Discussion Paper No. 12-064

Financial Intermediaries and Emissions Trading

Market Development and Pricing Strategies

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Non-Technical Summary

In this paper, the role of intermediaries, e.g. banks, under quantity based regulation with tradeable permits is examined. An example is the EU Emissions Trading Scheme (EU ETS). In the EU ETS, the total amount of eligible greenhouse gas emissions is fixed in a certain period of time and must not be exceeded. Per unit of emissions, one permit is assigned. Regulated firms are free to trade these permits on the open market, which allows achieving the environmental objective of not exceeding the total amount of emissions in an economically efficient way.

Trading of emissions permits is often arranged by intermediaries. Surveys amongst German companies regulated by the EU ETS showed, that most companies trade permits with the help of intermediaries instead of directly becoming active at the exchange. Direct trading at the exchange is mostly done by larger emitters. This paper first examines the choice of regulated firms to trade with intermediaries or directly at the exchange. In a second step, pricing strategies by intermediaries are discussed with a special focus on the possibility of monopolistic or monopsonistic pricing. The model shows that there is no chance for monopolistic or monopsonistic pricing by intermediaries if there are at least two non-colluding intermediaries in the market. A model of monopsonistic pricing for the case of a single intermediary in the market is discussed in detail.

Model applications, based on empirical data and official compliance data form the EU ETS in Germany show that under a competitive situation, the fees charged by intermediaries for permit trading services are rather small (less than 2% of the value of traded assets). Total costs for trading of allowances in the case of a single non-competitive intermediary are assessed to be six-times higher than in the competitive setup. For the EU ETS it can be concluded that there is no reason to expect monopolistic or monopsonistic pricing by intermediaries.

Das Wichtigste in Kürze

Dieses Arbeitspapier befasst sich mit der Rolle von Intermediären, z.B. Banken, in Regulierungssystemen, die auf handelbaren Eigentumsrechten basieren. Ein Beispiel dafür stellt der EU–Emissionshandel (EU–EHS) dar. Im EU–EHS ist die Gesamtmenge zulässiger Treibhausgasemissionen europaweit festgeschrieben und darf nicht überschritten werden. Pro Einheit an Emissionen wird ein Emissionsrecht ausgestellt. Regulierten Unternehmen steht es frei, diese Emissionsrechte auf Märkten zu handeln, wodurch das Umweltziel (Nicht-Überschreitung der Höchstmenge an Emissionen) kosteneffizient erreicht werden kann.

Der Handel mit Emissionsrechten wird oft mit Hilfe von Intermediären durchgeführt. Umfragen zeigten, dass die Mehrzahl der im EU–EHS in Deutschland regulierten Unternehmen nicht direkt an der Börse aktiv wird, sondern in direktem Kontakt mit Intermediären Emissionsrechte handelt. Direkter Handel an der Börse wird vor allem von großen Emittenten betrieben. In diesem Papier wird zunächst die Entscheidung regulierter Unternehmen für den Handel mit Intermediären oder den direkten Handel an der Börse modelliert. Anschließend werden Preibildungsstrategien von Intermediären beleuchtet und dabei insb. die Möglichkeit monopolistischen oder monopsonistischen Verhaltens von Intermediären in Erwägung gezogen. Im theoretischen Modell zeigt sich, dass monopolistisches oder monopsonistisches Verhalten von Intermediären höchst unwahrscheinlich ist, so lange mindestens zwei Intermediäre auf dem Markt aktiv sind. Ein Modell monopsonistischer Preisbildung für den Fall eines einzigen im Markt aktiven Intermediärs wird ausführlich dargestellt.

Modellanwendungen auf Basis empirischer Daten aus dem EU–EHS in Deutschland zeigen, dass unter kompetitiven Bedingungen die von Intermediären geforderten Entgelte für den Handel mit Emissionsrechten vergleichsweise gering sind (weniger als 2% des Wertes gehandelter Zertifikate). Für den Fall eines einzelnen nicht–kompetitiven Intermediärs würden die Gesamtentgelte etwa sechsmal so hoch ausfallen wie unter kompetitiven Bedingungen. Für das EU–EHS kann nicht davon ausgegangen werden, dass Intermediäre monopolistische oder monopsonistische Preise setzen können.

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Abstract

This paper examines the role of intermediaries in quantity regulation theoretically and presents a data application to the EU Emissions Trading Scheme (EU ETS). The choice of regulated firms to trade permits through intermediaries or directly at the exchange is discussed. Permit pricing strategies of intermediaries and possible issues of market power of intermediaries are modeled. Based on empirical data, the model application aims to assess the actual costs (fees, fixed costs) from permit trading, which represent costs of transacting. In a competitive setup, costs are relatively modest with about 1% to 2% of the permit price. In the EU ETS, firms that trade more than 283,000 tCO_2/year are likely to directly access the exchange while others trade with intermediaries. In the unlikely event of an intermediary having market power, overall costs would be six times higher in the model application. Options for regulated firms to access a permit exchange directly at low costs decrease the costs of transacting considerably in a competitive and non-competitive intermediary market.

Keywords: permit trading; financial intermediaries; market power
JEL-Classification: Q52; D42; D21

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1 Introduction

Trading of emissions allowances is a central feature of quantity regulation and fluid exchange of permits between entities with different marginal appreciation of emissions allowances is required for a least–cost solution to be achieved. For quantity–based regulation schemes in the United States it was reported that 'sticky' trading limited the success of regulation in terms of economic efficiency. While cost reductions compared to previous command–and–control approaches were realized, strict cost efficiency was not achieved [10, 12]. Transaction costs for permit trading are a potential source of efficiency losses in schemes of tradeable permits, firstly compared to a first–best situation with zero transaction costs and secondly, compared to regulation by prices, where no trading of allowances occurs [25, 22, 6].

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Intermediaries potentially play an important role in organizing permit trades at least costs mostly by decreased costs for searching and negotiating [5]. For the EU Emissions Trading Scheme (EU ETS), considerable activities of intermediaries in the permit market are reported. After the scheme started in 2005, a large number of intermediaries entered into the market, supplying services for regulated firms, including permit trading [4]. For the case of Ireland, it was reported that firms became active in permit trading with the help of intermediaries [15]. For Germany it was reported that most firms trade permits with the help of intermediaries. A survey from 2012 reported that 12.5% of firms in the EU ETS in Germany traded directly at the exchange, while the remaining firms did not [2, 19, 18]. In fact, intermediaries helped to keep the transaction costs for trading of allowances relatively moderate in the early years of the EU ETS [11].

It is commonly understood that firms specialize on task in which they have comparative advantages and that other tasks might be 'outsourced', i.e. goods and services are purchased on the market instead of produced inside the firm. While Coase [3] expected the cost for transacting to shape markets and firms, Alchian and Demsetz [1] suggested that the structuring of labor inputs in the sense of 'team production' are an important determinant of what is produced inside the firm or purchased from the market. Both arguments might be useful to explain the existence of intermediaries in markets for tradeable permits. If a firm regulated by an emissions trading scheme has no comparative advantage in managing financial products, like emissions allowances, then it will have an incentive to purchase the service of managing permit trades on the market. Dependent on the design of the regulation scheme, e.g. which firms are regulated, intermediaries could be an important part of emissions trading by reducing costs of transacting by offering services in which they have comparative advantages. To my best knowledge, the role of intermediaries in markets for tradable permits has so far not been examined in detail.

