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**Tax Shifting in Long-Term Gas Sales Contracts**

by

**Frank Asche**  
**Petter Osmundsen**  
**Ragnar Tveterås**

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# Tax shifting in long-term gas sales contracts<sup>\*</sup>

Frank Asche\*, Petter Osmundsen\*\* and Ragnar Tveterås\*\*

\* Stavanger University College / Norwegian School of Economics and Business Administration

\*\* Stavanger University College / Institute for Research in Economics and Business Administration

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## Abstract

Producers or consumers faced with an increase in taxes are usually able to shift parts of it to other levels in the value chain. We examine who are actually bearing the burden of increased taxes on natural gas in the EU-area - consumers or exporters. Strategic trade policy and cross-border consumer tax shifting are of particular interest, as the EU-area increasingly is a net importer of gas. Traditional tax incidence theory presumes spot markets. Natural gas in the EU-area, however, is to a large extent regulated by incomplete long-term contracts. Still, spot market forces could be indicative for tax shifting, by determining the ex post bargaining power in contract renegotiations. By examining tax shifting in gas sales data we test whether this is the case. To investigate tax incidence, we estimate natural gas demand elasticities for the household sector in EU countries as well as a reduced form import equation. We test whether gas import prices, which are predominantly determined by long-term contracts, have been influenced by end-user tax shifts.

Keywords: Energy Markets, Incomplete Contracts, Tax Incidence  
Jel class.no.: K12, L72, Q48, H23, G18, D63,

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## 1. Introduction

Energy taxes are imposed for fiscal and environmental reasons, both of which are much in focus in the EU-area due to Kyoto-requirements for reducing emissions and the EMU fiscal requirements of limiting deficits.<sup>1</sup> Deregulation of energy markets in the EU-area induces market shifts that call for a recalculation of energy taxes. One type of such shifts is reduced profit margins in transmission and distribution. Energy taxes are also discussed in relation to energy security in the 2000 EU Green Paper. A proposal is put forward for a tax on oil, gas and nuclear energy to finance a fund for start-up investments for renewable energies

The EU-countries are net importers of energy. According to the 2000 Green Paper the EU area is importing 60 per cent of its gas consumption and 90 per cent of its oil consumption, and the import shares are increasing. New economic trade theory (strategic trade theory) derives optimal commodity taxes for an importing country, from a fiscal perspective.<sup>2</sup> An insight from this theory is that a net importing country to some extent may improve its terms of trade (reduce the exporters' profit margins) by imposing commodity taxes (energy taxes), and also capture parts of the resource rent.<sup>3</sup> There are also factors that limit such taxes. With an increasing mobility of the corporate tax base, national energy taxes must be competitive - compared to other countries or regions – in order to prevent firms from moving elsewhere.<sup>4</sup> This is a matter of tax revenue and employment. As for households, energy taxes are prone to be degressive, i.e., to have adverse distributional effects, since a low-income household typically spends a large share of its budget on heating and transportation.

The "double dividend" literature<sup>5</sup> examines the hypothesis that a government can obtain two gains by increasing energy taxes: (a) an environmental gain, and (b) increased revenues, that may be used to reduce other distortive taxes and thereby yield an efficiency gain. An objection that has been put forward to this theory is that the result must hinge on

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<sup>1</sup> If correctly designed, an energy tax may correct for marginal environmental damage (Pigouvian tax). However, the same aim may be achieved by using emission regulations or quotas. Tradable quotas are particularly suited as a cost-effective way to reduce global warming. If emission quotas are sold or auctioned, these may also generate similar revenue as energy taxes.

<sup>2</sup> See, e.g., Debashis and White (1998).

<sup>3</sup> To calculate optimal commodity taxes the importing country needs knowledge of supply elasticities, demand elasticities and cross price elasticities for alternative sources of energy (substitutes).

<sup>4</sup> See, e.g., Zodrow and Mieszkowski (1986), Osmundsen, Hagen and Schjelderup (1998), and Olsen and Osmundsen (2000).

<sup>5</sup> See, e.g., Pezzy and Park (1998).

cases where the tax design was not optimal in the first place, and that a re-design of taxes therefore is not particular to energy taxes.

Tax incidence of oil taxes adheres to classical incidence theory, since oil to a large extent is traded on spot terms. Being traded on long-term contracts, tax incidence of natural gas is partly determined by the terms of these contracts and partly settled by renegotiations. Our focus in this paper is on tax incidence for natural gas, i.e., on whom is actually bearing the burden of natural gas consumer taxes.<sup>6</sup> Gas is of particular interest as this is an energy source with an increasing market share and since producers to a large extent are locked in (in the short run) as market access is determined by infrastructure and pipeline capacity. Moreover, since a large part of the natural gas consumed in the EU is imported, strategic trade policy and cross-border tax shifting are also of interest. To address these issues we combine contract theory, public economics and empirical analyses. We survey standard tax incidence theory, which is based on spot trading. This is illustrative for the oil market. Thereafter, we address gas supplies which contain interesting theoretical issues due to the supply structure, i.e., tax shifting in the context of long-term supply contracts. Tax incidence is now determined by renegotiations of incomplete supply contracts, an issue not covered by existing incidence theory.<sup>7</sup>

According to partial tax incidence analyses it is vital to estimate supply and demand elasticities to obtain information on incidence. We estimate demand elasticities for natural gas on a country panel of EU household sector data. To analyse tax incidence, it is important to establish demand elasticities in each country. A Bayesian “shrinkage” estimator is employed, which allows us to obtain country-specific elasticity estimates despite the limited number of observations available on each country. The advantage of this approach is that it avoids the homogeneous slope coefficient “straightjacket” of conventional econometric panel data models, and at the same time provides much more reasonable parameter estimates compared to separate econometric regressions on each country time series. A dynamic econometric demand model is specified since customers are likely to have larger substitution opportunities in the long run. In addition to the partial incidence effects, general equilibrium effects in energy markets must be considered. The relevant second-order effects are in our case primarily determined by cross-price elasticities, which we estimate. Traditional tax incidence

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<sup>6</sup> Policy implications of this issue are previously surveyed, e.g., by Austvik (1997). We extend his discussion by addressing theoretical aspects of energy tax incidence, and by undertaking empirical analyses to shed light on actual incidence in the OECD-area.

<sup>7</sup> See, e.g., Hamilton (1999), Itaya (1995), and Kotlikoff and Summer (1987).

models – market incidence models - presume spot trading. This is descriptive of the oil market. In this setting, most of the taxes are borne by inflexible market participants that are unable to escape the tax. Thus, for a given supply elasticity, a larger share of the tax will be borne by the consumers the lower is their demand elasticity.

