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ENERGY TAXES AND NATURAL GAS DEMAND IN EU-COUNTRIES – TAX INCIDENCE AND OPTIMAL EXPORT STRATEGIES

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 is actually bearing the burden of increased energy taxes in the EU-area - consumers or exporters. 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 actual gas sales contracts we test whether this is the case. To calculate tax incidence we derive demand elasticities, income elasticities and cross price elasticities for natural gas, oil and electricity, for different market segments (households, industry, power generators) in EU countries. Particular focus is on tax incidence in gas markets regulated by incomplete long-term contracts. Based on our findings we discuss normative energy tax issues related to revenue, environmental obligations and security of supply.

JEL Classification: K12, L72, Q48, H23, G18, D63.

Keywords: Energy Markets, incomplete contracts, tax incidence.

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1. Introduction

Energy taxes are imposed for fiscal and environmental reasons, both of which are in much focus in the EU-area due to Kyoto-requirements for reducing emissions and the EMU fiscal requirements of limiting deficits.[1] 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.[2] 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 thereby capture parts of the resource rent.[3] 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 - to prevent firms from moving elsewhere.[4] 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, in relative terms.

The "double dividend" literature [5] examines the hypothesis that a government can obtain two gains by increasing energy taxes: (a) 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

[1] 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.

[2] See, e.g., Debashis and White (1998).

[3] 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).

[4] See, e.g., Zodrow and Mieszkowski (1986), Osmundsen, Hagen and Schjelderup (1998), and Olsen and Osmundsen (2000).

[5] 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.

Our focus is on tax incidence, i.e., on whom is actually bearing the burden of energy taxes.[6] To address this issue we combine contract theory, public economics and empirical demand analyses. We survey standard tax incidence theory, which is based on spot trading. This is illustrative for the oil market. Thereafter, we address an issue relevant for gas supplies, 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.[7]

According to partial tax incidence analyses it is vital to estimate supply and demand elasticities. We estimate demand elasticities for natural gas in several European countries and North America. In the econometric model estimations, we apply a "shrinkage" estimator that allows for cross-country heterogeneity in demand elasticities. Tax incidence is likely to vary between the short and the long run since customers have larger substitution opportunities in the long run. We capture this effect by estimating demand elasticities both in the short and 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 first of all determined by cross-price elasticities, which we estimate.

Traditional tax incidence 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. Demand elasticities vary among market segments. Our econometric analysis shows that demand elasticities vary across countries. To support traditional tax incidence analyses, we calculate demand elasticities for different EU-countries.

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 Seebrugge, 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 still is available capacity (call

[6] Policy implications of this issue is previously surveyed, e.g., by Austvik (1997, 2000). We extend his presentation by addressing theoretical aspects of energy tax incidence, and by undertaking empirical analyses to shed light on actual incidence in the OECD-area.

[7] See, e.g., Hamilton (1999), Itaya (1995), and Kotlikoff and Summer (1987).

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 in stead 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 an econometric model, and compare our empirical findings with traditional tax incidence models assuming spot markets.

2. Tax incidence

Basic insights from tax incidence theory may be derived in a simple partial and static model. In the absence of taxation, equilibrium energy price is attained where demand equals supply:

(2.1) $$D(P) = S(P).$$

An energy tax, τ, introduces a wedge between prices to be paid by the consumers, P_c, and prices received by the producers, P_p:

(2.2) $$P_c = P_p + \tau,$$

with the after-tax equilibrium given by

(2.3) $$D(P_C) = S(P_P).$$

Differentiating (2.3), yields

(2.4) $$\frac{dP_p}{d\tau} = \frac{D'}{S' - D'},$$

or

$$\text{(2.5)} \qquad \frac{dP_p}{d\tau} = \frac{e_D}{e_S - e_D},$$

where e_D is the demand elasticity and e_S is the supply elasticity. This is a simple partial equilibrium approach that 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, 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. 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, 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. (2.5). It 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.