A few questions seem to be unanswered so far. Firstly, how do regulated firms decide whether they trade with the help of intermediaries or directly at the exchange? Secondly, how do intermediaries behave in the market for permits, i.e. how are their pricing strategies and is there potentially the risk of market power of intermediaries? While there are a number of contributions to potential market power of regulated firms [8, 7, 9, 14, 16, 17, 20, 21, 24, 27, 28, 16], there are so far no contributions on market power of intermediaries in the literature on environmental regulation. If intermediaries charge fees for their services, those fees represent costs of transacting on the permit market and will potentially decrease economic efficiency of quantity–based regulation [12, 25]. Therefore, an assessment of the magnitude of charged fees is of interest to evaluate potential impacts on economic efficiency of tradeable permits.

In the following section, a simple model is developed that explains the choice of the trading mode (intermediary vs. direct trading at exchange) of firms regulated by tradeable permits. It is shown that the choice of the trading mode is dependent on the number of traded permits in a certain period of time. Firms that trade larger volumes of permits are more likely to trade directly at the exchange compared to firms that trade smaller volumes. The result is derived by a simple fixed–cost argument and is supported by empirical data [2, 19, 18].

Section 3 focuses on permit pricing strategies of intermediaries. If there are (at least) two or more intermediaries in the permit market, a competitive market will evolve. In the unlikely case that one single intermediary is active in the permit market, the intermediary will have market power. A simple pricing scheme is developed where prices under market power are dependent on the individual characteristics of regulated firms (i.e. abatement costs, unrestricted emissions, and free allocation).

An application of the model is presented in Section 4. First, the case of competitive intermediaries is examined based on empirical findings and official compliance data from the EU ETS in Germany. The application results imply that unit fees charged by intermediaries are relatively small. To contrast the competitive case to the hypothetical case of a market with *one* intermediary with market power, the simple model presented in Section 3 is populated with German compliance data from the EU ETS. A central result of the model application is that total costs for permit trading (fees and fixed costs for exchange trading) are about six times higher in the hypothetical non–competitive case with an intermediary having market power, compared to the case of a competitive market.

2 The Choice of the Trading Mode

Suppose an emitter under regulation by tradeable permits that receives less allocation than its actual emissions and is a net buyer of permits. The firm has no preexisting trading desk and no staff experienced with exchange trading. If the firm wants to become active at an exchange to purchase permits, it has to install a trading desk. This would be associated with fixed costs of m[1]. The marginal permit price is assumed to equal the market price at the exchange g. Costs for trading a number of s permits on an exchange are

$$c_t = m + gs. \tag{1}$$

Alternatively, the firm may consult an intermediary to purchase permits. The intermediary offers a price $p \geq g$ for each permit purchased on behalf of the regulated firm[2]. The intermediary charges a trading fee per permit that is given by f

$$f = p - g. \tag{2}$$

[1]Fixed costs could include fees, hardware, trading software, proof of liquidity, staff training, security measures, change of organizational processes, etc. For a trading account at the European Energy Exchange (EEX) for example, fees of at least EUR 20,000 per year apply.

[2]To simplify this section, only firms that purchase permits are considered. However, assuming a symmetric fee f, the case of a firm that sells permits can be easily implemented. If the firm sells permits, the intermediaries offer would be $p_s \leq g$ with $f = g - p_s$.

The firm decides which option for permit trading it will choose by comparing the costs of intermediary services and exchange trading and choosing the option with the lowest costs. For the case of permit purchases, the firm minimizes costs by solving the problem

$$\min \quad c = \begin{cases} ps, & \text{if intermediary service with } \; p \geq g \\ m + gs, & \text{if exchange trading.} \end{cases} \tag{3}$$

Figure 1 illustrates the case of a firm that is a net buyer of permits. The firm can choose between trading at an exchange with costs $m + gs$, and the intermediaries price offer ps according to (3). As the Figure shows, the choice of the trading mode by the regulated firm is dependent on the amount of traded permits s. Equating $ps = m+gs$ and solving for s yields the threshold trading volume $\bar{s}$ that determines the choice between using intermediary services and internal exchange trading of a regulated firm. For trading volumes $s \leq \bar{s}$ (given m, p and g), intermediary services are considered. For $s > \bar{s}$ the firm installs a trading desk and purchases permits directly at the exchange. Equating $ps = m + gs$ and solving for s yields the intersection of the cost functions

$$\bar{s} \quad = \quad \frac{m}{p - g}. \tag{4}$$

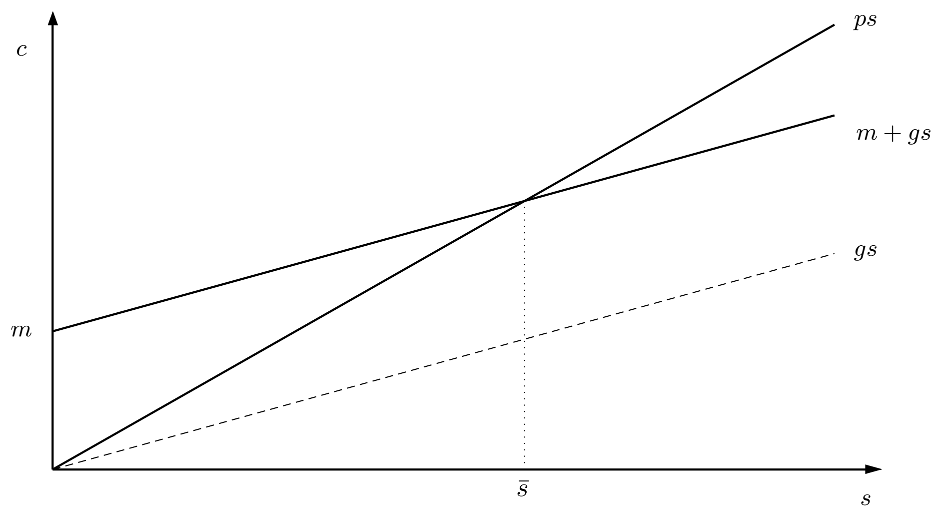

Figure 1: Costs of installing an internal trading desk ($m + gs$) and making use of intermediary services (ps) plotted on the number of traded permits s. For $s < \bar{s}$, the firm will trade with help of an intermediary. When $s \geq \bar{s}$, the firm will install an internal trading desk. The densely dashed line (gs) are the costs without additional fixed costs or fees.

For a given trading volume s, and prices g, and p, fixed costs m determine the choice of the trading mode. Consequently, a threshold value of m can be derived. Solving $ps = m + gs$ for fixed costs m yields

$$\bar{m} \quad = \quad s(p - g). \tag{5}$$

The assumption that the intermediary charges a unit fee f simplifies the model. If the fee also incurred a fixed cost component, the model would hold as well. A pure fixed fee charged by the intermediary would lead to a situation where the choice of the trading mode is independent of the number of traded permits. The firm would trade with the intermediary if the fixed fee is below the fixed costs for installing a trading desk m and vice versa.