Presently, the dominant share of natural gas in the EU-area is not traded on spot terms, but rather on long-term supply contracts. The UK, however, has had an active spot market for gas for some years. Recently, a spot market has developed in Zeebrugge, after the completion of the Interconnector gas pipeline between the UK and the Continent. But the prices tend to follow the prices set in the long-term contracts. Since there is still available capacity (call options) in the long-term contracts, they represent the marginal source of supply and thereby dictate prices. The traditional (spot market) tax incidence models are not directly valid in a setting of long-term contracts. Tax shifting is now instead determined by the contractual terms and the system for renegotiations. We let contract incidence denote tax shifting regulated by contracts as opposed to determined by spot markets. Still, spot market forces may affect underlying bargaining power in contract renegotiations, and thus be indicative for contract tax incidence. To ascertain tax incidence for natural gas import prices, we specify and estimate a reduced form equation. The actual contract incidence is compared to the spot incidence predicted by classical incidence theory.

## 2. Tax incidence

Basic insights from tax incidence theory may be derived in a simple partial and static model. An energy tax,  $\tau$ , introduces a wedge between prices to be paid by the consumers,  $P_c$ , and prices received by the producers,  $P_p$ :

$$(2.1) \quad P_c = P_p + \tau,$$

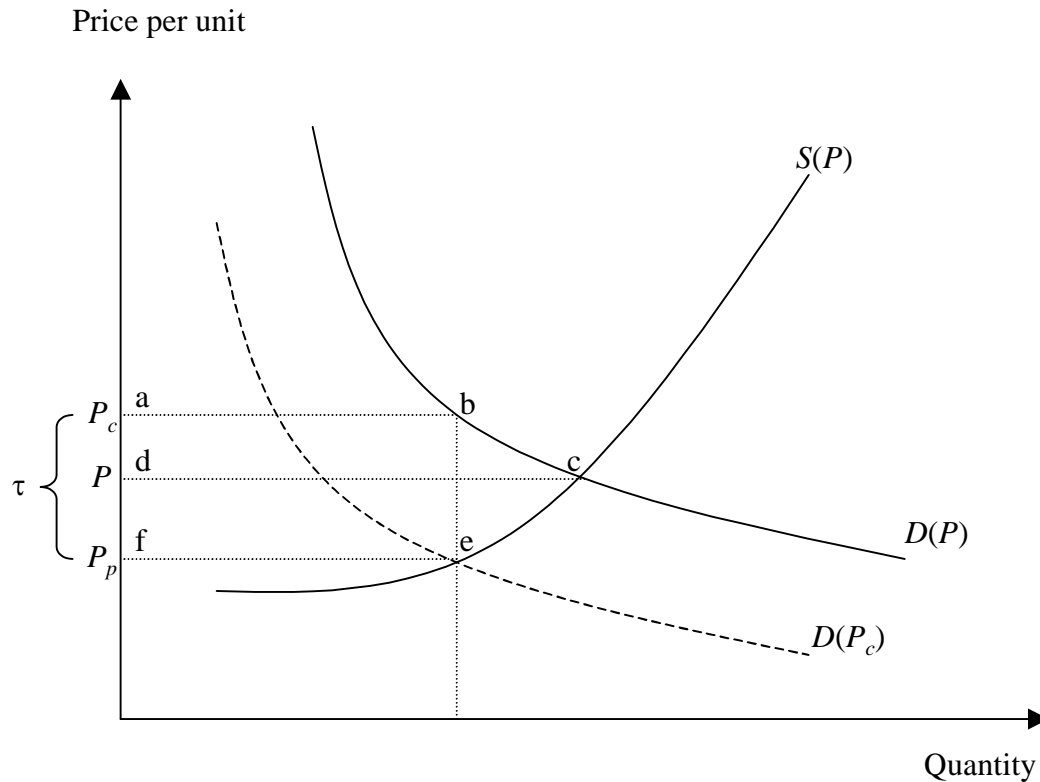
By differentiating the after-tax equilibrium given by  $D(P_c) = S(P_p)$ , we get the classical tax incidence formulae

$$(2.2) \quad \frac{dP_p}{d\tau} = \frac{e_D}{e_S - e_D},$$

where  $e_D$  and  $e_S$  are the demand and supply elasticities. This simple partial equilibrium approach does not capture all relevant aspects of tax incidence. Still, it provides an intuitive approach to tax incidence and according to Kotlikoff and Summers (1987) two important principles that emerge from the analysis remain valid also in a more fully specified model.

First, tax incidence does not depend on which part of a market the tax is assessed on, i.e., the person who effectively pays a tax is not necessarily the person upon whom the tax is levied. In particular, it is of no material relevance for actual tax bearing whether an energy tax is levied on extraction companies, transmission or distribution companies, or consumers. However, the fiscal implications may differ, we should add, if the different parties are located in different countries. According to the international source principle of taxation, companies are taxed at source, i.e., where the economic activity is located. Thus, government revenues of petroleum exporting versus importing countries are affected by which level in the value chain the taxes are levied upon. It is reasonable to consider this as a revenue game between exporting and importing nations.

The second principle emerging from the basic tax incidence model is that taxes will be shifted by those agents and factors that are more elastic in supply and demand, i.e. those who can escape the tax. Energy taxes can be shifted forward (downstream) to transmission companies, distribution companies or consumers, or backwards (upstream) to producers. Generally, the taxes will be borne by those who cannot easily adjust. Thus, taxes are borne by inelastic buyers or sellers, as is evident from Eq. (2.2). This can also be shown in a diagram. In Figure 1 taxes are illustrated as a negative shift in the demand curve, equal to the tax wedge.



**Figure 1. Tax incidence with a unit tax  $\tau$**

In pre-tax equilibrium, point  $c$ , the producer price equals the consumer price. We see that the introduction of a tax reduces the quantity traded, leading to a traditional deadweight loss (tax inefficiency) given by the triangle  $bce$ .<sup>8</sup> (If the tax correctly measures marginal environmental costs not paid for by the trading parties, however, this is not to be conceived as a deadweight loss but rather as a correction of a negative externality.) Also, both the producer and the consumer price are reduced, i.e., the tax burden is shared among the parties, with the area  $abcd$  representing the reduction in consumer surplus and  $cdfe$  the reduction in producer surplus.<sup>9</sup>

Tax incidence is most easily illustrated by examining some extreme cases. If supply is perfectly elastic (horizontal supply curve;  $e_s = \infty$ ), all of the energy tax is according to Eq. (5) borne by the customers ( $dP_p/d\tau = 0$ ). This would also be evident from Figure 1; if the supply curve were a linear curve parallel with the  $q$ -axis, the producer price would be given and all the tax would be shifted to the consumers. This could be the case of a unilateral tax increase

<sup>8</sup> We should point out that to get an exact measure of the deadweight loss, compensated demand functions must be applied, see the figure in Hines (1999). In our empirical work in Section 6 we develop compensated demand elasticities.

<sup>9</sup> We have assumed a piece tax. The economic effects of an ad valorem (percentage based) tax are analogous.

on oil in a single country. If the production is shipped by oil tankers, oil companies have great flexibility with respect to destination. To attract oil, an importing country would have to offer the same producer price as other countries. Note that this does not necessarily apply to gas supplies, as large irreversible investments in pipelines and take-or-pay supply contracts lock the supplier into a long-term relationship with its customers. The reverse result, where all the tax is borne by producers ( $dP_p/d\tau = -1$ ), would be the outcome if demand were perfectly elastic ( $e_d = \infty$ ), i.e., if the demand curve in Figure 1 were horizontal and parallel with the q-axis. This could be a case of perfect substitution, e.g., with industrial customers having dual burners. The most likely scenario, however, is that both supply and demand have finite elasticities, and that the tax burden is shared among sellers and buyers.