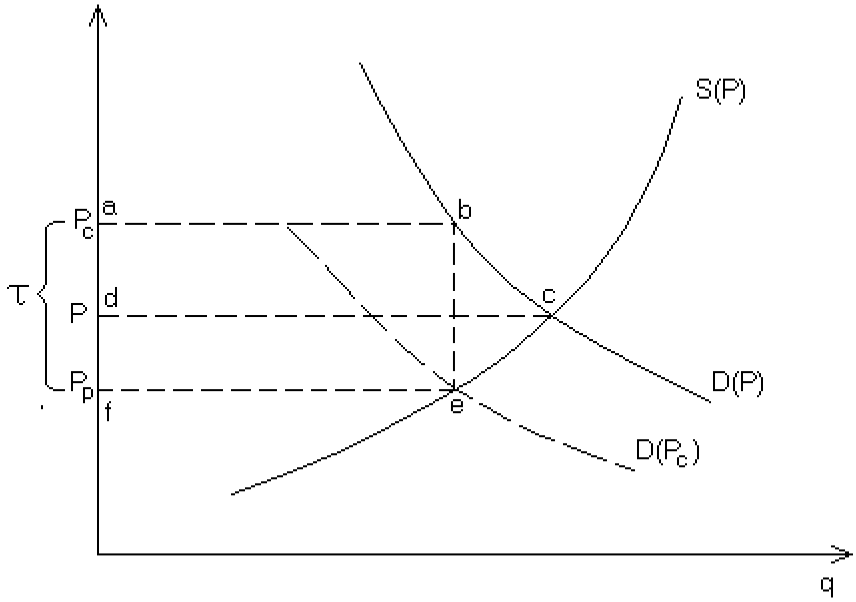

Figure 1: Tax incidence.

In before-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*.[8] 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.[9]

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 x-curve, the producer price is given and all the tax is shifted to the consumers. This could be the case of a unilateral tax increase of 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 locks the supplier into a long-term relationship with its customers. The reverse result, where all the tax is borne

[8] 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 a correction of a negative externality.
[9] We have assumed a piece tax. The economic effects of an ad valorem (percentage based) tax are analogous.

by producers ($dP_p / d\tau = -1$), would be the outcome if demand is perfectly elastic ($e_d = \infty$), i.e., if the demand curve in Figure 1 is horizontal and parallel with the x-curve. 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 it is complex, since the economy usually is not disturbed in one dimension, but rather a package of policies.[10] Still, the necessary conditions for ignoring general equilibrium effects - that the product in question have 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 like LFO and electricity.

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

[10] See Atkinson and Stiglitz (1980).

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.

2. 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 globally, liquid traded market price for natural gas as there is in 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 are able to sell the gas. 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 in the period 1990-1998 was 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 like 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 Quality (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.[11] 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).[12] Examples of alternative 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.[13] 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 the contract. Each of the alternative energy commodities is assigned a certain weight in the escalation

[11] 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.
[12] This is the basic structure on most gas contracts in Europe.

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

$$(2.1) \quad P_C = P_0 + \sum_j \alpha_j \left(AE_j - AE_{j0}\right) EK_{AEj} \lambda_j ,$$

where P_C is the gas price paid to the extraction company (producer price), P_O is the basis price, α_j is the weight in the escalation element for substitute j (often with $\sum_j \alpha_j = 1$), $\left(AEj - AEj_o\right)$ is the price change for substitute j (actual minus reference price), EK_{AEj} is an energy conversion factor, and λ_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.

3. 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, e.g., 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 number of feasible contingencies that are not explicitly covered by the contracts, e.g., the contractual response to deregulation. The contracts must be considered as incomplete, and revisions and renegotiations take place. According to Hart (1995), an incomplete contracts 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.

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[13] Some contracts also contain adjustments for inflation.

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 contracts 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 (6). Let us take the Kyoto case where natural gas is tax favored 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 with 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 (the export contracts contain differ at this point). 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.[14]

First of all, the issues of contract design. Should the contract, according to contract design principles, contain more specific regulations of who is to bear the burden or 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

[14] See, e.g., Hart (1995), Laffont and Tirole (1993), and Milgrom and Roberts (1992).

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 of 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 the contracting parties.

The take-or-pay contracts can be perceived as a sequence of gas futures and supply options. In each year the buyer has 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).[15] 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. (1.5) 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. The buyer may for additional volumes 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

[15] In addition to the volume options, the contacts also entail important options in timing, both on a daily and an annual basis.

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 that 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 status quo of the contract renegotiations, however, is no change in the import price in response to tax changes. This might be to the seller's advantage in the case of tax increases.