The simple approach taken above shows that the choice of the trading mode (intermediary service vs. exchange trading) is dependent on the number of traded permits s and fixed costs for becoming active at an exchange m. It is motivated by the empirical finding that firms with smaller trading volumes did not trade permits at exchanges in the first and second trading period of the EU ETS, while firms with larger trading volumes became active at exchanges [2]. Relaxing the assumption that firms can trade permits at market price g and allowing for fixed costs and unit fees in permit trading thus leads to different trading strategies of firms with different trading volumes and helps to explain the empirical evidence found for the EU ETS. The model assumes linear unit–costs for trading when trading with an intermediary and size–dependent unit–costs when trading at the exchange. While this assumption considerably simplifies the analysis in the following section, the approach differs to previous contributions such as Stavins [25] who explicitly mentions that unit fees taken by intermediaries might be dependent on the amount of traded permits and are therefore non-linear. While general transaction costs for permit trading will include unit fees as well as other expenditures, e.g. for information gathering and labor costs, total transaction costs might exhibit a non-linear structure and will be size–dependent (i.e. dependent on the number of traded permits) even in the case of non-size dependent unit fees as assumed here. Empirical studies suggest that, for the case of the German EU ETS, transaction costs for permit trading (excluding fees) show mild size dependence, which implies scale economies in the general management of permit trading [13].

3 Permit Pricing by Intermediaries

Since fees charged by intermediaries in the permit market influence the choice of the trading mode of regulated firms, the pricing strategy of intermediaries comes into focus. Pricing strategies may be determined by two main aspects. Firstly, by the number of intermediaries in the permit market, and secondly, by the 'reaction' of regulated firms to the intermediaries' price. Whether or not there is a competitive situation in permit supply by intermediaries is determined by the number of intermediaries active in the market. However, even in a non–competitive situation of permit supply, regulated firms would have the option to 'escape' the non–competitive pricing by intermediaries and purchase permits directly at the exchange. Subsection 3.1 examines the case of two or more intermediaries in the permit market, which will lead to a competitive situation. Subsection 3.2 examines the (unlikely) case of only *one* intermediary active in the market which behaves as a monopsonistic supplier of permits. In that case, the intermediary can offer a monopsonistic price, however, limited by the firm's options of becoming active directly at an exchange.

To examine the intermediaries pricing strategies, the regulated firm's demand for permits needs to be derived. The regulated firm's costs for pollution control are determined by abatement costs α and are dependent on the amount of pollution abatement

q. The abatement cost function is continuously differentiable so that $\frac{d^2 c_f}{dq^2} > 0$ for $q > 0$. Abatement costs are given by

$$c_f = \frac{1}{2}\alpha q^2. \tag{6}$$

The firm minimizes costs by choosing abatement quantity q. Its unrestricted emissions are q_0 and freely allocated permits are a. It is assumed that $a < q_0 - q$ and the firm is a net permit buyer. It considers the permit price p offered by the financial intermediary. The firm faces the problem

$$\min_q \quad \left[\frac{1}{2}\alpha q^2 + p(q_0 - q - a)\right]. \tag{7}$$

Solving problem (7) yields the optimal amount of abatement given the permit price p, which is the firm's reaction function to changes in the permit price

$$q_p = \frac{p}{\alpha}. \tag{8}$$

The regulated firm's demand for permits $s > 0$ equals the number of permits it will purchase when solving problem (7).

$$s = q_0 - q_p - a. \tag{9}$$

Substituting q_p in (9) by (8) yields the permit demand function in equilibrium

$$s = q_0 - \frac{p}{\alpha} - a. \tag{10}$$

3.1 Two or More Intermediaries

From the Bertrand paradox it follows that a number of (at least) two non-colluding intermediaries will be sufficient to generate a competitive environment on the permit market since there are no capacity constraints in permit supply by intermediaries[3], permits are a homogeneous good, and prices are set simultaneously [26].

Suppose the intermediaries' costs for supplying permits to a regulated firm are dependent on fixed costs c, costs for acquiring permits on the market g, and the number of permits s acquired for the firm

$$c_i = c + gs. \tag{11}$$

Then, in a market with two or more intermediaries, the permit price offered to a regulated firm would be equal to the marginal costs of the intermediaries

$$p_c = g. \tag{12}$$

[3]While a quantity constraint under quantity regulation generates a price, the quantity constraint is assumed not to be so strict that it hampers trading by intermediaries. Therefore, permits are assumed to be available on a market and that the quantity constraint only influences the price of permits but not their availability.

Intermediaries may charge fees for their services. This could be modeled by introducing an additional cost term in the intermediary's cost function (11)[4], but is omitted since it would unnecessarily complicate the analysis of non–competitive pricing. If intermediaries traded permits at price g without charging additional fees, no regulated firm would have an incentive to trade at an exchange, which is in contrast to empirical findings for the EU ETS [15, 2, 18, 19]. Fees charged by intermediaries are reconsidered in the data application in Section 4.

So far, the analysis has shown that intermediaries will behave competitive in allowance trading due to the homogeneous character of emissions allowances if there are at least two intermediaries in the market. An exemption would be the case of non-homogeneous permits, for example offset permits from the Clean Development Mechanism (CDM). From 2013 onwards, CDM permits from the destruction of industrial gases will be no longer eligible for compliance in the EU ETS. For the special case of CDM permits trading between intermediaries and firms regulated by the EU ETS, the Bertrand paradox might possibly not hold.

In principle it is possible that there will be only *one* intermediary in the market for allowances. Although this might not be true for the case of the EU ETS, pricing by a monopolistic/monopsonistic intermediary is examined in the following section.

3.2 A Single Intermediary

A monopsonistic supplier of permits would aim to maximize its return from permits sells. To do so, the intermediary equates the marginal revenues from permit sells to the marginal costs of acquiring permits on the market. The intermediaries costs are given by (11). The intermediaries revenue is derived by resolving the firms permit demand function in equilibrium (10) for p and multiplying by the number of traded permits s

$$R_i = (q_0 - s - a)\alpha s. \tag{13}$$

Equating marginal costs and marginal revenues, and solving for the amount of traded permits s yields the amount of permit sells to the firm that would maximize the intermediary's return

$$s_m = \frac{-g + \alpha(q_0 - a)}{2\alpha}. \tag{14}$$

The intermediary could offer the firm a price p_m that would incentivize the firm to purchase the amount of permits s_m that maximizes the intermediary's return. The monopsonistic permit price is given for $p_m = \alpha(q_0 - s_m - a)$, where the firm is in its internal cost minimum given its reaction function (8). Substituting s_m yields the monopsonistic price offer

$$p_m = \frac{1}{2}(g + \alpha(q_0 - a)). \tag{15}$$

[4]The cost function could be written as $c_i = c + gs + fs$, where f are administrative costs of the intermediary. In that case, the competitive permit price would be $p_c = g + f$, where f represents the 'fee'. Since adding an additional cost term would not change the results of the analysis of non–competitive pricing, but would increase complexity, the cost function is simplified as in Equation (11) and administrative costs of the intermediary are omitted.

The markup is dependent on the permit price on the market g, the firm's free allocation a and its unrestricted emissions q_0, and is positive as long as the firm is a buyer of permits. It is given by

$$f_m = \frac{1}{2}(\alpha(q_0 - a) - g). \tag{16}$$

Monopsonistic price setting is limited by two aspects. Firstly, the reaction function of the regulated firm (Equation 8). As the price offered by the intermediary rises, the firm abates more and its demand for permits decreases. As the price offer by the intermediary decreases, the firm abates less and its demand for permits increases. This has an impact on the revenues of the intermediary. The optimal (monopsonistic) number of sold permits is therefore given by s_m (14) at price p_m (15). The intermediary needs full information about the firm's reaction function to implement the monopsonistic price. Uncertainty about the firm's reaction to price changes will limit the options for monopsonistic pricing.

