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Dividend Taxation and DAX Futures Prices

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- Working Paper –

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Abstract

The taxation of dividends in Germany underwent major changes. We analyze the implications of these changes for the valuation of DAX futures contracts and test the resulting hypotheses empirically. We find that dividend taxation cannot explain the level of deviations from the cost-of-carry relation, but does have explanatory power for the time series patterns of these deviations. Futures prices are lower in years with higher dividend yields, and prices of the June contract (which is the nearby contract in the quarter in which most firms pay their dividends) are lower than those of the other contracts. Multivariate regressions confirm the finding that dividend taxation affects futures prices.

JEL Classication: G13

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1 Introduction

In a frictionless world the prices of stock index futures are determined by the cost-of-carry relation and thus only depend on the current index level, the discount rate and the expected dividend yield. In the case of a total return index (which assumes that dividends are reinvested) the cost-of-carry relation simplifies even further because the expected dividend yield drops out of the pricing equation (e.g. Prigge and Schlag (1992), Bühler and Kempf (1995)). Consequently, in a frictionless world the level of a total return index should be equal to the discounted futures price. However, empirically this simple relation does not seem to hold. Several authors (e.g. Prigge and Schlag (1992), Loistl and Kobinger (1993), Bühler and Kempf (1995)) have documented that the prices of the DAX futures contract violate the simple cost of carry relation. They find that the futures contracts are systematically undervalued.

One factor that potentially contributes to deviations from the cost-of-carry relation is the taxation of dividends[1] in Germany. Investors are unable to perfectly replicate the DAX futures contract because the taxation of dividends is different in the spot market and the futures contract. The facts that (1) different investors may face different marginal tax rates, (2) the tax regime is subject to change and (3) domestic investors are taxed differently than foreign investors (on this see McDonald (2001)) complicate the analysis. Several authors (Kempf and Spengel (1993), Röder and Bamberg (1994), Janssen and Rudolph (1995), Bamberg and Dorfleitner (2002), Weber (2004), Weber (2005)) have tried to incorporate the tax treatment of dividends into the cost-of-carry relation. While some authors analyze whether there are arbitrage opportunities relative to a modified cost-of-carry model[2] (e.g. Röder and Bamberg (1994), Janssen and Rudolph (1995), Merz (1995)), no paper so far has provided reliable empirical evidence on the importance of dividend taxation for the pricing of stock index futures in general and the DAX futures contract in particular.

Our paper attempts to close this gap in the literature. We analyze the pricing of the DAX futures contracts in the period 1992-2011. Two salient features of the German capital market facilitate our analysis. First, during our sample period there were major changes in the taxation of dividends. This allows us to analyze how changes in dividend taxation affect futures prices. Second, German firms, unlike US firms, pay dividends only once a year. Consequently, individual dividend payments are larger than those in the US, and dividend payments are clustered in the second quarter of the year. This should facilitate the identification of systematic patterns in futures prices.

The DAX futures contract trades on a quarterly cycle with maturity dates on the third Friday of March, June, September and December. In our empirical analysis we focus on the nearest-to-delivery contract because it is by far the most liquid contract. As noted above, German firms pay yearly dividends, and the dividend dates are concentrated in the second quarter. Therefore, the contract most heavily affected by dividend payments in its last three months prior to maturity is the June contract.[3] Consequently, we derive our conclusions from (1) a comparison of the June contract to the other contracts and (2) an analysis of the time-series behaviour of the June contract prices. As a robustness check we also analyze second-nearest-to-delivery contracts. By the same argument as above, in this case the September contract should be most heavily affected by dividend payments.

Our empirical results indicate that dividend taxation is unable to explain the level of deviations from the cost-of-carry relation. On the positive side, it does have explanatory power for the time series patterns of these deviations. We observe lower futures prices in years with higher dividend yields, and prices of the June contract (which is the nearest-to-delivery contract in the quarter in which most German firms pay their dividends) are lower than those of the March, September and December contracts. Multivariate regressions confirm the finding that dividend taxation affects futures prices in the second quarter.

The paper is organized as follows. Section 2 describes the institutional background. In section 3 we derive our hypotheses. Section 4 describes our data set and presents descriptive statistics. Section 5 presents the methodology and results of our empirical analysis. Section 6 concludes.

2 Institutional Background

The German DAX index futures is one of the most liquid futures contracts in the world. In 2010, a total of 41 million contracts with a volume of 3.5 trillion Euros were traded. The daily average volume amounted to 160,000 contracts.

The underlying of the futures contract, the Deutscher Aktienindex (DAX) was introduced in 1987. It is (in contrast to other major equity indices such as the S&P 500 or the EuroStoxx 50) a total return (performance) index. Dividends, which German companies usually pay once a year, are re-invested into the dividend-paying stock. Once a year, the DAX index is adjusted and the re-invested dividends are re-distributed to all firms in the index in proportion to their market capitalization. This is done to prevent a bias in the index towards dividend-paying stocks. Theoretically the DAX thus assumes a re-investment of the gross-dividend (*Bruttobardividende*)[4] of every dividend-paying stock into the index. This reinvestment assumption is critical and has specific implications in the context of the German tax regime.