As for natural gas supply elasticities, adjustments have to be made to the theoretical tax incidence model. The model is cast in a framework of spot trading. Most of the natural gas delivered to the European Continent, however, is not traded on spot terms. The gas deliveries are typically regulated by long-term contracts, so-called take-or-pay contracts. Traditional spot market incidence is thus replaced by incidence regulated by contract regulations and procedures for re-negotiation. Tax shifting in a setting of long-term contracts is not addressed in the present literature. The most important elements of the gas sales contracts, and the implications for tax incidence, are the topics of the next Section.

We have discussed tax incidence empirically in relation to a basic tax incidence theory and contract theory, with an emphasis on the effect of differing demand elasticities among countries. The effects of elasticities are general, i.e., they also apply to more advanced incidence models. In advanced incidence theory, however, additional factors are derived that may affect incidence. Ideally, we would calculate the general equilibrium before and after the tax change. The changes would then provide a description of the incidence of the tax. This is obviously too complicated to pursue. Even at a theoretical level this is complex, since the economy is usually not disturbed in one dimension, but rather a package of policies.<sup>10</sup> Still, the necessary condition for ignoring general equilibrium effects - that the product in question has a market that is small relative to the entire economy - is typically not satisfied for different types of energy inputs. It is therefore necessary also to explore general equilibrium effects. We do this by deriving cross price elasticities with substitutes such as light fuel oil (LFO) and electricity.

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<sup>10</sup> See Atkinson and Stiglitz (1980).



The effect of energy taxes (input factor taxes) depends on whether the customer is a firm or a household. As for households, an increase in the price of one particular type of energy induces substitution effects. We might expect substitution towards alternative means of energy. In the short term the household may be locked into a particular technology (demanding a certain type of energy), and the substitution effect is therefore likely to be higher in the long run than in the short run. As for firms, there will be substitution effects and output effects. Some industries, like power generators, have installed dual burners, which are likely to produce a strong substitution effect, even in the short run. Thus, we might expect a strong interfuel competition. Firms are facing different types of competitive pressure in different market segments, calling for a differentiated tax shifting. This is analogous to price differentiation. Price differentiation could generally be possible for natural gas, due to limited capacity in pipelines, and for other energy inputs to households, since they may lack access to the spot market.

### **3. Gas Sales Contracts**

The majority of gas sales in the EU-area is regulated by long-term gas sales contracts. To examine tax incidence of natural gas we must understand the price structure of these contracts. Since there is no regional, let alone global, liquid traded market price for natural gas as there is for oil, the market value for natural gas in each sector is typically determined relative to the price of the principal competing fuel. In the presence of long-term contracts the tax incidence theory based on spot markets does therefore not apply. Instead, the tax-shifting pattern is determined by the pricing formulae in the sales contracts.

In regulating contract volumes, the exporting and the importing companies have conflicting interests. Since gas storage is expensive and in limited supply, the importer would like to have flexibility with respect to volumes, thus being able to adjust to changes in downstream demand. Demand fluctuates, especially over the seasons, with a higher demand in winter than in summer. The exporters, on the other hand, have to sink large irreversible investments in extraction, processing, and transportation facilities. Before doing so, they would like to have assurances that they will be able to sell the gas over a considerable period of time, thus securing a return on their investments. Also, to exploit the extraction, processing and transportation capacity, the seller would prefer to deliver a stable gas stream at maximum capacity utilisation. The exporter would – before making large irreversible investments – like

to have some sort of guarantee of recouping his investments. One way of doing this would be to impose a specific price, a minimum price, or other types of price guarantees for the entire period of delivery. However, this may eliminate the upside potential for the seller, and it would also be a bad bargaining strategy for the seller to reveal his reservation price. The buyers, on the other hand, would like the gas price to be responsive to the price of substitutes (such as oil products), so that they remain competitive. It is in the interest of both parties to have some flexibility in the gas price so that it can adjust to market changes and keep gas a competitive energy source. The solution is to let the price be flexible but to guarantee the seller that he will be able to sell certain minimum amounts (volume commitments).

The challenging task for gas contract design is to trade off conflicting interests with respect to volume and price. The exact contents of these contracts are secret, but the general contract structure is common knowledge in the gas industry. The major part of gas export to the EU-region has until now been sold on long-term *take-or-pay* contracts, see Brautaset *et al.* (1998). In these contracts, the buyer agrees to receive a certain volume of gas per year or, alternatively, to pay for the part of this gas volume that it does not want to receive. At the same time, the buyer has an option to take out more gas than these minimum annual amounts, thus conveying flexibility. Substantial volume flexibility is also available on a daily basis. The contracts specify two types of reference volumes, Daily Contract Quantity (DCQ) and Annual Contract Quantity (ACQ). The annual flexibility is regulated by an interval around the ACQ, e.g., the buyer is committed to take or pay 85-95 per cent of ACQ, and may have specific options on annual volumes exceeding ACQ. As for the daily flexibility and commitments, the buyer may be committed to take or pay 40-50 per cent of DCQ, and the seller may be committed to deliver up to 110 per cent of DCQ. Additional flexibility for the buyer is provided by the right to receive at a later time gas that has been paid but not taken (*Make Up Gas*), and the right to reduce future delivery if gas take exceeds the commitments in some years (*Carry Forward Gas*).

The current price on gas delivered according to the long-term take-or-pay contracts is determined by a price formula. The formula links the current gas price to the price of relevant energy substitutes, thus continuously securing the buyer competitive terms.<sup>11</sup> The price formula consists of two parts, a constant basis price (fixed term) and an escalation supplement linking the gas price to alternative forms of energy (variable term).<sup>12</sup> Examples of alternative

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<sup>11</sup> Adjustments in the gas price are not automatically imposed, though, but by periodical (monthly or quarterly) recalculations of the contract price by using the price formula and updated prices on substitutes.

<sup>12</sup> This is the basic structure of most gas contracts in Europe.

energy commodities used in pricing formulas for natural gas are light fuel oil, heavy fuel oil, coal, and electricity. Usually a combination of alternatives is used for escalation purposes (weighted average of energy prices) to reflect the markets for substitutes.<sup>13</sup> Different techniques are used, e.g., using different types of price lags in the price formulas. The basis price reflects the parties' evaluation of the value of the gas at the time of entering into the contract. Each of the alternative energy commodities is assigned a certain weight in the escalation element, reflecting the competitive situation between natural gas and the substitute. The price change of each energy commodity is multiplied by an energy conversion factor, to make the substitute and natural gas commensurable. Thereafter, the individual escalation terms are multiplied by pass through factors, i.e., the change in the price of the substitute is not fully reflected in the gas price. A typical price formula is given by

$$(3.1) \quad P_p = P_0 + \sum_j \alpha_j (AE_j - AE_{j0}) EK_{AE_j} \lambda_j,$$

where  $P_p$  is the gas price paid to the extraction company (producer price),  $P_0$  is the *basis price*,  $\alpha_j$  is the weight in the escalation element for substitute  $j$  (often with  $\sum_j \alpha_j = 1$ ),  $(AE_j - AE_{j0})$  is the price change for substitute  $j$  (actual minus reference price),  $EK_{AE_j}$  is an *energy conversion factor*, and  $\lambda_j$  is the *pass through factor* for price changes in substitute  $j$ .