Secondly, the firm has the option to trade permits on the exchange with fixed costs m (Equation 3). The threshold trading volume, as derived in Equation (4), will determine if the firm trades with the intermediary at price p_m or becomes active at the exchange. Plugging p_m into Equation (4) yields the monopsonistic threshold trading volume $\bar{s}_m$ which is given by

$$\bar{s}_m = -\frac{2m}{g + (a - q_0)\alpha}. \tag{17}$$

For trading volumes $s > \bar{s}_m$, the firm would trade permits on the exchange instead of purchasing permits from the intermediary at price p_m. As a reaction to the ability of the firm to trade at the exchange, the intermediary could offer the monopsonistic price p_m if $s \leq \bar{s}_m$ and an alternative price if $s > \bar{s}_m$. The best responds of a monopsonistic intermediary to the firm's ability to trade at the exchange would be to mimic the firm's costs for exchange trading as in Equation (1) and offer an alternative unit–price not exceeding

$$p_n = g + \frac{m}{s}. \tag{18}$$

Under the assumption that there is only *one* intermediary in the market, the intermediary could charge the monopsonistic price p_m for trading volumes less or equal the critical trading volume ($s \leq \bar{s}_m$) and a price p_n for trading volumes above the threshold ($s > \bar{s}_m$). Price p_n is below the monopsonistic price, above the competitive price, and does not exceed the costs of a firm to trade on the exchange. Thus, the monopsonistic intermediary would discriminate prices depending on the actual volume of trades (Figure 2).

3.3 The Difference between Purchasing and Selling

In the previous sections a firm that is net purchaser of permits was assumed to simplify the model. If a firm would be a net seller of permits, the model would still hold, but instead of fees or markups that are added to the permit price g, fees or markups would have to be subtracted. Assuming a symmetric fee f that applies when permits are

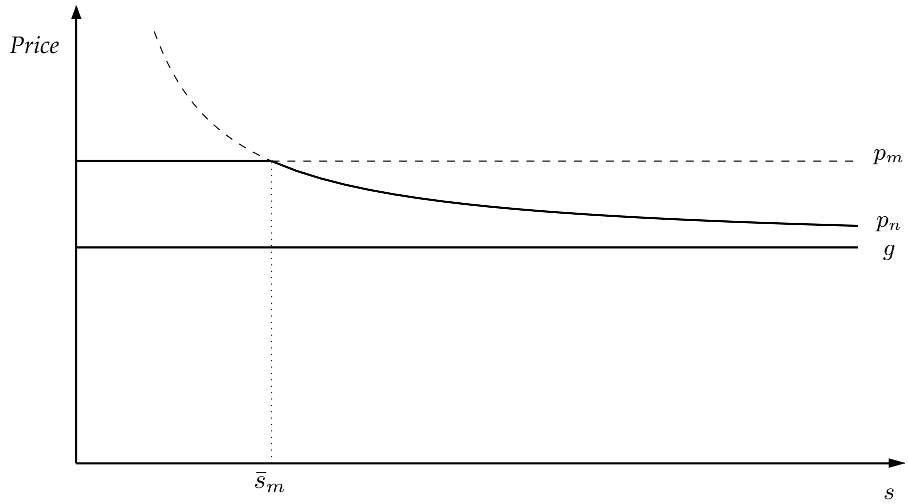

Figure 2: Price discrimination by an intermediary with market power. The intermediary offers the monopsonistic price p_m for trading volumes $s \leq \bar{s}_m$. For trading volumes $s > \bar{s}_m$, the mimicking price p_n is offered. Regulated firms with a preexisting trading desk trade at the market price g because they face no additional costs from introducing trading.

purchased or sold, there will be a spread in actual perceived permit price by firms dependent if they are net seller or net buyer of permits. If the firm trades with an intermediary at a price p, the spread will be

$$p = \begin{cases} g + f, & \text{if net purchaser} \\ g - f, & \text{if net seller.} \end{cases} \tag{19}$$

If the firm trades at the exchange, a spread will result from fixed costs for trading. The actual perceived permit price p is given for

$$p = \begin{cases} g + \frac{m}{s}, & \text{if net purchaser} \\ g - \frac{m}{s}, & \text{if net seller.} \end{cases} \tag{20}$$

In both cases, costs for participating at the market lead to a deviation from the market price g. If the firm is net purchaser of permits and faces costs, fees increase costs. If the firm is net seller of permits, fees decrease the revenue from selling permits. If fees or markups are small, this will have almost no effect on the final outcome of regulation or the final allocation of resources. However, if fees or markups are considerable, it will lead to a situation where the final allocation is dependent on the initial allocation of permits, i.e. if the firm is net seller or net purchaser of permits (Figure 3). This is because price $p = g + f$ will result in different abatement volumes than price $p = g - f$. If there is more than one regulated firm, each firm will approach its cost minimum given the fee. However, since economic efficiency of regulation by quantities requires that abatement costs of all sources are equated so that no source can abate at lower costs, economic efficiency could be decreased if per unit fees differ between firms or if some firms are net sellers while others are net buyers.

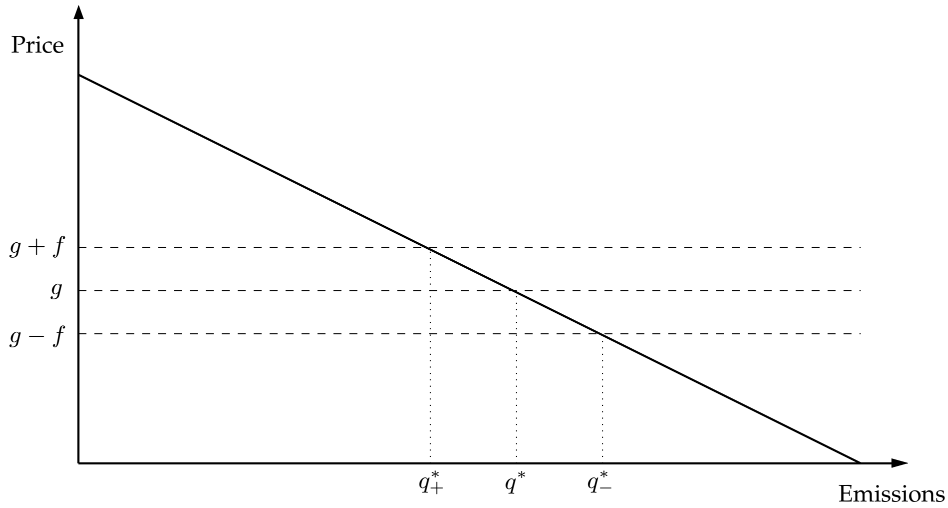

Figure 3: Actual abatement when fees f are taken into account for abatement decisions. The abatement volume without any costs for selling/purchasing permits is q^*. If fees apply for trading, q^*_+ is the abatement level for a firm that is net purchaser of permits and q^*_- is the abatement level for a firm that is net seller of permits.

4 Application: The EU ETS in Germany

Based on official compliance data and survey data from German firms in the EU ETS, the model from Section 2 and 3 can be populated with real world data. Compliance data of German firms are aggregated from the installation level (about 1,700 installations) to the firm level (816 firms). Aggregation is essential to achieve 'correct' trading volumes since trading is organized at the firm level rather than on the installation level.