4. Development of Natural Gas Taxes

Figure 2 shows import prices and end-user prices for natural gas in selected countries in USD per MBtu. The choice of countries has been dictated by data availability. We only plot the ex tax price for a particular sector when a tax is actually levied on that sector. Hence the selection of curves for each country provides information on the natural gas taxation regime in that country. The major exception here is the United States, where the IEA does not present data on average taxes. [16] We see that all the European countries included in Figure 2 have levied taxes on natural gas to the household sector. This sector will be examined more closely later. For the industry sector and the electricity sector only Germany and the Netherlands have imposed taxes. However, the Figure 2 indicates that the relative size of the tax is much smaller for these sectors than for households. When we look at other countries, which are not included in Figure 2 due to lack of import prices we generally find that taxes on the industry sector and the electricity sector are small. Hence, in the following we focus particularly on households.

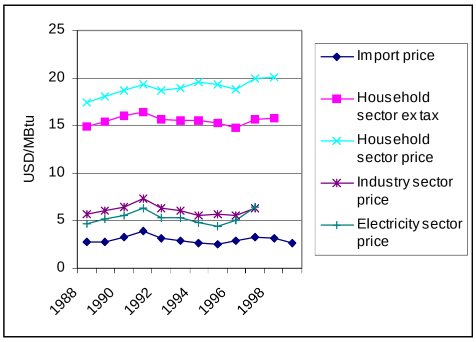
A more comprehensive overview of the development in household natural gas taxation in Europe is provided in Figure 3. The figure plots the total tax in percent of the ex tax price. We see that there were large differences in the tax rate at the end of the 1990s. In 1997, the last year with observations for all countries, UK and Switzerland had the lowest tax rates

[16] Unlike most countries, taxes on natural gas are not set by the national government in the USA. See IEA "Energy Prices & Taxes: Quarterly Statistics" for a description of the tax regime in each country.

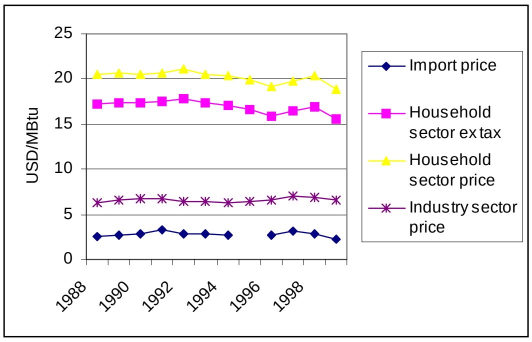
(around 7%) and Italy had the highest tax rate (76,5%).[17] However, for all countries there is a positive trend in the tax rate from the late 1970s to the end of the 1990s. To get a clearer picture of the overall development we aggregate the national tax rates of the twelve countries to a simple non-weighted average in Figure 4. We choose to compute two averages, where one includes and one excludes Italy. From this figure we see that when Italy is included, the

[17] 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.