The pass through factors are typically high, e.g., 0.85 or 0.90. Thus, natural gas prices in these contracts are highly responsive to price changes in substitutes, and exhibit a high volatility. This implies that the exporters are carrying a large fraction of the price risk. Price adjustments for substitutes are based on the difference between current and historic prices. Current prices are calculated as average prices for a reference period, ranging from three to nine months. This gives reliable price data and implies a certain lag in the price adjustments, both upwards and downwards.

#### 4. Tax Incidence for Natural gas

The take-or-pay contracts are complex, containing a number of detailed regulations of contingencies related to quantities and prices. For example, the contracts specify the changes in gas prices that will take place in response to a change in the oil price. Still, there are a

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<sup>13</sup> Some contracts also contain adjustments for inflation.

number of feasible contingencies that are not explicitly covered by the contracts, e.g., the contractual response to deregulation. The contracts must therefore be considered as incomplete, and revisions and renegotiations take place. According to Hart (1995), an incomplete contract is best seen as providing a suitable backdrop or starting point for such renegotiations rather than specifying the final outcome. The contract should be designed to ensure that, whatever happens, each party has some protection against bad luck and opportunistic behaviour by the other party.

Tax incidence of oil taxes adheres to classical incidence theory, since oil to a large extent is traded on spot terms. Being traded on long-term contracts, tax incidence of natural gas is partly determined by the terms of the take-or-pay contracts and partly settled by renegotiations. Under certain conditions and at certain time intervals the parties of a gas sales contract may demand price revisions. The basis for such renegotiations is that (outside the control of the contracting parties) the value of gas has changed substantially - relative to the available substitutes - in the buyer's home country. The overall objective is to maintain the competitiveness of gas supplies. As for changes in energy taxes, however, oil tax changes should not call for renegotiations, to the extent that they are covered by the pricing formula (3.1). Let us take the Kyoto case where natural gas is tax favoured due to less environmental damage. In the presence of an increase in oil taxes, and no adjustments in taxes on gas, the producer gas price would increase by the full extent of the tax according to the pricing formula, to the extent that the oil price that is part of the pricing formula is tax inclusive.<sup>14</sup> An isolated increase in oil taxes is therefore fully shifted to the gas customers. Thus, there is a cross tax incidence effect from the oil market to long-term gas sales, specified by the gas sales contracts. This is also reasonable, as the competitiveness of natural gas has increased due to the change in relative tax rates.

But what happens if there is an increase in gas taxes in the customer's country, e.g. due to EMU revenue requirements? The implication of such a tax change is not explicitly regulated by the pricing formula or other terms of the take-or-pay contracts. If the gas taxes are changed relative to alternative sources of energy, however, the tax change may instigate the buyer to demand renegotiations of the producer price. Tax changes are reportedly an essential part of contract renegotiations. It is therefore interesting to characterize this situation in terms of standard contract theory.<sup>15</sup>

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<sup>14</sup> The export contracts differ at this point.

<sup>15</sup> See, e.g., Hart (1995), Laffont and Tirole (1993), and Milgrom and Roberts (1992).

First of all, the issues of contract design. Should the contract, according to contract design principles, contain more specific regulations of whom is to bear the burden or receive the gains of changes in natural gas taxes? A typical reason for having incomplete contractual terms is enforcement problems, e.g., when critical parameters are not perfectly observable to one or both of the contracting parties, or when such parameters are not verifiable to a court. Neither of these enforcement problems seems to apply to energy taxes that are easily measured.

Second, the issue of risk sharing. Increases in energy taxes can be perceived as a political risk. Standard contract theory prescribes that each of the contracting parties should be held accountable for the risk within their own control sphere. The residual risk should be borne by the party with the lowest risk aversion. As for the latter, both the sellers and buyers of natural gas in the EU-area are large diversified companies, calling for a sharing of the residual risk. Whether corporations can influence energy taxes is an open question. Large transmission companies are likely - on behalf of their customers - to have some influence on energy taxes in their home countries, at least much more influence than the seller if he is located in a different country. Overall, therefore, theory prescribes that the buyer should carry more of the energy tax risk, thus providing them with incentives to keep taxes low, to the benefit of both contracting parties.

The take-or-pay contracts can be perceived as a sequence of gas futures and supply options. Each year the buyer is committed to pay for a minimum quantity. In addition, the buyer has an option to take additional volumes for a given price (relative to substitutes). This, of course, deviates from the standard spot tax incidence model. In lack of markets, market forces are replaced by contracts, and the incidence of taxes on natural gas is determined by renegotiations. Still, underlying market forces could have bearing on renegotiation processes. It is therefore interesting to outline an analogy to standard incidence theory.

An important reference point is the minimum quantities that both the seller and the buyer are committed to, *for a given relative price*. This means that we have perfectly inelastic demand and supply, which according to Eq. (2.2) implies that the tax incidence is undetermined. We get the same result from a graphical analysis, as both curves would be vertical in Figure 1. Accordingly, the shifting of natural gas taxes is instead determined by renegotiations, in which the market principle, i.e., the competitiveness of natural gas in interfuel competition, is decisive.

For the additional volume the buyer has an option to buy, the situation may be a bit different. For additional volumes the buyer may arbitrage between different sources of gas

supply, i.e., the supplier is likely to face a decreasing demand curve for additional volumes. With a decreasing demand curve and a vertical supply curve, one would expect that all the gas tax is shifted to the producer. This presumes, however, that the price is flexible for extra sales. This is not the case for the take-or-pay contracts, as the relative price is fixed by the contract. Hence, if the contractual gas price is not perceived competitive - or if the buyer does not need additional gas - the option is not exercised. In this case, however, there is excess capacity in the pipelines. The seller may thus be tempted to reduce prices for marginal volumes. But this may turn out to induce price pressure on the main supplies and on new gas contracts.

Since it is the producer that undertakes the highest specific investments in infrastructure, it is this contracting party that most needs contractual protection against opportunism from the buyer. In the context of taxation, the seller also needs protection against opportunistic tax setting by the buyer's government which may want to capture parts of the resource rents from the exporting country. It is unclear whether the existing contracts give the sellers due protection in this respect. The tax shifting between sellers and buyers of natural gas is determined by renegotiations of incomplete gas sales contracts.

