rules will at least partially internalise the externality caused by interdependent demands. A slightly different solution, which will be explored in this paper, is to grant the gas exporter an exclusive right to export permits. If the gas exporter wants to export permits, it will then first have to buy the permits in the domestic market. In this way, the permit rent can be distributed across several sectors of the economy, at the same time as the externality between permit export and gas export is internalised.

We find that the internalisation of the externalities caused by interdependent demands of natural gas and emission permits does reduce the optimal permit price, but the effect is insignificant. Hence, our analysis supports the conclusion that the FSU will indeed utilise its market power in the permit market, despite being a large fossil fuel exporter. This conclusion might not have been equally strong if we had also included the effect of high permit prices on FSU's profits from oil exports. However, it is extremely difficult to forecast the changes in the producer price of oil in the wake of climate policies due to unpredictable OPEC behaviour. If the OPEC countries do not change their target producer price after the implementation of climate policies, there is no reason to worry about our model not including the oil sector. Our analysis also shows that the optimal export level of gas from the FSU is strongly affected by the interdependence between the gas and the permit markets.

The analysis will proceed as follows: In Section 2, we present a theoretical model that demonstrates the interdependence between the demand for fossil fuels and the demand for emission permits. The optimal strategies for a monopoly fossil fuel exporter and a monopoly permit exporter are characterised both when these agents operate as separate economic units and as one integrated unit. The theoretical analysis will show that the effect of integration on the price of permits is ambiguous. Hence, numerical analysis is required. Section 3 presents a numerical general equilibrium model. The model is a variant of the GTAP-EG model, but it is extended by including market power both for the FSU permit exporter and for the FSU gas exporter. Our results are discussed in Section 4. We focus on 1) how the optimal permit price and the optimal gas export are influenced by the ability of permit exporters and gas exporters to influence the price of emission permits, and 2) how the integration of gas and permit exports into one single economic unit will affect the optimal permit price and gas exports. Section 5 concludes.

2 A simple theoretical model

This section presents a theory for interrelated demands between a fossil fuel and emission permits. The purpose of the model is to illuminate some of the important mechanisms that are at play in the numerical simulations that will follow.[2]

We assume that there is one country that is a monopoly exporter of emission permits y and a monopoly producer of a fossil fuel x_g (which for convenience is called gas).[3] Gas is a substitute with alternative fuels, represented by x_a.[4] The inverse fuel demand function is given by

---

[2] The model is a simplified version of the model presented in Hagem and Mæstad (2002). While Hagem and Mæstad (2002) include oligopolistic behaviour in the fossil fuel market, the model presented here has one single monopoly fossil fuel exporter.

[3] The numerical model includes other gas and permit sellers as a competitive fringe.

[4] In reality, as well as in our numerical simulations, there are several alternative fuels with different emission intensities. It is however enough to include one such alternative fuel in order to illustrate the central mechanisms of the model.

$$p_i = p_i(x_i, x_j) \quad i, j \in (g, a), \tag{1}$$

with the assumed properties $\partial p_i / \partial x_i < 0$ and $\partial p_i / \partial x_j \leq 0$.

The consumption of one unit of gas causes e_g units of greenhouse gas emissions, while the emission factor of the alternative fuel is e_a. An international environmental agreement à la the Kyoto Protocol defines upper bounds on the emissions of greenhouse gases in each of the participating countries. Emission permits are traded internationally at the permit price q. A positive permit price implies a downward shift in the inverse demand function of fuels. Producers are then faced with the following effective inverse demand functions (or producers' prices)

$$p_i(x_i, x_j) - e_i q, \qquad i,j \in (a,g), \quad i \neq j \tag{2}$$

The market for the alternative fuel is assumed to be perfectly competitive. The equilibrium quantity is then found where the "producer price" given by (2) equals the marginal costs of production. We characterize the equilibrium in the market for the alternative fuel in a reduced form as follows

$$x_a = x_a(x_g, q) \tag{3}$$

The equilibrium quantity of the alternative fuel x_a will decline with the gas volume x_g because the fuels are substitutes (i.e., $\partial x_a/\partial x_g \leq 0$). A higher permit price will also reduce the quantity of the alternative fuel (for a given level of x_g) as long as the emission factor e_a is positive (i.e., $\partial x_a/\partial q \leq 0$).