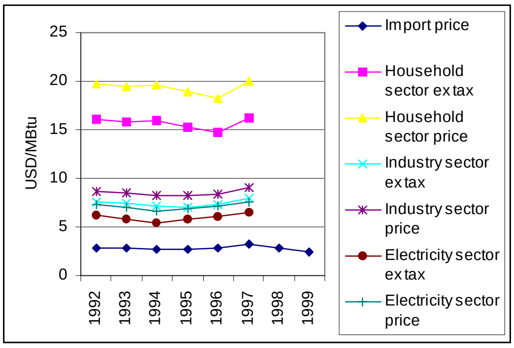
Belgium



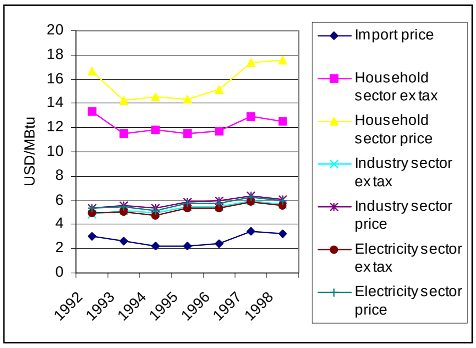
France



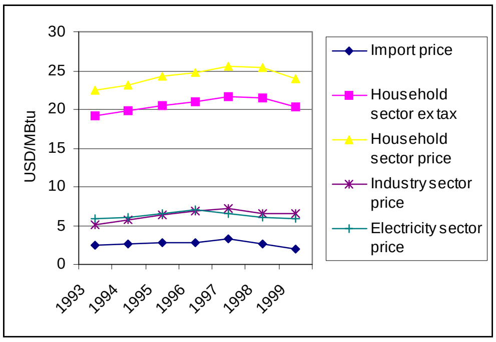
Germany



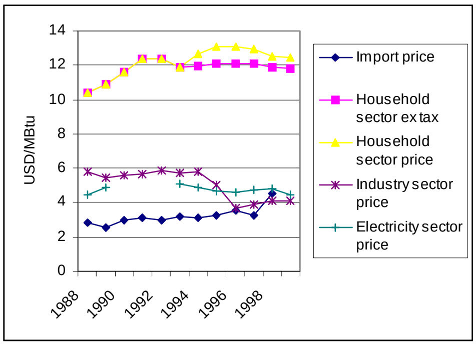
Netherlands



Spain



UK



USA

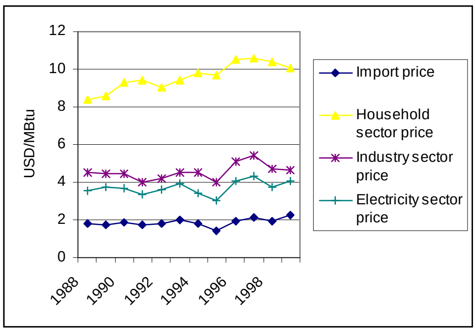


Figure 2. Nominal Import and End-User Prices in USD (1995 Exchange Rate) per MBtu for Selected Countries (Data source: IEA)

average tax rate has increased from around 10% in 1978 to around 30% in 1998. When Italy is excluded we find that the average tax rate has increased from 7% to 21%.