Letting  $x_i$  denote utility,  $\xi_i$  the reference point (threat point) of contract party  $i$ , and  $\alpha$  the relative bargaining power; the standard Nash bargaining solution (Roth, 1979) is where the weighted Nash product

$$(x_1 - \xi_1)^\alpha (x_2 - \xi_2)^{1-\alpha}$$

is maximised. This bargaining abstraction generates three alternative hypotheses: (a) import taxes are shared among the buyers and sellers, (b) import taxes are borne by the buyers, and (c) import taxes are borne by the sellers. Hypothesis (a) corresponds to a case of symmetric bargaining power in contract renegotiations ( $\alpha$  close to 0.5), or a case where spot markets are dictating renegotiations of long-term contracts. Hypothesis (b), on the other hand, corresponds to a case where the seller has the most bargaining power ( $\alpha$  close to 1), or where the status quo of the bargaining game is maintained. An argument in favour of the latter is that asymmetric bargaining power is necessary for the seller to recoup irreversible investments in infrastructure. Correspondingly, there are usually no explicit regulations in the take-or-pay contracts as to the response to higher taxes in the import country. This might be to the seller's advantage in the case of tax increases, as the status quo is no tax shifting. Hypothesis (c) corresponds to the case where the buyer has most bargaining power ( $\alpha$  close to 0). This

hypothesis is of particular interest in the gas market, since it has been argued that the EU exploits market power to obtain a share of the resource rent. Before testing these hypotheses we give a brief outline of the general trend in EU natural gas taxes.

## 5. Development of Natural Gas Taxes

Most EU countries have levied taxes on natural gas to the household sector. For the industry sector and the electricity sector fewer countries have imposed taxes, and the relative size of the tax is much smaller for these sectors than for households, reflecting the notion that governments are concerned about the international competitiveness of their domestic industries. Hence, with our focus on tax incidence, we focus particularly on the household sector in the following.

A more comprehensive overview of the development in household natural gas taxation in EU countries is provided in Table 1. The table presents tax rates for the first and last year that data are available for each country. We see that there were large differences in the tax rate at the end of the 1990s. In 1997, the last year with observations for all countries, UK had the lowest tax rates (7%) and Italy had the highest tax rate (76.5%).<sup>16</sup> However, for all countries there is a positive trend in the tax rate from the late 1970s to the end of the 1990s. To get a clearer picture of the overall development over time, we aggregate the national tax rates of the eleven countries to a simple non-weighted average in Figure 2. From this figure we see that the average tax rate has increased from around 10% in 1978 to around 30% in 1998.<sup>17</sup>

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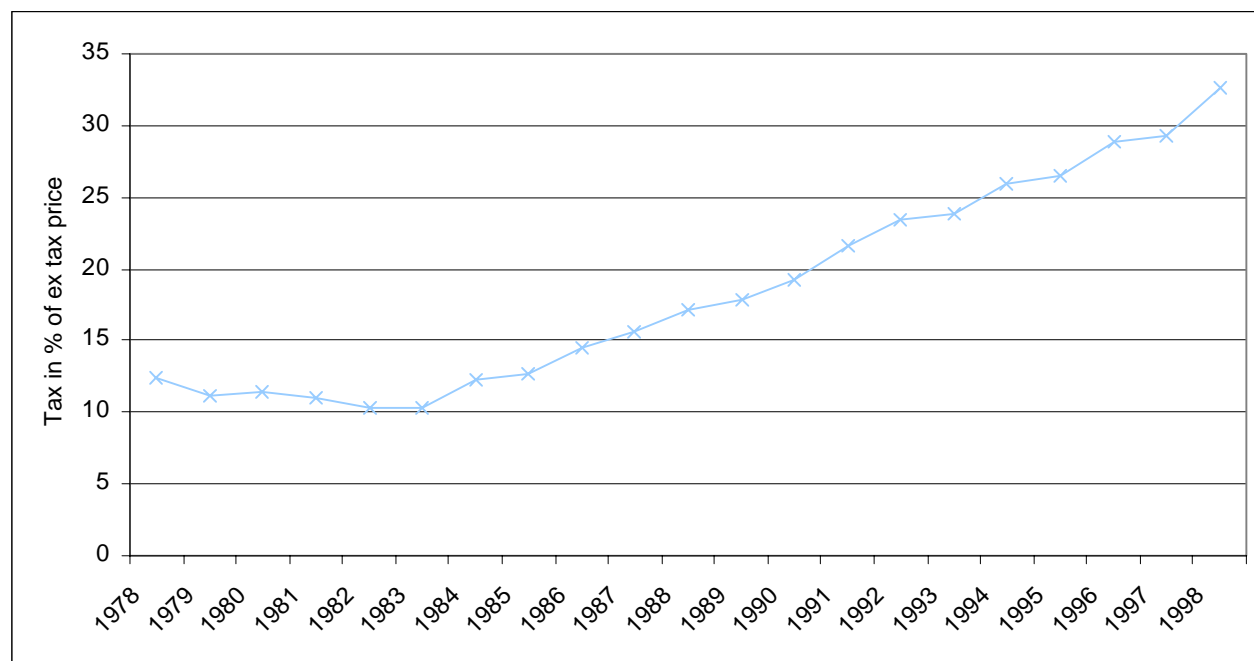
<sup>16</sup> One possible explanation to especially high gas tax in Italy is that Italy is perceived - relative to the other EU-countries - to have high tax collection costs. Gas taxes are easy to enforce, due to small monitoring problems.

<sup>17</sup> When Italy is excluded, we find that the average tax rate has increased from 7% to 21%.

**Table 1. Taxes and Natural Gas Prices Paid by the Residential Sector\* (Data source: IEA)**

Country	Year	Excise tax		Value added tax		Total Tax		Price incl. tax
		USD	Percent	USD	Percent	USD	Percent	USD
Austria	1979	0.00	0.00 %	50.57	8.00 %	50.57	8.00 %	682.74
	1998	43.41	15.05 %	66.44	23.03 %	109.85	38.07 %	398.39
Belgium	1978	0.00	0.00 %	22.63	6.00 %	22.63	6.00 %	400.05
	1997	15.51	4.91 %	69.57	22.03 %	85.08	26.95 %	400.84
Denmark	1984	0.00	0.00 %	145.90	21.99 %	145.90	21.99 %	809.36
	1997	33.51	6.87 %	130.39	26.72 %	163.90	33.58 %	651.95
Finland	1978	3.30	1.62 %	0.00	0.00 %	3.30	1.62 %	207.12
	1997	10.97	8.82 %	29.78	23.93 %	40.75	32.75 %	165.18
France	1978	0.00	0.00 %	83.95	17.60 %	83.95	17.60 %	560.85
	1997	0.00	0.00 %	71.39	20.60 %	71.39	20.60 %	417.92
Germany	1978	0.00	0.00 %	52.74	12.00 %	52.74	12.00 %	492.20
	1997	23.70	7.15 %	53.29	16.07 %	77.00	23.21 %	408.68
Ireland	1983	0.00	0.00 %	32.07	3.79 %	32.07	3.79 %	877.93
	1997	0.00	0.00 %	47.80	12.49 %	47.80	12.49 %	430.68
Italy	1978	93.88	32.25 %	23.10	7.94 %	116.99	40.18 %	408.11
	1997	180.19	49.08 %	100.71	27.43 %	280.90	76.51 %	648.06
The Netherlands	1978	0.31	0.13 %	42.19	18.02 %	42.50	18.16 %	276.60
	1997	36.20	13.96 %	51.71	19.94 %	87.91	33.90 %	347.20
Spain	1978	16.51	3.48 %	0.00	0.00 %	16.51	3.48 %	490.65
	1998	6.32	1.50 %	68.43	16.24 %	74.75	17.74 %	496.08
UK	1978	0.00	0.00 %	0.00	0.00 %	0.00	0.00 %	349.78
	1997	0.00	0.00 %	20.94	7.00 %	20.94	7.00 %	320.06

\* Taxes and prices have been deflated to 1995=100 and multiplied by the USD exchange rate in the last observation year for each country. Taxes are in percent of ex tax price.