The demand for emission permits faced by the permit exporter can be divided into two components. First, there is permit demand generated by gas consumption and consumption of the alternative fuel (i.e., $e_a x_a + e_g x_g$). Second, there is the residual permit demand from all other emission sources in the participating countries, represented by the demand function $d(q)$. The residual permit demand is assumed to decline with the price of permits ($d_q < 0$). The net demand for emission permits faced by the permit exporter is then $e_a x_a + e_g x_g + d(q) - Q$, where Q is the total emission quota allocated to the participating countries (except the permit exporting country).

Let $c(y)$ be the costs of generating y units of permits for export. The profit from permit exports, π_p, is then

$$\pi_p(y) = qy - c(y) \tag{4}$$

The shape of the cost function is determined by the initial allocation of permits to the monopoly permit exporter, and by its abatement costs. Due to a high initial allocation of permits to the FSU in the Kyoto Protocol, the FSU may be able to export a certain amount of permits at zero costs. Exports beyond this amount will require domestic abatement.

The equilibrium condition in the market for emission permits can now be formulated as

$$e_a x_a(x_g, q) + e_g x_g + d(q) - Q = y \tag{5}$$

Eq. (5) defines the equilibrium permit price as a function of the total gas consumption and the Russian supply of emission permits, $q = q(x_g, y)$. The equilibrium permit price is a decreasing function of permit supply (i.e. $\partial q/\partial y < 0$). The sign of $\partial q / \partial x_g$ is however ambiguous. Higher gas exports will increase the demand for permits if there are no alternative fuels or if the alternative fuels are less emission intensive than natural gas. However, if the alternatives are more polluting than gas, higher gas production will reduce in the consumption of these alternatives, which implies that the demand for emission permits may fall.[5]

The profit of the gas producer, π_g, can now be defined as a function of the gas production quantities and the supply of permits. Marginal production costs have been normalised to zero.

$$\pi_g(x_g, y) = (p_g(x_{g,} x_a) - e_g q)x_g = (p_g(x_g, x_a(x_g, q(x_g, y))) - e_g q(x_g, y))x_g \tag{6}$$

Profit maximizing behaviour will determine the optimal gas quantity as a function of the level of permit exports ($x_g = x_g(y)$).

The optimal strategies for the gas and permit exporters will depend on the organisation of the activities. In the first stage of our analysis, we treat them as separate agents that maximise their respective profits independently. We call this the case of *uncoordinated* market power. In the second stage, we treat the gas and permit exporters as one integrated unit that maximises the joint profit. This is the case of *coordinated* market power. As a point of reference, however, we start by presenting the optimal solution in the case of a competitive permit market. This is useful, because we want to investigate whether the effect of coordination on the permit price is large or small relative to the standard monopoly effect.

2.1 Competitive permit market

With a competitive permit market, there is no difference between the uncoordinated and the coordinated solutions, since all agents take the permit price as given. Assuming that the gas producer has market power in the gas market, the first order conditions for profit maximisation are as follows:

$$\frac{\partial \pi_p}{\partial y} = q - c' = 0 \tag{7}$$

$$\frac{\partial \pi_g}{\partial x_g} = p_g - e_g q + \left(\frac{\partial p_g}{\partial x_g} + \frac{\partial p_g}{\partial x_a}\frac{\partial x_a}{\partial x_g}\right)x_g = 0 \tag{8}$$

[5] See Hagem and Mæstad (2002) for a more thorough discussion of the price derivatives.

Eq. (7) states that with perfect competition in the permit market, the permit price will equal marginal abatement costs. Eq. (8) is simply the standard monopoly condition including the cross-price effect through substitution with alternative energy sources.

2.2 Uncoordinated market power

With market power in both the permit market and the gas market, and with the permit and gas exporters operating as separate economic units, the first order conditions are:

$$\frac{\partial \pi_p}{\partial y} = q - c' + \frac{\partial q}{\partial y} y = 0 \tag{9}$$

$$\frac{\partial \pi_g}{\partial x_g} = p_g - e_g q + \left(\frac{\partial p_g}{\partial x_g} + \frac{\partial p_g}{\partial x_a} \frac{\partial x_a}{\partial x_g} \right) x_g + \frac{\partial q}{\partial x_g} \left(-e_g + \frac{\partial p_g}{\partial x_a} \frac{\partial x_a}{\partial q} \right) x_g = 0 \tag{10}$$

Eq. (9) shows that the optimal permit exports are now given by the standard formula for a monopolist's supply, where marginal revenue from permit exports equals marginal abatement costs. For a given level of gas sales, the level of permit exports is reduced in order to raise the permit price and extract the monopoly rents.