In a first application, the unit fees for permit transactions in a competitive situation are determined. Survey data of German firms in the EU ETS that link the firm's choice of the trading mode (intermediary vs. exchange) to their net trading volumes are used to determine the unit fees that are required to reproduce the trading pattern based on the model from Section 2. The application is scaled-up from the small survey sample to all firms in the German EU ETS by feeding-in the trading fees. In a second application, the hypothetical outcome of a market with a monopsonistic intermediary is examined using the pricing strategy developed in Section 3.2. Unit fees for trading and exchange traded volumes are compared for the competitive and non–competitive (monopsonistic/monopolistic) case to allow for a comparison of market efficiency in both cases.

4.1 Actual Trading Patterns in Germany

A sample of 56 out of 816 firms in the German EU ETS is available that documents the trading activities of firms and is merged with official compliance data. In the sample 12.5% of firms trade directly at the exchange [2]. Firms that trade directly at the exchange also trade otherwise, e.g. 'over the counter', in bilateral trades, and with banks. The remaining firms trade with the help of intermediaries, which can be banks or bilateral trades with other firms, but are not active on the exchange. Firms that trade on the exchange in average run 12 installtions, while firms that are not active on the exchange run in average 2 installations. Firms that are active at the exchange also have higher annual emissions (1.4 million tCO_2 in median[5]) compared to firms that are not active at the exchange (0.076 million tCO_2 in median). Also annual trading volumes, defined as the absolute value of the difference between annual emissions and annual free allocation, differ strongly between firms that trade at the exchange (730,000 tCO_2 in median) and firms that do not trade at the exchange (28,000 tCO_2 in median). Thus, the choice of the trading mode clearly is dependent on emission levels and trading volumes of firms in the sample. The larger the emission levels and trading volumes of a firm, the higher the probability that it becomes active at the exchange.

Table 1 shows the unit fees f that are required to reproduce the share of 12.5% of firms trading at the exchange for different fixed costs to set up a trading desk m. At fixed costs of EUR 50,000[6], the unit fee that reproduces the survey's result amounts to EUR 0.176, or 1.2% of the permit price when the price would be EUR 15 (average price level in the EU ETS from 2008 to June 2011). The result can be easily reproduced by using Equation (4). At $m = 50,000$ and $f = 0.176$, the threshold trading volume $\bar{s}$ where exchange trading could be implemented in a cost efficient way is given by $m/f = 284,091$.

While fixed costs m have a relatively strong impact on the unit fee that is required to reproduce the empirical pattern of 12.5% firms trading at the exchange, the treshold trading volume $\bar{s}$ is relatively high and comparably robust for changes in fixed costs m. As shown in Table 1, the treshold volume of traded permits is above 283,000 tCO_2 for reasonable values of m.

Fixed costs m (EUR)	Unit fee f (EUR)	f/EUR15	$\bar{s}$ (tCO_2)
30,000	0.106	0.007	283,019
40,000	0.141	0.009	283,688
50,000	0.176	0.012	284,091
60,000	0.211	0.014	284,360
70,000	0.246	0.016	284,553
80,000	0.281	0.019	284,698
90,000	0.317	0.021	283,912
100,000	0.352	0.023	284,091

Table 1: Unit fees f (in Euro) required to have 12.5% of firms in the survey sample (n=56) trading at the exchange at fixed costs for installing a trading desk m (in Euro). f/EUR15 is the cost share of unit fees at permit price EUR 15. $\bar{s}$ (tCO_2) is the threshold trading volume (Equation 4).

Now that the required fees f that reproduce the observed trading patterns given fixed costs for exchange trading m are derived, the fees are applied to *all* firms regulated by the EU ETS in Germany (n=819) to obtain trading patterns in the population. Given fee f and fixed costs for exchange trading m, effective costs are calculated for both trading options (intermediary vs. exchange trading) dependent on the number of traded permits of each firm and the chosen trading model (intermediary vs. exchange). The trading volumes implied by the data $\hat{s}_i$ are given by free allocation in 2011 minus veri-

[5]Since there is large variation in annual emissions and annual trading volumes, the median is used instead of the mean.

[6]For a trading account at the European Energy Exchange (EEX) for example, fees of at least EUR 20,000 per year apply for a full trading account by June 2012 according to official EEX documents. Internal costs for the firm to set up the trading desk might lead to fixed costs in a range of 30,000 to 50,000 or higer. In 2012, EEX announced to offer a special discount for firms that wish to participate *only* at public permit auctions.

fied emissions in 2011[7].

Each firm chooses its trading mode as given by Equation (3). After each firm has decided on how to trade allowances, the total costs for intermediary services or exchange trading can be calculated. Firms that decide for intermediary services pay a fee per unit of traded allowances and face costs $\hat{s}_i \cdot f$. Firms that decide on exchange trading face fixed costs m.

m EUR	f EUR	% Firms at exchange	% Emissions at exchange	% Traded at exchange	Costs (total) mEUR	Costs (average) tEUR
30,000	0.106	5.37%	77.53%	86.78%	3.6	4.4
40,000	0.141	5.25%	77.32%	86.59%	4.8	5.9
50,000	0.176	5.25%	77.32%	86.59%	6.0	7.3
60,000	0.211	5.25%	77.32%	86.59%	7.2	8.8
70,000	0.246	5.25%	77.32%	86.59%	8.4	10.2
80,000	0.281	5.25%	77.32%	86.59%	9.6	11.7
90,000	0.317	5.25%	77.32%	86.59%	10.8	13.1
100,000	0.352	5.25%	77.32%	86.59%	12.0	14.6

Table 2: Percent of Firms that trade at the exchange with their share of emissions in the German EU ETS and the corresponding share of traded permits. Costs are displayed on the right hand side with total costs in million EUR and average costs per firm in thousand EUR.

Table 2 shows that rising fixed costs and fees have almost no effect on the number of firms that trade at the exchange and the share of traded emissions at the exchange. This is because the threshold trading volume $\bar{s}$ in Table 1 is unsensitive for changes in fixed costs m and fees f when reproducing the empirical pattern. Table 2 also shows that the larger share of traded permits is traded at the exchange (86% of about 154 million permits) and that these large volumes are traded by a small number of firms (about 5% out of n=819). Total costs and average costs per firm are sensitive to changes in fixed costs m and fees f. Since the fees were derived so that the empirical trading patterns in the small sample could be mimicked (Table 1) for given fixed costs m, fixed costs are the main driver of total and average costs in Table 2. Since a trading account for carbon permits, for example at the European Energy Exchange (EEX), comes at costs of about EUR 20,000 and additional internal costs (personal costs, hardware, training of staff etc) apply, fixed costs of $m = 50,000$ seem to be a good guess for actual fixed costs for exchange trading. At $m = 50,000$, total costs amount to EUR 6 million and average costs per firm are EUR 7,300 with a quiet large standard deviation of EUR 13,000[8].

4.2 Hypothetical Outcome of Non–Competitive Pricing

To compare the application of competitive pricing to the hypothetical case of non–competitive permit pricing by intermediaries, the model from Section 3.2 is populated with data from the German part of the EU ETS. In a first step, the monopsonistic/monopolistic price p_m (Equation 15) and the alternative 'mimicking price' p_n (Equation 18) are calculated. Firms choose a trading mode in a second step. Firms choose to

[7]Free allocation is fixed for each installations from 2011 to 2008 if there are no major changes at the installation.