**Figure 2. Average Tax in 11 EU Countries on Natural Gas to Household Sector**



## 6. Econometric Analysis of Household Gas Demand

In the previous Section we found that taxes on natural gas to households in the EU have increased. As shown in Section 2, elasticity estimates are required for empirical analysis of tax incidence. In this Section we present an econometric model of household sector energy demand. We have a panel data set with annual observations from several OECD countries at our disposition. In panel data analysis it is customary to pool the observations from each unit (here: country) together, and estimate models with unit-specific intercepts which are specified as random or fixed. However, the coefficients associated with the explanatory variables, the slope coefficients, are assumed to be equal across units. In our context this implies, for example, that the own price elasticity of natural gas is identical across countries. In light of results from previous econometric studies and other empirical evidence, homogeneity restrictions on slope coefficients are not very appealing (Maddala *et al.*, 1997; Garcia-Cerrutti, 2000). Hence, our models should be specified to allow for cross-country heterogeneity in demand elasticities.

### 6.1. Shrinkage Estimation

Estimation of separate demand models for each country gives the greatest degree of flexibility with respect to elasticity estimates. However, earlier studies have demonstrated that such regression models often provide implausible elasticity estimates, for example, positive own-price elasticities (Atkinson & Manning, 1995). In this paper we employ a Bayesian “shrinkage” estimator on our demand models (Maddala *et al.*, 1997). This estimator allows for slope coefficient heterogeneity, but imposes some additional structure on the generation of the true coefficient values compared to separate regression models. This additional structure is the assumption of a common probability distribution from which the true parameter values of the demand models are drawn for each country. The coefficients estimated by the shrinkage method will be a weighted average of the overall pooled estimate and separate estimates from each country.<sup>18</sup>

In its most general form the demand model is specified as

$$(6.1) \quad y_i = X_i \beta_i + u_i, \quad i = 1, 2, \dots, N,$$

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<sup>18</sup> The “shrinkage” estimator shrinks estimates from separate regression models towards a population average.

where  $y_i$  is a  $T \times 1$  vector,  $X_i$  is a  $T \times k$  matrix of observations on the  $k$  explanatory variables,  $\beta_i$  is a  $k \times 1$  vector of parameters, and  $u_i$  is a  $T \times 1$  vector of random errors which is distributed as  $u_i \sim N(0, \sigma_i^2 I)$ .

We assume that

$$(6.2) \quad \beta_i \sim IN(\mu, \Sigma),$$

or equivalently that

$$(6.3) \quad \beta_i = \mu + v_i,$$

where  $v_i \sim N(0, \Sigma)$ . Equation (6.2) specifies the prior distribution of  $\beta_i$  in the Bayesian framework. The posterior distribution of  $\beta_i$  depends on  $\mu$  and  $\Sigma$ . If  $\mu$  and  $\Sigma$  are not known, priors must be specified. When  $\mu$ ,  $\sigma_i^2$  and  $\Sigma$  are known, the posterior distribution of  $\beta_i$  is normal with mean and variance given by

$$(6.4) \quad \beta_i^* = \left( \frac{1}{\sigma_i^2} X_i' X_i + \Sigma^{-1} \right) \left( \frac{1}{\sigma_i^2} X_i' X_i \hat{\beta}_i + \Sigma^{-1} \mu \right), \text{ and}$$

$$(6.5) \quad V(\beta_i^*) = \left( \frac{1}{\sigma_i^2} X_i' X_i + \Sigma^{-1} \right)^{-1},$$

respectively.  $\hat{\beta}_i$  is the OLS estimate of  $\beta_i$ .

If the matrix  $X_i$  includes lagged values of  $y_{i,t}$ , the normality of the posterior distribution of  $\beta_i^*$  holds only asymptotically and under the usual regularity conditions assumed in dynamic regression models.

In the empirical Bayesian approach that we employ, we use the following sample-based estimates of  $\mu$ ,  $\sigma_i^2$  and  $\Sigma$  in equation (6.4):

$$(6.6a) \quad \mu^* = \frac{1}{N} \sum_{i=1}^N \beta_i^*$$

$$(6.6b) \quad \hat{\sigma}_i^2 = \frac{1}{T-k} (y_i - X_i \beta_i^*)' (y_i - X_i \beta_i^*)$$

$$(6.6c) \quad \hat{\Sigma} = \frac{1}{N-1} \sum_{i=1}^N (\beta_i^* - \mu) (\beta_i^* - \mu)'$$

We see that the prior mean  $\mu^*$  is an average of the  $\beta_i^*$ , the estimate of the prior variance  $\Sigma^*$  is obtained from deviations of  $\beta_i^*$  from their average  $\mu^*$ , and the estimate of  $\sigma_i^2$  is obtained from the residual sum of squares using  $\beta_i^*$ , not the OLS estimator  $\hat{\beta}_i$ .

The equations (6.6) are estimated iteratively. In the initial iteration the OLS estimator  $\hat{\beta}_i$  is used to compute  $\mu^*$ ,  $\sigma_i^2$  and  $\Sigma^*$ . To improve convergence (6.6c) is modified as

$$(6.6c') \quad \hat{\Sigma} = \frac{1}{N-1} \left[ R + \sum_{i=1}^N (\beta_i^* - \mu) (\beta_i^* - \mu)' \right],$$

where  $R$  is a diagonal  $k \times k$  matrix with small values along the diagonal (e.g. 0.001). According to a Monte-Carlo study by Hu and Maddala (1994), the iterative procedure gives better estimates in the mean squared sense for both the overall mean  $\mu$  and the heterogeneity matrix  $\Sigma$  than two-step procedures.

## 6.2. Empirical Model and Results

The demand for natural gas ( $y_N$ ) in the household sector of country  $i$  in year  $t$  is specified as

$$(6.7) \quad \ln y_{N,i,t} = \beta_0 + \beta_y \ln y_{N,i,t-1} + \sum_{f=E,F,N} \beta_f \ln p_{f,i,t} + \sum_{f=E,F,N} \beta_{ft} \ln p_{f,i,t} \cdot t + \beta_I \ln I_{i,t} + \beta_{It} \ln I_{i,t} \cdot t + u_{i,t},$$

where  $p_f$  is the price paid by the residential sector for fuel  $f$ ,  $f = E$ (lectricity),  $F$ (uel oil),  $N$ (atural gas),  $I$  is income measured by private consumption, and  $t$  is a time trend variable. The terms involving  $t$  allow for changes in demand elasticities over time. The own-price elasticity of natural gas demand is  $e_{NS} = (\beta_N + \beta_{Nt})$  and  $e_{NL} = (\beta_N + \beta_{Nt}) / (1 - \beta_y)$  in the short and long run, respectively. Analogous measures apply to the other prices and income. We expect light fuel oil (LFO) to be a substitute for natural gas. Electricity is also a substitute, but in

many countries electricity is primarily used for electric appliances and to a smaller extent for heating. Hence, we expect smaller cross-price elasticities between natural gas demand and the price of electricity.