The effect on the gas market equilibrium of gas producers being able to influence the permit price is more ambiguous, though. The effect via the permit price is captured by the last term in eq. (10). The expression within the brackets, $\left(-e_g + \frac{\partial p_g}{\partial x_a} \frac{\partial x_a}{\partial q} \right)$, represents the effect of increased price of emission permits on the producer price of gas. The term $-e_g$ reflects the direct, negative impact of higher permit price on the producer price of gas. The other term, $\frac{\partial p_g}{\partial x_a} \frac{\partial x_a}{\partial q}$, is the indirect effect on the producer price of gas via substitution with the alternative fuel as the permit price changes. If increased gas export increases (reduces) the permit price ($\partial q / \partial x_g > 0 \; (< 0)$), this term is positive (negative). Hence, on theoretical grounds we can determine neither the effect of increased gas production on permit prices nor the effect of changes in the permit price on the producer price of gas.

2.3 Coordinated market power

With coordination the emission and permit exporters maximise their joint profit $\pi = \pi_p + \pi_g$. The first order conditions are as follows:

$$\frac{\partial \pi}{\partial y} = q - c' + \frac{\partial q}{\partial y} y + \frac{\partial q}{\partial y} x_g \left(-e_g + \frac{\partial p_g}{\partial x_a} \frac{\partial x_a}{\partial q} \right) = 0 \tag{11}$$

$$\frac{\partial \pi}{\partial x_g} = p_g - e_g q + \left(\frac{\partial p_g}{\partial x_g} + \frac{\partial p_g}{\partial x_a} \frac{\partial x_a}{\partial x_g} \right) x_g^R + \frac{\partial q}{\partial x_g} \left(-e_g + \frac{\partial p_g}{\partial x_a} \frac{\partial x_a}{\partial q} \right) x_g + \frac{\partial q}{\partial x_g} y = 0 \tag{12}$$

By comparing equations (9) and (10) with equations (11) and (12), we realise that coordination affects the behaviour of both the permit and the gas exporter. The new term in eq. (11) reflects the marginal effect of permit exports y on gas profits, while the new term in eq. (12) refers to the marginal effect of gas exports on permit export revenues. As pointed out in the discussion above, the signs of these additional terms are ambiguous. The equilibrium effects of coordinating the decisions of gas and permit exports are therefore ambiguous. Since it is unclear whether a higher permit price will increase or reduce the producer price of natural gas, coordination may either increase or reduce the optimal mark-up on emission permits. Also, since higher gas exports have an ambiguous impact on the price of emission permits, coordination may either increase or reduce the optimal gas export volume. These ambiguities call for further analysis through numerical simulations.

3 A numerical general equilibrium model

We construct a numerical general equilibrium model in order to explore the mechanisms elaborated above. The model is based on the GTAP-EG model (Rutherford and Paltsev 2000), which is a static multi-regional model. The data-input to the model is the GTAP-EG dataset, which is a reconciled database of the Global Trade Analysis Project (GTAPv5) database, and International Energy Agency (IEA) energy statistics. The GTAP database contains production and bilateral trade flow data for 1997. Unfortunately, the database does not allow us to distinguish the countries of the Former Soviet Union from each other, so that while our interest lies primarily with Russia, we have to deal with the region as a whole in our model.

While the model contains data for 1997, we want to run scenarios for the Kyoto commitment period 2008-2012 (using 2010 as a representative year). The emission projections that we use were generated by the Oxford Model for Climate Policy Analysis (Bartsch and Müller 2000) and certain unpublished data from that model.[6] Because we use a static model, we need to assume that the structure of the economy does not change between 1997 (for which we have data) and 2010 (for which we have emission projections), and to scale the required 2010 emissions reductions to the 1997 emissions[7].

The model has 22 world regions and 7 commodities (coal, crude oil, natural gas, petroleum products, electricity, energy intensive goods, and other goods).

The model is an Arrow-Debreu general equilibrium model in Mathiesen format (Mathiesen 1985), and it is programmed in GAMS-MPSGE. There are two principal agents in the model - producers and consumers (representative agents).