[8]The percentiles of the distribution are 5% (EUR 43); 25% (EUR 394); 50% (EUR 1,486); 75% (EUR 6,211); 95% (EUR 50,000) based on n=819 observations.

trade with the intermediary if and only if $p_m < p_n$ or trade directly at the exchange otherwise. To calculate p_m based on the German compliance data, $\hat{s}_i$ and α_i are required for each firm i in the sample. The variables are generated based on the data by[9]

$$\hat{s}_i \quad = \quad |\mathit{verified}_i^{2008} - \hat{q}_i - \mathit{allocated}_i^{2011}|. \tag{21}$$

The change in emissions in the period from 2008 to 2011 is given by[10]

$$\hat{q}_i \quad = \quad \mathit{verified}_i^{2008} - \mathit{verified}_i^{2011}. \tag{22}$$

The abatement cost coefficient (based on Equation 8) is calculated by

$$\hat{\alpha}_i \quad = \quad \frac{\hat{p}}{\hat{q}_i}. \tag{23}$$

The average shadow price $\hat{p}$ for the years 2008 to 2011 is assumed to be EUR 15 since this price level prevailed from 2008 to June 2011. Higher (lower) prices $\hat{p}$ would lead to a lower (higher) share of firms that trade with the monopsonistic/monopolistic intermediary as shown in Figure 4. The *changes* in the share of firms that trade at p_m is dependent on m and is approximately independent of the choice of $\hat{p}$ as the Figure shows.

After calculating prices p_m and p_n individually for each of the 771 firms that remained in the sample[11] the share of firms that trade with intermediaries or at the exchange can be observed and resulting costs can be calculated. Since prices p_m and p_n are dependent on the firms characteristics, no single price can be reported. Figure 5 plots prices p_m and p_n as resulting from the application and dependent on the annual trading volume of firms, assuming $m = 50,000$ and $g = 15$. The existence of a single monopsonistic/monopolistic intermediary would result in a situation where 10% of firms trade with the help of the intermediary while the remaining firms trade directly at the exchange at $m = 50,000$ and $g = 15$. As Figure 5 shows, offered permit prices would be rather high in the hypothetical case of the presence of a single intermediary. Tables 4 and 5 present detailed results on the share of firms that would trade with the monopsonistic/monopolistic intermediary for different values of m. Table 4 also presents results when m is randomly choosen for each firm based on different standard deviations for m. Table 5 presents a similar sensitivity analysis for the abatement cost coefficient α. In both cases, the results are stable when a random shock is added to m or α, even if the share of firms that trade with the intermediary decrease with rising standard deviation.

The results of the model application are summarized in Table 3 for different fixed costs m. As an outcome of monopolistic/monopsonistic permit trading by a single interme-

[9] When plugging (22) into (21), the equation collapses to $\mathit{verified}_i^{2011} - \mathit{allocated}_i^{2011}$ and is equivalent to the method used in Section 4.1.

[10] To use as much information as possible when calculating $\hat{\alpha}_i$ in Equation (23), the change in emissions over the years 2008 to 2011 is considered here.

[11] The sample collapsed from 819 to 771 because full information over the years 2008 to 2011 is needed to calculate $\hat{\alpha}_i$ in Equation (23). Since some firms opted in to the EU ETS after 2008, 48 missing observations are generated when calculating $\hat{q}_i$. Consequently, those firms are dropped from the sample for the application.

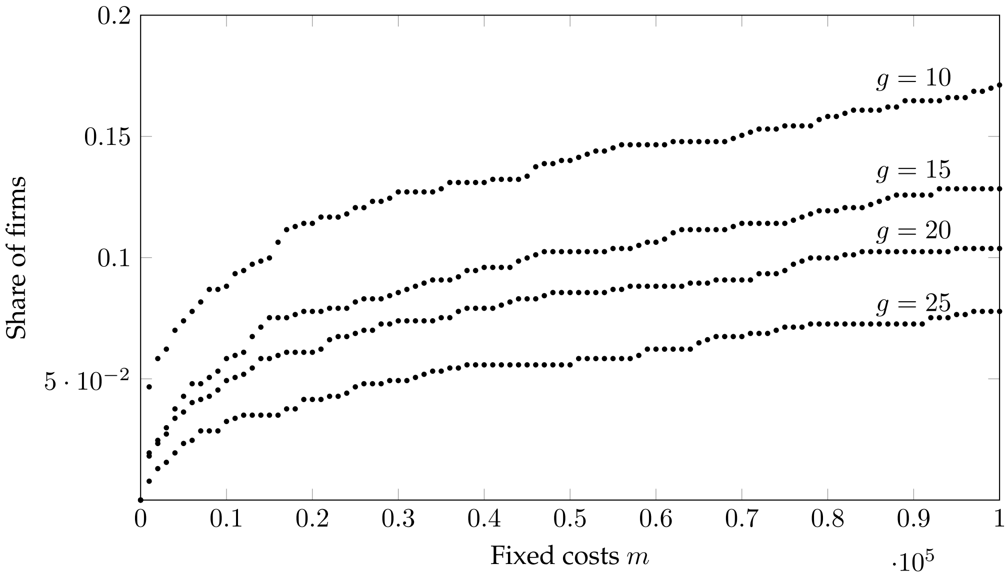

Figure 4: Share of firms that trade with the monopsonistic/monopolistic intermediary, evaluated for combinations of m and g.

diary, most firms (about 90%) would trade at the exchange at price p_n. The markup of the intermediary ($p_m - g$) ranges in median from 3.73 (at $m = 30,000$) to 5.93 (at $m = 100,000$) at $g = 15$ and is dependent on the fixed costs for exchange trading. This is an intuitive result since firms have the option to 'escape' the intermediaries market power by trading directly at the exchange. Lower costs for exchange trading therefore drives down the markup in median. Costs for exchange trading in median are given by $p_n - g$. Independent of assumed fixed costs m, the largest share of permits (99%) is traded at the exchange. This result is similar to the result of competitive pricing by intermediaries, but the share of permits traded at the exchange is about 13% higher in the non–competitive setup. Total costs range from 21.7 million EUR (at $m = 30,000$) to 69.7 million EUR (at $m = 100,000$) and are mainly driven by the fixed costs for exchange trading m. Fixed costs also drive up average costs per firm, which are 28.1 thousand EUR (at $m = 30,000$) and increase to 90.4 thousand EUR (at $m = 100,000$).

m EUR	% Firms at exchange	$p_m - g$ median	$p_n - g$ median	% Traded at exchange	Costs (total) mEUR	Costs (average) tEUR
30,000	91.44%	3.73	2.87	99.92%	21.7	28.1
40,000	90.40%	4.43	3.73	99.85%	28.7	37.2
50,000	89.75%	4.64	4.58	99.84%	35.6	46.2
60,000	89.36%	4.82	5.44	99.83%	42.5	55.2
70,000	88.59%	5.11	6.28	99.81%	49.4	64.0
80,000	88.07%	5.31	7.15	99.78%	56.2	72.9
90,000	87.42%	5.85	7.76	99.77%	63.0	81.7
100,000	87.16%	5.93	8.38	99.76%	69.7	90.4

Table 3: Percentage of firms that trade at the exchange, average markup p_m and quasi markup p_n for exchange trading. Costs are displayed on the right hand side with total costs in million EUR and average costs per firm in thousand EUR.