Table 2 shows the shrinkage estimates of the natural gas demand elasticities in the household sector. All elasticities have the expected signs, and are less elastic in the short run than in the long run. Demand seems to be basically unitary elastic with respect to income in the short run and elastic in the long run. This indicates that the budget share of gas is constant relative to income in the short run, but increasing with higher income. Given further economic growth, this indicates that demand for natural gas is likely to continue to increase, and that natural gas will continue to gain higher market shares. All own-price elasticities are negative, but demand is relatively inelastic, and light fuel oil seems to be a stronger substitute than electricity. According to the Kyoto agreement fuel oil taxes should be high relative to tax on natural gas due to higher CO<sub>2</sub> emissions per unit. One implication of the empirical results in Table 2 is that an increase in light fuel oil taxes relative to natural gas taxes, reflecting the CO<sub>2</sub> emissions, would typically lead to an increase in natural gas demand.

**Table 2. Shrinkage Estimates of Natural Gas Demand Elasticities in the Household Sector\***

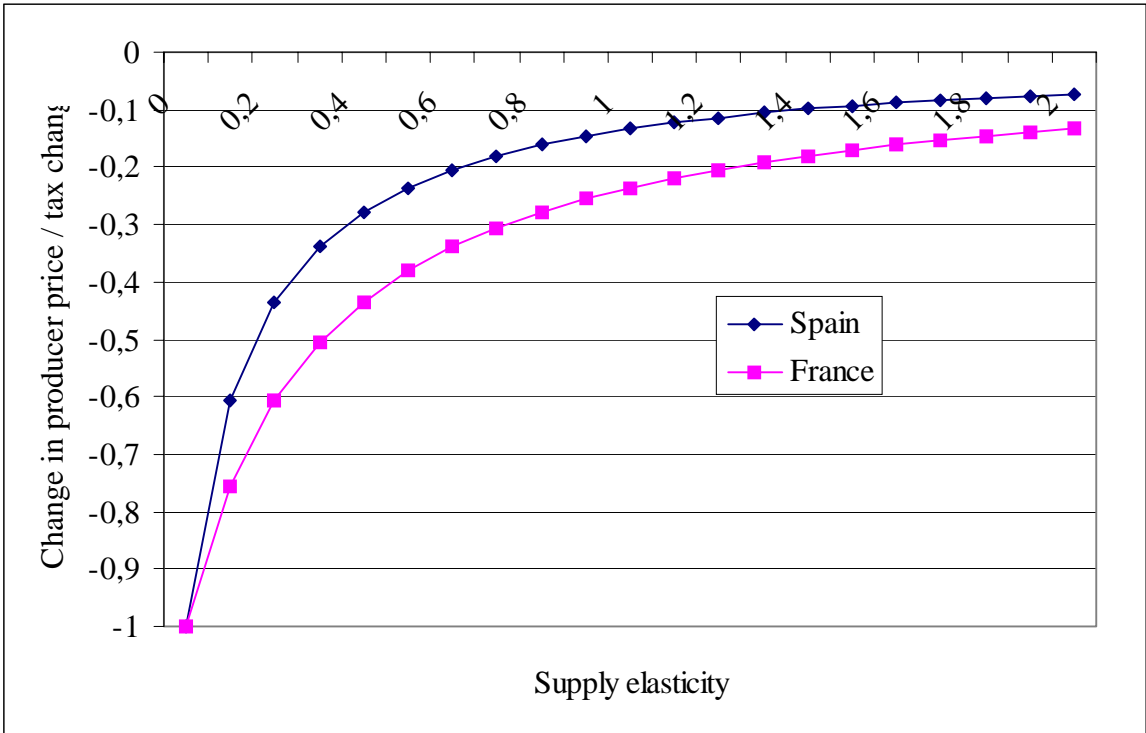
	Gas short run	Gas long run	LFO short run	LFO long run	Electricity short run	Electricity long run	Income short run	Income long run
Austria	-0.251	-0.357	0.224	0.318	0.174	0.246	1.031	1.463
Belgium	-0.265	-0.377	0.197	0.280	0.139	0.197	1.055	1.502
Denmark	-0.264	-0.372	0.378	0.531	0.284	0.399	0.954	1.341
Finland	-0.295	-0.413	0.353	0.494	0.228	0.319	0.930	1.300
France	-0.308	-0.434	0.277	0.390	0.159	0.223	1.008	1.419
Germany	-0.250	-0.348	0.375	0.523	0.222	0.310	0.975	1.360
Ireland	-0.282	-0.398	0.236	0.334	0.143	0.202	1.030	1.456
Italy	-0.247	-0.350	0.167	0.236	0.013	0.019	1.041	1.475
Netherlands	-0.234	-0.335	0.117	0.167	0.149	0.212	1.083	1.547
Spain	-0.154	-0.216	0.389	0.546	0.276	0.387	0.945	1.326
UK	-0.223	-0.317	0.246	0.349	0.127	0.181	1.040	1.479

\* Evaluated in the sample mean year for each country.

It is worthwhile to note the substantial variation in the magnitude of the elasticities. In particular, French natural gas demand is twice as elastic as Spanish demand in own price. Hence, the degree to which consumers in different EU countries have to bear taxes can differ substantially. Since demand elasticities are indicative of ex post bargaining power, the elasticities in Table 2 provide vital information to gas sellers as to in which countries special protective contract provisions are called for. However, as demand is fairly inelastic in both the

short and the long run, in all the countries, it is clear that consumers have to pay a substantial part of the taxes if the supply is not extremely inelastic.

Given the estimated short-run and long-run demand elasticities we can calculate tax incidence predicted by spot incidence theory by means of formula (2.2), if one assumes a certain level for the supply elasticity. One intermediate result is that – as expected – a larger fraction of the tax increase will be borne by the suppliers in the long run than in the short run, due to more elastic long-run demand and higher substitution possibilities. The technological structure of the natural gas industry means that the elasticity of supply is well below 1 and decreases rapidly with high capacity utilization rates.<sup>19</sup> For example, if the elasticity of supply is 0.7, we calculate the incidence on producer price predicted by the spot incidence model for the two European countries representing the extremes in Table 2 with respect to own-price elasticities, i.e. Spain and France. The short-run elasticities are  $-0.154/(0.7+0.154) = -0.180$  and  $-0,308/(0,7+0,308) = -0.306$ , respectively. Figure 3 plots the tax incidence for these two countries for different supply elasticities.



**Figure 3. Ratio of Change in Producer Price to Tax Change for Spain and France**

<sup>19</sup> For empirical evidence on the structure of natural gas supply in Europe, see e.g. Mathiesen, Roland & Thonstad (1987) and Golombek, Gjelsvik & Rosendahl (1998).