Production is divided into fossil fuel and non-fossil fuel production, which have different nesting structures (see Appendix). The output of fossil fuel production is a CES aggregate of a natural resource input and a non-resource input. The non-resource input is a Leontief composite of labour and intermediates. Non-fossil fuel production has a structure where the output is a Leontief composite of intermediate non-energy goods and a four level CES aggregate of energy (coal, oil, natural gas and electricity) and primary factors (capital and labour).

The representative consumer, who is endowed with all primary factors, allocates its income between investment and private demand. Private demand is derived from utility maximising behaviour, where utility is a constant elasticity aggregate of non-energy and energy

[6] Personal communication: A. Aaheim, 2002, Researcher CICERO, Oslo.

[7] Because of this scaling the absolute numbers in the model will be misleading. We therefore report only relative changes.

consumption. Both intermediate demand and final demand are modelled through an Armington aggregation of domestic and imported goods.

We have kept the production trees and all elasticities of substitution as in the original GTAP-EG model (see Appendix).

We have extended the GTAP-EG model in two areas, by including emissions trading and by introducing market power in the FSU permit exports as well as in the FSU gas exports.

We assume that the Kyoto protocol is implemented through an international emissions trading scheme, such that emissions of CO_2 from the production and use of fossil fuels require emission permits[8]. In the model this is represented through a zero elasticity of substitution (Leontief technology) between the fossil fuel and the emission permit inputs to the production (intermediate and final energy demand). The amount of permits required for each unit of fossil fuel is determined through emission coefficients, which are implemented in the GTAP-EG model, and which are calibrated to actual emission in 1997.

Each region is given an endowment of tradable emission permits. The size of the endowment is equal to the Kyoto commitment of the region. The market is modelled as an international emission permits trading pool – where all regions initially sell their permits, before the sectors in each region purchase the permits that they need – at a world price.

Market power is exercised by the FSU in the permit and gas export markets. Market power is implemented by letting the model search simultaneously for the two optimal mark-ups by iterating through the various equilibria until the maximal profits are found. [9] The effect of a mark-up in this setting is similar to an export tax. Our formulation implies that domestic gas and permit prices in the FSU are equal to marginal production costs, where the marginal costs of producing permits for export are equal to the domestic marginal abatement costs.

4 Results and discussion

We use the model to explore the two main questions: 1) what does market power imply for the optimal permit price when there is market power in the gas market and gas producers also take the effect on permit prices into account? 2) what are the effects of coordinating the gas and permit exports from the FSU?

The model was used to run three principal scenarios. In the first scenario, “competitive”, there is a competitive permit market, while the FSU has market power in the international gas market. We use this scenario as a point of reference for the second scenario, “uncoordinated market power”. In this scenario, both permit producers and gas producers take into account the effect of their decisions on permit prices. But since they do not take into account the effect of the permit price on each other profits, there is an externality between the gas sellers and the permit sellers. In the third scenario, “coordinated market power”, this externality is internalised by choosing the export quantities that maximise the joint profit of permit and gas sellers. The results are summarised in table 1.

[8] The model includes no other greenhouse gases than CO_2 . Furthermore, no sinks are included, nor are there any emission reductions through the Clean Development Mechanism.

[9] In order to preclude the possibility of finding only a local optimum, we start the iterations from both extremes of possible markups/prices in both markets.

4.1 Competitive permit market

We use the "competitive" scenario as a baseline throughout the paper. Therefore, all marginal costs – which are equal to the prices in all markets but the international gas market – in the competitive case are normalised to one. In the export market for gas, the producer price will be equal to marginal cost plus a markup.

In addition to prices and quantities, the markup profit (not the revenue) from the gas market, is also normalised to one. In the rest of this paper, all results are reported as changes relative to this scenario.

The table shows that in the competitive scenario the gas exporter chooses a 61% markup. The producer price on gas exports will therefore be 1.61. The FSU exports 29.9% of its total emission allowances. The FSU's market share in the international permit market is then 64%, suggesting a considerable potential for exercising monopoly power.