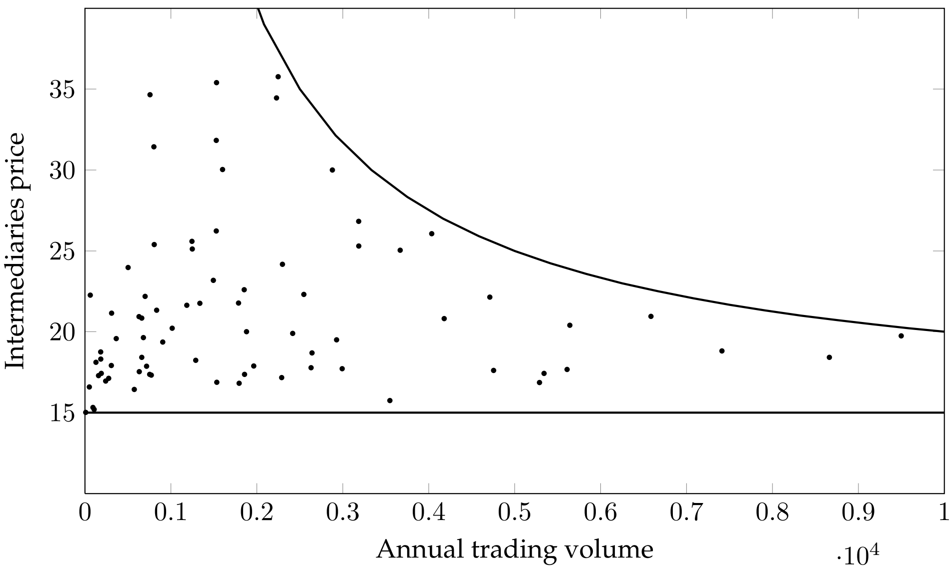

Figure 5: Price p_m (dotts) constrained by price p_n and g for $m = 50,000$ and $g = 15$. In the application, most firms trade at the exchange at p_n. About 10% of firms trade at p_m, which are plotted here.

4.3 Discussion

The model applications presented above examined two different situations for the EU ETS permit market. Section 4.1 aims to assess fees for permit trading by intermediaries based on the simple model from Section 2 and based on survey data and official compliance data from the EU ETS in Germany. It revealed that in a competitive setup with two or more intermediaries in the market, fees for permit trading by intermediaries are relatively low with about EUR 0.17 per traded permit when fixed costs m for direct trading at the exchange of EUR 50,000 are assumed (Table 2). This is about 1% of the permit price when the permit price level is assumed to be EUR 15, as it has been the case in the years 2008 to June 2011 in the EU ETS.

Section 4.2 examined the hypothetical case of *one* single intermediary in the permit market as described by the model in Section 3.2, where it is assumed that the intermediary is able to exert market power towards regulated firms in permit trading. The intermediary's market power will be limited by the regulated firms 'fallback option' to trade permits directly at the exchange. As a consequence of monopsonistic/monopolistic pricing by the intermediary, the market structure would change considerably compared to the case of competitive pricing. Assuming fixed m costs for direct trading at the exchange of EUR 50,000, about 90% of firms would trade at the exchange compared to 5% in the competitive setup. 99% of permits would be traded directly at the exchange by regulated firms compared to 87% in the competitive setup. Figure 5 shows that the presence of a single intermediary with market power would drive up permit prices considerably dependent on the firm characteristics, such as the reaction on changes in the permit price and annual trading volumes. The markup per traded permit is assessed to be 4.64 in median, assuming $m = 50,000$ (Table 3).

A comparison of average costs for the case of a non–competitive market and the competitive case shows that average costs for permit trading (fees and fixed costs) in the non–competitive setup are about six times higher. Underlying fixed costs m for direct trading at the exchange determine average costs in both cases. Average costs per regulated firm are EUR 7,300 in the competitive setup compared to EUR 46,200 in the non–competitive setup, assuming $m = 50,000$.

Two important conclusions can be drawn from the model application. Firstly, the fixed costs m for direct trading at the exchange are an important determinant of the costs for permit trading in the competitive and the non–competitive case. When designing an emissions trading scheme, close attention should thus be paid to the potential of regulated firms to access the market directly at moderate costs. In the EU ETS in Germany, the market is currently structured so that firms with annual trading volumes of more than 283,000 permits can access the exchange in an economic fashion. Firms with smaller trading volumes rely on intermediaries for permit trades. Secondly, the share of unit fees that are taken by intermediaries for permit trades are moderate in the competitive setup, ranging from 1% to 2% of the permit price when a price of EUR 15 is assumed. Total costs in the EU ETS in Germany are expected to range from EUR 3.6 million (at $m = 30,000$) to EUR 12 million (at $m = 100,000$). When compared to general transaction costs in the German EU ETS (excluding trading fees) that are estimated to be EUR 8.7 million per year and that mostly stem from compliance obligations (i.e. measurement, reporting, and verification of emissions) [13], total fees for permit trading add considerable costs to the general cost category of accessing the market and transacting, even in the presence of a competitive permit market.

5 Conclusion

This paper examined the choice of the permit trading mode (intermediary vs. direct exchange trading) of a firm regulated by an emissions trading scheme. Given fixed costs for becoming active at an exchange and unit fees per traded permit charged by intermediaries for their services, it was shown that a regulated firm will decide on the trading mode dependent on the volume of permits it intends to trade. Firms with larger trading volumes tend to become active directly at the exchange while firms with smaller volumes trade with the help of intermediaries. This result is supported empirically by surveys amongst firms regulated in the EU ETS in Germany [2, 19, 18] and a study from Ireland [15].

An examination of permit pricing strategies of intermediaries showed that a number of (at least) two non–colluding intermediaries in the permit market is sufficient to generate a competitive market. This finding is based on the Bertrand Paradox [26] given that emissions permits can be regarded as a homogeneous good where intermediaries face no capacity constraints in producing the service of permit trading.

This paper is, to my best knowledge, the first to examine the case of a monopolistic/monopsonistic intermediary that can exert market power in permit trading towards regulated firms. Market power of an intermediary requires that there is strictly *one* intermediary in the market, which is a highly unlikely case. If there is strictly one intermediary in the market, it will offer a permit price (and charge a fee or markup) that is dependent on the permit price on the exchange, a firm's reaction coefficient (i.e. abatement costs), unrestricted emissions, and free allocation. The regulated firm has the 'fallback option' to trade permits directly at the exchange given fixed costs. As a best–response, an intermediary with market power would discriminate prices dependent on the regulated firm's permit demand.

The unit fee or markup charged by an intermediary will, in the competitive setup as well as in the non–competitive setup, lead to a deviation from the first-best abatement volume as in Montgomery [23]. Free allocation will have an impact on actual costs for permit trading, which removes the 'independence property' of allocation [11]. The costs for permit purchases or sales, whether they occur as fixed costs for accessing an exchange, as unit fees or a markup from monopolistic/monopolistic behavior of an intermediary, can be seen as cost for transacting, which are proven to be welfare decreasing in schemes of tradeable permits [25, 12].