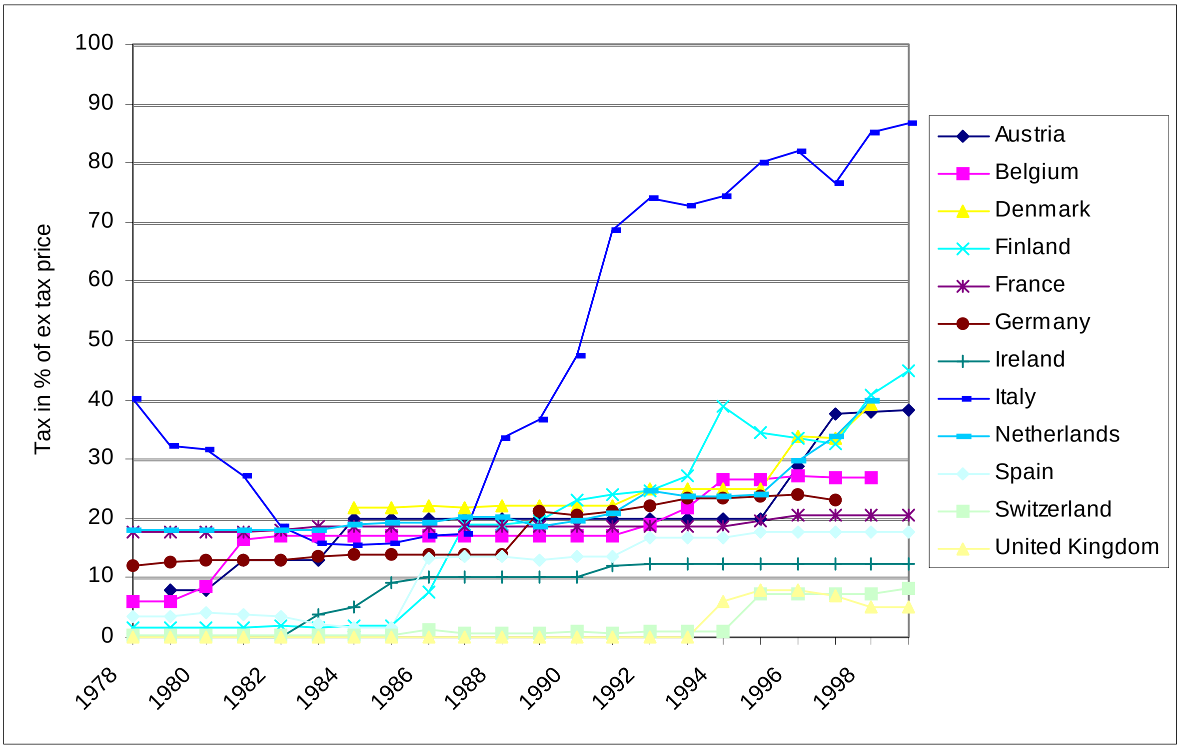


Figure 3. Tax on Natural Gas to Household Sector in Percent of Ex Tax Price

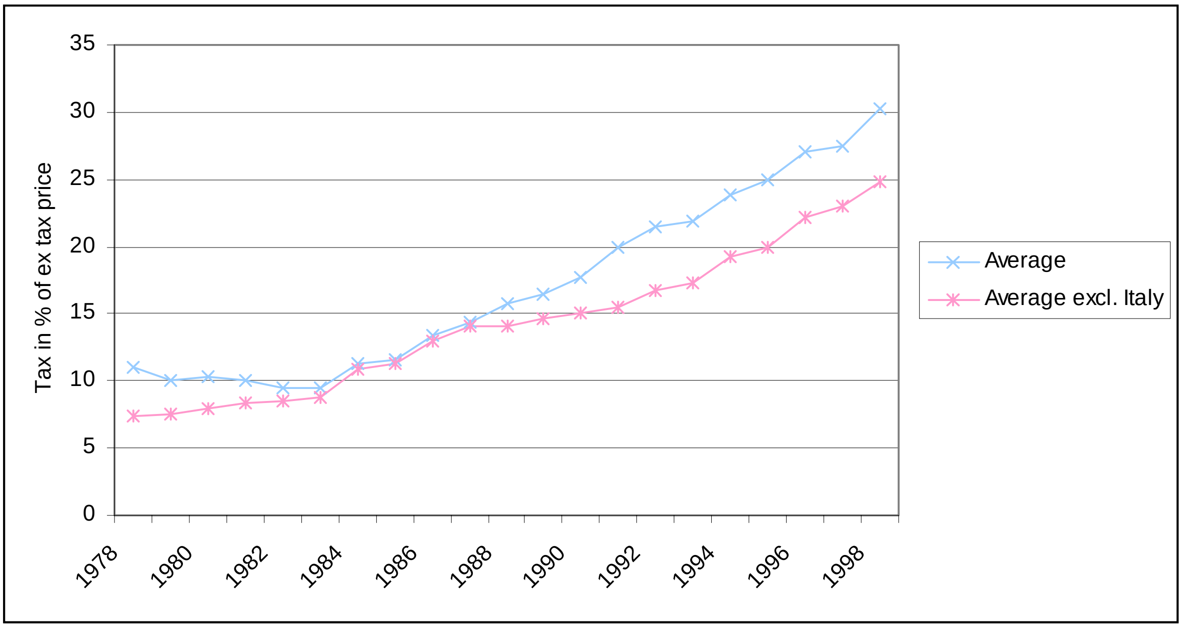


Figure 4. Average Tax in 12 European Countries on Natural Gas to Household Sector in Percent of Ex Tax Price

5. Econometric Analysis of Household Gas Demand

In the previous section we found that taxes on natural gas has increased in the household sectors of European countries. 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 to 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.

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 "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.[18]

In its most general form the demand model is specified as

(5.1) $y_i = X_i \beta_i + u_i, \qquad i = 1, 2, \ldots, N,$

[18] 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, β_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

(5.2) $\beta_i \sim IN(\mu, \Sigma)$,

or equivalently that

(5.3) $\beta_i = \mu + v_i$,

where $v_i \sim N(0,\Sigma)$. Equation (5.2) specifies the prior distribution of β_i in the Bayesian framework. The posterior distribution of β_i depends on μ and Σ. If μ and Σ are not known, priors must be specified. When μ, σ_i^2 and Σ are known, the posterior distribution of β_i is normal with mean and variance given by

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

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

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

If the matrix X_i include lagged values of y_i the normality of the posterior distribution of β_i^* holds only asymptotically and under the usual regularity conditions assumed in dynamic regression models.

In the empirical Bayes approach that we employ, we use the following sample-based estimates of μ, σ_i^2 and Σ in equation (5.4):

(5.6a) $\mu^* = \frac{1}{N}\sum_{i=1}^{N}\beta_i^*$

(5.6b) $\hat{\sigma}_i^2 = \frac{1}{T-k}\left(y_i - X_i\beta_i^*\right)'\left(y_i - X_i\beta_i^*\right)$

(5.6c) $\hat{\Sigma} = \frac{1}{N-1}\sum_{i=1}^{N}\left(\beta_i^* - \mu\right)\left(\beta_i^* - \mu\right)'$.

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

The equations (5.6) are estimated iteratively. In the initial iteration the OLS estimator $\hat{\beta}_i$ is used to compute μ^*, σ_i^2 and Σ^*. To improve convergence (5.6c) is modified as

(5.6c') $\hat{\Sigma} = \frac{1}{N-1}\left[R + \sum_{i=1}^{N}\left(\beta_i^* - \mu\right)\left(\beta_i^* - \mu\right)'\right]$,

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 μ and the heterogeneity matrix Σ than two-step procedures.