4.2 Uncoordinated market power

In the "uncoordinated" scenario, we introduce market power in the international permit market. This causes a set of adaptations. The optimal markup on permits is 300%. With a 300% markup the international permit price increases by 24% to 1.240. Permit exports are almost halved; only 16.1% of the total FSU allowances are now exported. The profit from permit market exports is large. We have normalised the permit market profit relative to the profit from gas exports in the competitive case. The permit market profits are then 2.758.[10]

When the permit price changes, the demand for gas is affected. As discussed in section 2, whether a higher permit price leads to a positive or a negative shift in the inverse demand function for gas is an empirical question. One possible outcome is that, since gas is less emission intensive than other fossil fuels, there is a positive effect on the producer price of gas through the substitution from other fossil fuels towards gas. However, it turns out that in our model, on aggregate, the increased international permit price has a negative effect on the (export) demand for gas. As a response to the exogenous negative shift in the inverse demand function for gas, it is optimal for the gas producer to reduce its gas exports. In addition, before choosing a new export level, the gas producer will take into account the possibility to influence the producer price of gas through the price of permits. Since a higher permit price leads to a decrease in gas profits, the gas producer has an incentive to reduce its gas supply as that causes the permit price to fall. This result is shown in test runs with the model. In equilibrium, total FSU gas exports have declined by as much as 10.4%.

Since the permit exports have decreased, more permits are sold on the domestic market, and the domestic permit price falls to 0.310. This leads to a strong increase in the domestic demand for gas in the FSU (14.1%). The total effect on gas production in the FSU is an increase by 8.8%. Since gas production expands, we move up along the marginal cost curve, and the marginal cost of gas production increases to 1.112. In the new equilibrium the optimal markup on gas exports is 49%, and this gives a producer price on gas exports of 1.657. The possibilities to influence permits prices reduce the profits of the gas exports to 0.846. The combined profits in the permit and gas markets are then 3.604.

[10] Though the absolute numbers can be misleading, it might be useful to get some sense of the absolute size of the permit revenue; Permit revenues account for around 1.7% of GDP, and using the 1997 GDP for FSU, that would be about US$ 10 billion.

Table 1: Results

Parameter	"Competitive"	"Uncoordinated"	"Coordinated"
Permit market			
Domestic price	1.000	0.310	0.321
International price	1.000	1.240	1.236
Markup	0 %	300 %	285 %
Exports (of FSU quota)	29.9 %	16.1%	16.5%
Profits	0	2.758	2.776
Gas market			
Domestic price (=mc)	1.000	1.112	1.118
International price	1.61	1.657	1.554
Markup	61 %	49 %	39 %
Gas exports	1.000	0.896	0.959
Profits	1.000	0.846	0.838
Total profits	1.000	3.604	3.614

4.3 Coordinated market power

With the "coordinated" scenario we can explore the effects of internalising the externalities caused by interdependent demands and imperfect competition in the permit and gas markets. Since an increase in the international permit price decreases the profits from the gas exports (as reported above), and as an increase in the gas (export) supply leads to a higher international permit price (shown in test runs with the model), coordination of the market power implies a larger export of both permits and gas. The increased permit supply (which produces a lower international permit price), will increase the foreign demand for gas, and the increased supply of gas will increase the price received for the permits exported. The joint agent chooses to lower the markup on permits to 285%, and the markup on gas to 39%.

This results in a small decline in the international price of permits from 1.240 to 1.236. Hence, we conclude that taking into account the effect on gas profits has a negligible effect on FSU's incentives to exert market power in the permit market. Compared with the uncoordinated case, the export of permits increases by only 2.5% in our model runs.

Our results are qualitatively the same as those obtained by Holtsmark (2003), but the magnitudes are much smaller in our study. A likely explanation for this divergence is our finer sectoral disaggregation. As argued by Holtsmark, the tax structure on fossil fuels in Europe, with high taxes on oil and low taxes on gas, implies that higher permit prices may cause substitution from gas to oil, despite the fact that gas is a cleaner fuel. Although this effect may show up in aggregate models, like the one used by Holtsmark, we expect it to be much weaker in disaggregate models. The reason is that in sectors where substitution between oil and gas is most likely to take place (e.g., the electricity sector), oil is not as heavily taxed as in the transport sector, where the substitution possibilities are much weaker. Hence, high permit prices will have a more positive impact on gas demand in a disaggregated analysis, which may explain why we find that coordination has a negligible effect on the optimal permit price.

Coordination increases the profits from the permit exports slightly to 2.776 (up 0.65%). The first move of the permit agent is to export more permits than would have been optimal if it was not for the coordination policy. The isolated effect of this increase in exports would be to decrease the profits from this market. However, because the gas agent also increases exports, and because increased gas exports lead to an increase in the permit price, the final outcome is an increase in the profits from the permit market.