Based on survey data from firms regulated by the EU ETS in Germany and German compliance data, a model application examined the case of competitive and non–competitive behaving intermediaries for the EU ETS in Germany. The application implies that costs for transacting (i.e. unit fees) are relatively low in a competitive setup, ranging from EUR 0.10 to 0.35 per traded permit dependent on assumed fixed costs for accessing an exchange directly. Fees are below 2% of the permit price when assuming the permit price to be EUR 15, the approximate average price in the EU ETS for the years 2008 to 2011. For the German EU ETS this would imply that most firms (about 95%) trade with the help of intermediaries. Firms with annual trading volumes of more than 283,000 permits become active directly at the exchange. Since the EU ETS is dominated by few large emitters and a larger number of smaller emitters, about 86% of the traded volume of permits is traded directly at the exchange even if only about 5% of regulated firms are active at the exchange.

For the hypothetical case of non–competitive pricing by a single intermediary, the model application implies that most firms would trade directly at the exchange because of a considerable unit fee (markup) charged by the intermediary with market power. However, if the intermediary with market power is able to successfully mimic the regulated firms costs for becoming active at the exchange, it might be able to achieve a large market share. The total costs for permit trading in the non–competitive case are six time higher in the model application compared to the competitive case.

Overall, it can be concluded that the risk of monopsonistic/monopolistic trading behavior of an intermediary is very low. If there are (at least) two non-colluding intermediaries, a competitive market will evolve. In the unlikely case that there is strictly *one* intermediary in the market and that it could possibly exert market power, market power can be successfully prevented by offering a low–cost option for regulated firms to purchase or sell permits directly at an exchange. Low–cost options for direct market access will decrease the costs of transacting in the competitive and non–competitive case. Low-cost options for direct market access could be generated by appropriate auctioning platforms, possibly being organized or monitored by a public agency if necessary.

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Fixed costs m	Standard deviation σ	Lower CI (0.05)	Mean	Upper CI (0.95)
30000	0	.08560311	.08560311	.08560311
40000	0	.09597925	.09597925	.09597925
50000	0	.10246433	.10246433	.10246433
60000	0	.10635538	.10635538	.10635538
70000	0	.11413749	.11413749	.11413749
80000	0	.11932555	.11932555	.11932555
90000	0	.12581064	.12581064	.12581064
100000	0	.12840466	.12840466	.12840466
30000	1000	.0843061	.08565932	.08690013
40000	1000	.09468223	.09568958	.09597925
50000	1000	.10246433	.10246433	.10246433
60000	1000	.10505836	.10683528	.10894942
70000	1000	.11284047	.11388241	.11413749
80000	1000	.11802854	.11919585	.11932555
90000	1000	.12581064	.12583226	.12581064
100000	1000	.12840466	.12840466	.12840466
30000	2000	.08365759	.08580199	.08819715
40000	2000	.09338521	.09534804	.09597925
50000	2000	.10116731	.10241245	.10246433
60000	2000	.10505836	.1073022	.10894942
70000	2000	.11284047	.1134933	.11413749
80000	2000	.11802854	.11905318	.12062257
90000	2000	.12451362	.12586685	.12710765
100000	2000	.12840466	.12840466	.12840466
30000	3000	.08300908	.08577605	.08819715
40000	3000	.09338521	.09518807	.09727626
50000	3000	.10116731	.10226978	.10376135
60000	3000	.10505836	.10735408	.11024643
70000	3000	.11154345	.11342412	.11413749
80000	3000	.11673152	.11880674	.12062257
90000	3000	.12451362	.12574147	.12710765
100000	3000	.12840466	.12837872	.12840466
30000	4000	.08300908	.0860614	.08819715
40000	4000	.0920882	.09516213	.09727626
50000	4000	.0998703	.10209685	.10376135
60000	4000	.10505836	.10748379	.11024643
70000	4000	.11154345	.11339819	.1154345
80000	4000	.11673152	.11881971	.12062257
90000	4000	.1232166	.12559015	.12710765
100000	4000	.12710765	.12832685	.12840466
30000	5000	.08300908	.08596195	.08949416
40000	5000	.0920882	.09501081	.09727626
50000	5000	.0998703	.10194553	.10376135
60000	5000	.10505836	.10757457	.11024643
70000	5000	.11154345	.11351924	.1154345
80000	5000	.11673152	.11892348	.12062257
90000	5000	.1232166	.12544315	.12710765
100000	5000	.12710765	.12818849	.12840466

Table 4: m_i randomly drawn. Percentage of firms that trade with intermediaries (mean and confidence intervals) for fixed costs m and for installation specific fixed costs generated by drawing costs m_i from a normal distribution $N(m, \sigma)$ for 300 runs. Price $g = 15$ assumed.

Fixed costs m	Standard deviation σ	Lower CI (0.05)	Mean	Upper CI (0.95)
30000	0	.08560311	.08560311	.08560311
40000	0	.09597925	.09597925	.09597925
50000	0	.10246433	.10246433	.10246433
60000	0	.10635538	.10635538	.10635538
70000	0	.11413749	.11413749	.11413749
80000	0	.11932555	.11932555	.11932555
90000	0	.12581064	.12581064	.12581064
100000	0	.12840466	.12840466	.12840466
30000	.01	.06355383	.07381323	.08690013
40000	.01	.07003891	.08195417	.09468223
50000	.01	.07522698	.08750108	.10116731
60000	.01	.08041505	.09380026	.10635538
70000	.01	.08949416	.10045828	.11413749
80000	.01	.09403373	.10610895	.11932555
90000	.01	.09727626	.11078686	.12386511
100000	.01	.10116731	.11564635	.12840466
30000	.02	.05966277	.07073065	.08171206
40000	.02	.06614786	.07816256	.09079118
50000	.02	.07068741	.08415478	.09792477
60000	.02	.076524	.08956766	.10376135
70000	.02	.08300908	.09634674	.10894942
80000	.02	.08690013	.10131864	.1154345
90000	.02	.09143969	.10495461	.11932555
100000	.02	.09468223	.10940337	.1232166
30000	.05	.04928664	.06285343	.076524
40000	.05	.05836576	.07120623	.0843061
50000	.05	.06420233	.07716385	.08949416
60000	.05	.07133593	.08287073	.09597925
70000	.05	.07392996	.08845655	.10376135
80000	.05	.07911803	.09324254	.10894942
90000	.05	.08236057	.09696066	.11219195
100000	.05	.08690013	.10162127	.11673152
30000	.1	.04280156	.05415478	.06614786
40000	.1	.05123217	.06204928	.07522698
50000	.1	.05577172	.06765673	.08171206
60000	.1	.06225681	.07527021	.08819715
70000	.1	.06679636	.07986598	.0920882
80000	.1	.07133593	.08501513	.09922179
90000	.1	.07522698	.08796369	.10051881
100000	.1	.07846952	.09234328	.10700389
30000	.2	.03372244	.04293558	.05317769
40000	.2	.04150454	.0505923	.06225681
50000	.2	.04669261	.05687851	.0687419
60000	.2	.04798963	.06158236	.07392996
70000	.2	.05317769	.06629486	.07911803
80000	.2	.05836576	.07058798	.08560311
90000	.2	.06095979	.07469952	.08819715
100000	.2	.06355383	.07751405	.08949416

Table 5: $\hat{\alpha}_i$ randomly drawn. Percentage of firms that trade with intermediaries (mean and confidence intervals) for fixed costs m and values of $\hat{alpha}_i$ randomly drawn from a normal distribution $N(0, \sigma)$ for 300 runs. Price $g = 15$ assumed.