The demand for natural gas in the residential sector is specified as

(5.7) $$\ln y_{N,i,t} = \beta_0 + \beta_y \ln y_{N,i,t-1} + \sum_{f=E,F,N}\beta_f \ln p_{f,i,t} + \sum_{f=E,F,N}\beta_{f1} \ln p_{f,i,t-1} + \beta_I \ln I_t + \beta_{I1} \ln I_{t-1} + u_{i,t},$$

where p_f is the price paid by the residential sector for fuel f, f = E(lectricity), F(uel oil), N(atural gas), and I is income measured by private consumption. The own-price elasticity of natural gas demand is $e_{NS} = \beta_N$ and $e_{NL} = (\beta_N + \beta_{N1})/(1 - \beta_Y)$ 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 1 shows the shrinkage estimates of the natural gas demand elasticities in the household sector. Except for the electricity price, all elasticities have the expected signs. The electricity elasticities are small, however, and probably reflects that natural gas and electricity have different roles. According to Table 1 gas demand is most sensitive to income changes, and less sensitive to changes in the own price and the price of fuel oil.

Table 1. Shrinkage Estimates of Natural Gas Demand Elasticities in 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	-0.127	-0.158	0.142	0.177	0.007	0.009	0.537	0.669
Belgium	-0.115	-0.143	0.145	0.180	0.011	0.014	0.574	0.716
Canada	-0.082	-0.102	0.136	0.169	-0.022	-0.027	0.608	0.758
Denmark	-0.171	-0.213	0.202	0.252	-0.022	-0.028	0.429	0.535
Finland	-0.263	-0.328	0.164	0.205	-0.063	-0.078	0.356	0.444
France	-0.131	-0.163	0.156	0.195	-0.018	-0.023	0.552	0.688
Germany	-0.153	-0.191	0.159	0.198	-0.042	-0.052	0.524	0.653
Ireland	-0.223	-0.279	0.145	0.181	-0.066	-0.082	0.446	0.556
Italy	-0.115	-0.143	0.062	0.077	-0.111	-0.138	0.609	0.758
Netherlands	-0.072	-0.089	0.092	0.115	0.062	0.077	0.633	0.789
Spain	-0.133	-0.166	0.219	0.274	0.043	0.054	0.450	0.561
Switzerland	-0.167	-0.208	0.108	0.134	-0.119	-0.148	0.470	0.586
UK	-0.059	-0.074	0.153	0.191	-0.010	-0.012	0.612	0.763
USA	-0.070	-0.087	0.124	0.155	0.040	0.050	0.619	0.772

According to the Kyoto agreement fuel oil should have a higher tax than natural gas due to higher CO2 emissions per unit. One implication of the empirical results in Table 1 is that an increase in fuel oil taxes which is equal to or larger than a tax increase on natural gas leads to an increase in natural gas demand.

Given the estimated short run and long run demand elasticities we can calculate tax incidence by means of formula (2.5). 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 larger substitution possibilities. If we have supply elasticities available, exact incidence may be calculated by the formula. Given the technological structure of the industry, one can postulate rather small supply elasticities with a reasonably high capacity utilization.[19] For example, if the elasticity of supply is 0.7, then the incidence on producer price for two

[19] For discussions of the supply side structure in Europe, see e.g. Mathiesen, Roland & Thonstad (1987) and Golombek, Gjelsvik & Rosendahl (1998)

European countries representing the extremes in Table 1 with respect to own-price elasticities, the Netherlands and Finland, is –0.072/(0.7+0.072) = -0.093 for and -0,263/(0,7+0,263) = -0.273 in the short run, respectively. Figure 5 plots the tax incidence for these two countries for different supply elasticities.