Coordination affects gas exports significantly (up 7.0%). Domestic gas sales in the FSU fall only slightly (due to the increased domestic permit price). Still, the total FSU gas production increases, and again we move up along the marginal cost curve. While the domestic gas producer price (marginal cost) increases to 1.118, the export gas producer price decreases due to lower mark-up. Mark-up profits from the gas market are now 0.838. This is a decrease of 1% from the uncoordinated scenario.

The combined profits from the two markets are 3.614. This is an increase of only 0.28% from the uncoordinated case. However, the small change in total profits hides some larger (but opposing) changes. First, the overall increase in profits is the result of a somewhat larger increase in profits from the permit market – which is partially offset by a smaller decrease in profits from the gas market. Export volume effects are greater though, especially in the gas market where exports are up by a significant 7.0%.

These results reveal that the absolute and marginal profits from the permit market are greater than those from the gas market. Gas market profits are “sacrificed” in order to increase the permit market profits.

5 Concluding remarks

In this paper we have explored the incentives of the FSU to exert market power in the international emission permit market while taking into account 1) that the FSU is a large natural gas exporter, 2) that the FSU has market power in the European gas market, and 3) that the optimal exercise of market power is interdependent between the two markets. We find that the FSU has a strong incentive to restrict its permit supply in order to drive up the permit price. Being able to influence permit prices also has a strongly negative impact on the optimal level of natural gas export from the FSU. This reduction in exports is caused by three factors: first, that a higher price on emission permits reduces the demand for natural gas; second, that higher gas sales reduce the producer price of gas through a higher permit price, and third, that domestic gas demand increases in the FSU as the domestic permit price falls. Furthermore, the interdependency between the permit exporter and the gas exporter has only a negligible impact in the optimal mark-up in the permit market. However, export of natural gas increases significantly as gas producers take into account the positive effect on permit prices of higher gas exports.

Our results are, of course, specific to the scenarios that we have chosen. The emission projections have a very significant bearing on the extent of FSU market power – because they determine how many permits the FSU will be able to sell at a given price. Also, the model parameters, such as the substitution elasticities, will affect the outcome.

There is scope for further empirical work on theses issues. One possible extension would be to model an oligopoly in the gas market. Then, the coordination of gas and permit exports might give the FSU strategic advantages or disadvantages vis-à-vis other gas producers. With such strategic effects, it is no longer obvious that it is profitable to coordinate the decisions of the gas and permit exporters in the FSU (see Hagem and Mæstad, 2002).

References

Bartsch, U. and B. Müller, 2000, Fossil Fuels in a Changing Climate - Impacts of the Kyoto Protocol and Developing Country Participation, Oxford University Press, Oxford.

Bernard, A., S. Paltsev, J. Reilly, M. Vielle and L. Viguier, 2003, Russia's Role in the Kyoto Protocol. Discussion paper, MIT Joint Program on the Science and Policy of Global Change.

Bernstein, P. M., W. D. Montgomery, T. Rutherford, and G.-F. Yang, 1999, Effects of Restricting International Permit Trading: The MS-MRT model, The Energy Journal, Special Issue, 221-256.

Böhringer, C., 2002, Climate Politics from Kyoto to Bonn: From Little to Nothing? The Energy Journal 23, 51-73.

Hagem C. and O. Mæstad, 2002, Market power in the market for greenhouse gas emission permits - the interplay with the fossil fuel markets, Working Paper 2002:08, CICERO, Oslo, Norway.

Hahn, R. W., 1984, Market Power and Transferable Property Rights, Quarterly Journal of Economics 99, 753-765.

Holtsmark, B., 2003, Russian behaviour in the market for permits under the Kyoto Protocol, Climate Policy **3**, 399-415.

IEA, 2001a, Gas Information, OECD/IEA, Paris.

IEA, 2001b, Oil Information, OECD/IEA, Paris.

Mathiesen, L., 1985, Computational Experience in Solving Equilibrium Models by a Sequence of Linear Complementarity Problems, Operations Research **33**, 1225-1250.

Moe, A. and K. Tangen, 2000, The Kyoto Mechanisms and Russian Climate Politics, The Royal Institute of International Affairs, London.

Weyant, J. (ed.), 1999, The Costs of the Kyoto Protocol: a Multi-Model Evaluation, The Energy Journal, Special Issue, International Association for Energy Economics.

Weyant, J. and J. Hill, 1999, Introduction and Overview, in Weyant, J. (ed.), The Costs of the Kyoto Protocol: a Multi-Model Evaluation, The Energy Journal, Special Issue, International Association for Energy Economics.