## 7. Empirical Analysis of Natural Gas Import Price Incidence

In Section 6 we showed that demand for gas in the EU is highly inelastic, and that consumers according to spot incidence theory are likely to bear a substantial part of any tax except for in situations with extremely inelastic supply. We now turn to actual tax bearing in long-term gas sales contracts.

Given the complexity of the value chain it is not possible to specify a full structural model. However, to assess how the tax burden is divided it is sufficient to specify a reduced form model that gives the impact on the price of taxes and other exogenous variables in the system. We assume that the exogenous factors determining the import price for natural gas in the EU, are the oil price, the tax level, and private final consumption. The Brent spot price is included to account for the fact that natural gas price contract formulas are heavily influenced by the price of oil. Hence, there should be a strong positive relationship between the import price and the oil price. Private consumption is included to account for shifts in the demand curve. In addition, we include the lagged import price for natural gas to account for adjustment costs. The equation to be estimated is:

$$(7.1) \quad \ln IMP_{i,t} = \alpha_i + \alpha_{IMP1} \cdot \ln IMP_{i,t-1} + \alpha_{OIL} \cdot \ln OIL_{i,t} + \alpha_{TAX} \cdot \ln TAX_{i,t} + \alpha_{CONCAP} \cdot \ln CONCAP_{i,t} + u_{i,t},$$

where  $IMP_{i,t}$  is the import price to country  $i$  in year  $t$ ,  $OIL$  is the spot price of Brent blend oil,  $TAX$  is the tax on natural gas in the household sector, and  $CONCAP$  is private final consumption per capita. Country-specific effects  $\alpha_i$  are included to capture cross-country differences in technology, infrastructure, competition and regulation which influence the import price. The log-log specification implies that the coefficients can be interpreted as short-run elasticities. The parameter on the  $TAX$  variable is of particular interest, since it provides information on the tax incidence. In particular,  $\alpha_{TAX}=0$  corresponds to the case where the buyers bear the full impact of the tax. If  $0 < \alpha_{TAX} < 1$ , the tax is shared. The closer  $\alpha_{TAX}$  is to 0, the smaller part of the burden is shifted to the sellers, and vice versa for  $\alpha_{TAX} = 1$ . If  $\alpha_{TAX} = 1$ , the seller bears the full burden of the tax.

Even with these simplifying assumptions, it is difficult to obtain the required data for all EU-countries. Our data set therefore becomes smaller than in Section 6, as sufficient data are available only for Belgium, Finland, France, Germany, Italy, the Netherlands, Spain and

the UK. However, as all the main gas consuming countries in the EU are included in this sample, it should still give a good indication of the total effect.

**Table 3. Empirical Results from Import Price Regression Model\***

Elasticity	Short-run elasticities			Long-run elasticities		
	Est.	St.Err.	t-ratio	Est.	St.Err.	t-ratio
$E_{OIL}$	0.512	0.090	5.680	0.660	0.143	4.605
$E_{TAX}$	0.005	0.012	0.380	0.006	0.016	0.378
$E_{CONCAP}$	0.278	0.150	1.850	0.359	0.188	1.904

\*  $N = 49$  observations.  $R^2$  adjusted = 0.71. The short run elasticities correspond to the parameters  $\alpha_{OIL}$ ,  $\alpha_{TAX}$ , and  $\alpha_{CONCAP}$ . The estimate of  $\alpha_{IMPI}$  is 0.224 with standard error 0.112.

Table 3 presents the short- and long-run elasticities from the estimated import price regression model. Use of a country-specific intercept is supported by an F-test with a test statistic of 3.11, which leads to rejection of homogeneity at the 1% level ((7, 37) df). According to Table 3 the import price increases significantly with a higher oil price both in the short and long run. Furthermore, a higher per capita income leads to a significantly higher gas import price. Both these relationships are as expected, given the structure of the market, the long-run contracts, and the increased demand for natural gas. However, there is no significant negative relationship between the import price of gas and the gas taxes. In other words, these results indicate that the import countries have not been able to shift parts of the tax increases backwards to the producers, i.e., the data support hypothesis (b) in Section 4. Thus, it seems that spot market forces have not been decisive in the renegotiations of the take-or-pay contracts. The spot incidence model does not give good predictions for contract incidence in gas markets.

One reason for the lack of spot influence on contract renegotiation is that there has not been an efficient spot market at the European Continent in the period we analyse. The gas transmission companies have had several sources of gas to select from, mainly Russia, The Netherlands, Norway and Algeria. The long-term contracts with these countries, first of all The Netherlands and Norway, also contain swing elements (call options) that allow for additional volumes. But even if the take-or-pay contracts have periodical renegotiations, they probably do not mimic spot contracts. First of all, contract volumes are to a large degree fixed, and not subject to renegotiation. Second, a few of the contracts have special provisions dealing with tax increases. The deviations from spot trading were necessary - at the time - to induce large irreversible investments in infrastructure, taking into account the political risk of increased energy taxes in the importing countries once gas penetration is high.

## 8. Conclusion

Gas exports are - for technical and economic reasons - most often transmitted by means of pipelines. Presently, this implies limited export flexibility, and often the entire gas supply from a pipeline goes to a single customer, typically a large transmission company. The supplier is thus locked into a long-term relationship with one commercial party. Due to the high level of irreversible and specific investments, this involves a high hold-up risk, which is why natural gas exports often are regulated by long-term contracts that protect each of the contracting parties from opportunistic behaviour. We focus on a similar case where the seller is exposed to risk from the government in the customer's country. By introducing energy taxes, importing countries may capture parts of the resource rent.<sup>20</sup> The shifting of the tax is determined by a process of renegotiation of incomplete gas sales contracts, and hence deviates from the normal spot based theory of tax incidence. The fact that both sellers and buyers may be locked in is also interesting in a strategic trade policy perspective.

In this paper we study the market for natural gas in the EU. Our demand analysis indicates that demand is relatively heterogeneous between the different countries, and long-run responses are substantially stronger than short-run responses. Still, demand is always fairly inelastic, and hence consumers are likely to bear a substantial part of any tax, provided that the supplies are not extremely inelastic. Both light fuel oil and electricity seem to be substitutes to natural gas, with fuel oil as the strongest. Hence, the Kyoto requirement that oil is taxed more heavily is likely to lead to a positive environmental effect as energy demand will shift towards natural gas.

When investigating whether the increases in taxes in the EU have had an impact on the import price for natural gas, we can strongly reject this hypothesis both in the short and long run. Hence, the long-run contracts or the current market structure have so far been able to protect the exporters of natural gas from rent capture by the importing countries, and the increased taxes on natural gas have then mainly transferred revenue from consumers to governments within the EU. With this structure, it is also clear that one cannot say that taxing natural gas has been used as a tool in strategic trade policy.

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<sup>20</sup> The gas exporter is locked into a long run relationship with both the importer and the tax authorities in the importing country. Thus, bargaining over the resource rent could be perceived as a multi-principal multi-agent game.



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