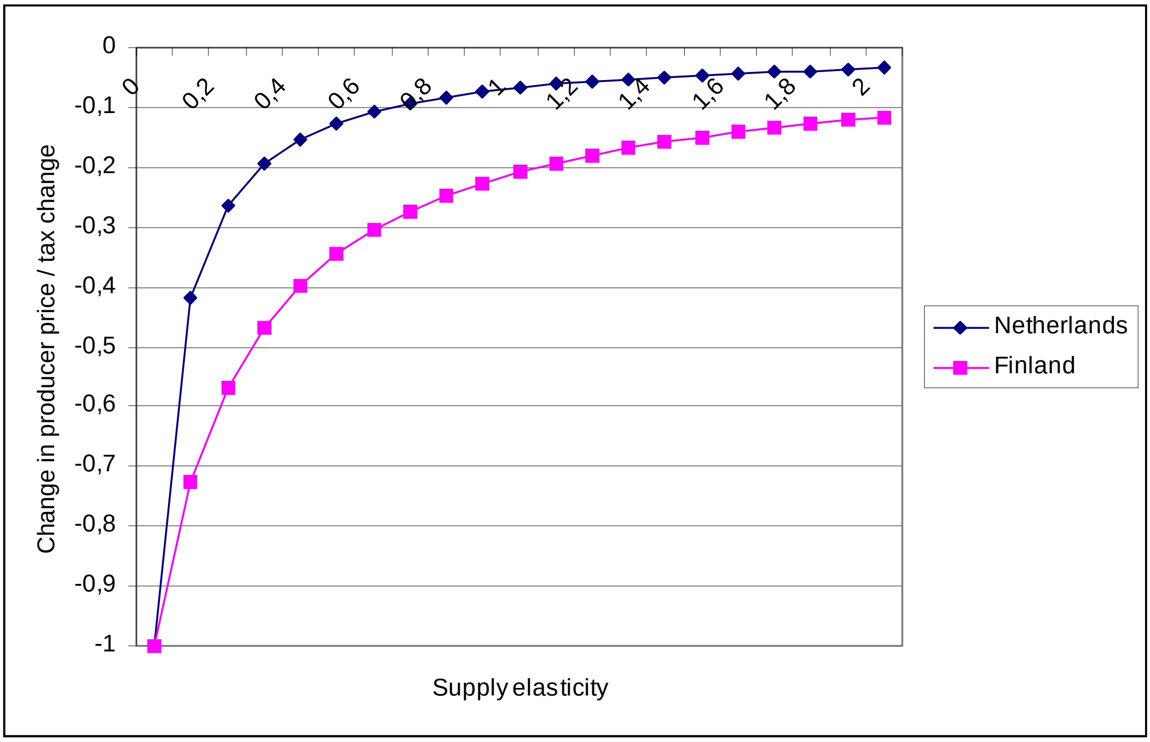


Figure 5. Ratio of Change in Producer Price to Tax Change for Netherlands and Finland

The analysis in this section provides some empirical insights on the effect of taxes on end-user prices in the household sector. Import prices should also decline when taxes increase in an end-user sector. However, as suggested earlier in this paper, the extent of backward tax shifting in the value chain is influenced by several institutional and technological factors.

We have examined tax incidence from the perspective of tax incidence theory, presuming spot markets. The spot market approach could be interesting in a situation of long-term contracts if spot market forces were decisive in renegotiations of the contracts, in terms of dictating the ex post bargaining power. In the next section we check whether this actually were the case, by using contract data to analyse the actual effect of taxes on import prices.

6. Empirical Analysis of Natural Gas Import Price Incidence

How has import prices (i.e. producers) been affected by the increase in taxes on households? If transmission companies and local distribution (T&LD) companies receive approximately a fixed fee per unit of the gas they bring from the border to the consumers, then the aggregate supply curve of producers will be a parallel curve below the aggregate supply curve of the T&LD companies. If a unit tax is introduced or increased, and supply curves are upwards sloping then the producer price and T&LD price should decline, according to tax incidence theory. Has this happened? If we go back to Figure 2 it is difficult to visually observe whether this has taken place.

In order to uncover the effect of taxes on import prices we estimate the following regression model:

$$(6.1) \quad \ln IMP_{i,t} = \alpha_i + \alpha_{OIL}\cdot\ln OIL_{i,t} + \alpha_{TAX}\cdot\ln TAX_{i,t} + \alpha_{PRIVCON}\cdot\ln CONCAP_{i,t} + u_{i,t},$$

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 consumption per capita – a proxy for income. The Brent spot price is included to account for the fact that natural gas contract prices 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 household sector demand curve. With an upward sloping producer supply curve we expect a positive relationship between private consumption and the import price. Country-specific effects α_i are included to capture cross-country differences in technology, competition and regulation which influence the import price. The log-log specification implies that the coefficients can be interpreted as elasticities.

Table 2 presents the empirical results from the import price regression model. Unfortunately, we have to drop the majority of observations due to the lack of import price data for many countries and years.[20] We first estimate a pooled model where $\alpha_i = \alpha_0$ for all i. The coefficients in this model have all the expected signs and are significant at conventional confidence levels. In particular, the estimate of α_{TAX} suggests that higher taxes in the household sector is associated with lower import prices, i.e., lower producer prices, in the pooled model.

Table 2. Empirical Results from Import Price Regression Model*

Coeff.	Pooled model			Fixed effects model		
	Coef.	St.Err.	t-ratio	Coef.	St.Err.	t-ratio
α_{OIL}	0,473	0,105	4,524	0,511	0,091	5,617
α_{TAX}	-0,029	0,007	-4,171	0,003	0,013	0,265
α_{CONCAP}	0,170	0,067	2,551	0,294	0,137	2,147
α_0	-4,230	1,371	-3,085	-7,360	3,102	-2,373

* N = 59 observations.

However, the results change when we estimate a model with country-specific fixed effects. Use of country-specific intercept is supported by an F-test with a test statistic of 4.06, which leads to rejection of homogeneity at the 1% level ((8,47) df). As in the pooled model, the import price increases significantly with a higher oil price and higher per capita income. But there is no longer a significant negative relationship between the import price and household taxes. Since, the fixed-effects models is the most credible, we are lead to conclude that in this sample increases in household sector taxes had a negligible effect on import prices. In other words, import countries have not been able to shift parts of the tax increases backwards to the producers. Thus, spot market forces have not been decisive in the renegotiations of the take-or-pay contracts.

One obvious reason for 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. Still, 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, some 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.

Conclusion

By deriving income elasticities and cross price elasticities, we have examined some of the general equilibrium effects of energy taxes. In addition, there are dynamic incidence effects to

[20] The following countries were included in our estimating sample: Austria, Belgium, Finland, France, Germany,

be considered. Tax increases on capital intensive industries may generally have the effect of reducing the market value of the capital assets, thus capitalising the effects of the tax change. An unexpected tax increase, in any part of the value chain, is likely to reduce the value of natural resource licenses and the value of irreversible investments made in extraction and transportation facilities. For countries that are net importers of energy it may therefore be tempting to raise energy taxes, at the expense of the exporting firms (windfall loss). This static gain for the importing country, however, would lead to dynamic costs in terms of reduced investment incentives, lower future energy supply, and higher prices in the future. Unexpected reductions in profits, being caused by regulations or tax increases, has a double investment disincentive effect. It not only reduces expected future returns but also induces political risk. Exporters may suspect that gas taxes are kept low initially, to develop gas infrastructure, and increased when gas penetration is high. Note that this not necessarily would have to be a clever scheme designed to capture resource rents, but rather a natural development in tax design. At first, gas development in the importing countries are typically headed by the ministry of energy in each individual country. When gas consumption rises it raises the attention of the ministry of finance (or the EU) who discovers a potential new source of tax revenue.

Energy taxes may also have implications for the reliability of supply, as we have seen for the supply of electricity in California. In that case, supply fell due to price regulations, reducing the producers' margins. An increase in energy taxes will - as we have demonstrated - be partly shifted to the producers and thus have the same effect of reducing margins and investment incentives. Resource extraction has long lead times. Exploration and resource estimation is a time consuming process and field development usually takes several years. Also, the development in supply is often not smooth, due to large average size of new development projects. Negative supply shocks can therefore not be precluded.

Tax incidence for different types of energies in different market segments are vital inputs to the strategy generating process of petroleum companies. In developing optimal export strategies, the companies will have to ascertain the probability of a rent capturing strategy by various importing countries. To reduce the extent of this type of downside risk, two types of strategies may be pursued, 1) maintaining export flexibility, and 2) reducing the possibility for rent capturing by contractual terms. In spot trading, e.g., for oil, the first strategy is the traditional choice. Export flexibility in this setting requires interoperability of

Italy, Netherlands, Spain, UK.

transportation systems and a certain number of alternative commercial outlets for the oil that is extracted. If an importing country unilaterally increases its oil consumption tax, oil exporters thus have the possibility of diverting their exports away from that particular country. This corresponds to exporting countries having high supply elasticities for exports to any particular country, implying that a unilateral increase in consumption energy taxes must to a large extent be borne by the consumers of that particular country. In case of a coordinated tax increase in a number of importing countries, however, producers have not the same possibility to shift taxes to consumers. Coordinated imported tax increases thus pose a considerable commercial risk for energy exporters.

Gas exports are – for technical and economic reasons - most often transmitted by means of pipelines. Presently, this implies limited export flexibility, 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. Our preliminary empirical findings indicate that these contracts so far have been able to protect the exporters of natural gas from rent capture by the importing countries.

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