In order to find the arbitrage-free price of the DAX futures contract we start from the perfect markets cost-of-carry model as described e.g. by Cornell and French (1983a,b).[5] According to this model the arbitrage-free futures price for a *price index* is

$$F(t,T) = I_t e^{r(T-t)} - \sum_{i=1}^{N} D_j e^{r(T-\tau_j)} \quad (1)$$

where F(t,T) denotes the value at time t of a futures contract maturing at time T, I_t denotes the value of the index at time t, r is the continuously compounded interest rate, D_j is the dividend paid by firm j at time τ_j and N is the number of firms in the index. Until maturity of the futures contract the dividend payments are aggregated and deducted from the index because dividends are not re-invested into the index. Dividends are taxed at the investors marginal tax rate and will not create any tax distortions.

The perfect markets cost-of-carry model for a futures contract on a *performance index* such as the DAX is actually even simpler (see Prigge and Schlag (1992) and Bühler and Kempf (1995)). Because dividend payments are reinvested into the index, the futures price is unaffected by dividend payments. The arbitrage-free futures price thus is

$$F(t,T) = I_t e^{r(T-t)} \quad (2)$$

The derivation of this relation is based on the assumption that an investor can replicate the dividend reinvestment strategy assumed in the construction of the index. This requires that (1) the investor receives the gross dividend on the ex-dividend day and can reinvest it into the stock at the ex-dividend price, that (2) dividends received by the investor are taxed at exactly the tax rate that is assumed in the construction of the index and that (3) the investor replicates the yearly index rebalancing procedure described above.

Kempf and Spengel (1993) drop assumption (2) and model the German tax regime in effect until 2000 in more detail. They take into account that, at the level of the investor, dividends are taxed at the investor's marginal tax rate. Consequently, the willingness to pay for a futures contract depends on the investor's marginal tax rate. The equilibrium price of the futures contract will then depend on the tax rate of the marginal investor.[6]

Kempf and Spengel (1993) and Janssen and Rudolph (1995) as well as Bamberg and Dorfleitner (2002) and Weber (2005) further derive futures valuation formulas for alternative tax systems. In the next section we build on their results and restate the theoretical effects of dividend taxation on futures prices. We then describe the characteristics of the three tax regimes that were in effect during our sample period. We use numerical examples to quantify the effect of the tax regime on futures prices. We then derive our hypotheses from these theoretical considerations and numerical examples.

Derivation of DAX futures prices under a general tax regime

In this section, we derive a general expression for the futures price that is valid in all tax regimes. We define the following variables. r is the continuously compounded interest rate. We assume that borrowing and lending rates are equal. $D(j)$ is the cash dividend paid by firm j at time $\tau(j)$. $n(j)$ denotes firm j's weight in the DAX. s_k is the tax rate on all capital gains and losses from investments in the equity and futures markets. The interest income and expenses are taxed at rate s_z. s_d denotes the rate at which dividends are taxed at the investor level. The following derivation of the fair futures price is based on Weber (2004) and Bamberg and Dorfleitner (2002) who develop similar arbitrage tables as the one we present below.

We follow Weber (2004) and assume a tax system that treats gains and losses symmetrically. We further assume that there are no transaction costs and no short selling restrictions. We take the perspective of an arbitrageur who is selling the futures contract and is long in the spot market. This is without loss of generality. The opposite case - an investor who is long in the futures market and short in the equity market - results in an identical no-arbitrage table, except that all signs are reversed.

[Insert Table 1 about here]

At time $t = 0$ the arbitrageur invests, at price S_0, into a portfolio of stocks that replicates the DAX index. This investment is financed by a loan. At the same time the arbitrageur sells the equivalent amount of DAX futures contracts F. At time $t = 0$ the cash flows add up to zero. At time $\tau(j)$ DAX constituent stock j pays dividend $D(j)$. The arbitrageur pays the tax on the dividend and then reinvests an amount into stock j that is exactly equivalent to the reinvestment amount assumed in the construction of the DAX index. Because the taxation of the dividends which is assumed in the construction of the index may differ from the actual taxation of the arbitrageur, this may result in a non-zero cash flow. Any such difference is financed by an additional loan or is invested into an interest-bearing bank account. At maturity, the investor has to pay capital gains tax at rate s_k on the profits and losses of his DAX portfolio (including the reinvested dividends), and on the profit or loss of his futures position $F - S_T$. He repays all loans and subtracts from these payments his interest tax credit (the credit is at tax rate s_z). The cash-flows up to maturity add up to zero. To find the fair futures price, we add up the cash flows at maturity, set them to zero and solve for F (as can be seen in Table 1). This results in the following general futures price formula that corrects for taxes.

$$\begin{aligned} F^* = \quad & S_0(e^{rT}(1-s_z)+s_z-s_k)\frac{1}{(1-s_k)} \\ & -[s_k \textstyle\sum_j n(j)D(j) - s_d \sum_j n(j)D(j)[e^{r(T-\tau(j))}(1-s_z)+s_z]]\frac{1}{(1-s_k)} \end{aligned} \tag{3}$$

Obviously, if $\sum_j n(j)D(j) = 0$ and $s_k = s_z$ (i.e. the tax rate on capital gains is equal to the tax rate on interest income) the formula reduces to the simple cost-of-carry formula 2. Furthermore, if we assume $s_k = s_z$ the formula simplifies to:

$$F^* = S_0 e^{rT} + s_d e^{r(T-\tau(j))} \sum_j n(j)D(j) - \frac{s_k}{1-s_k}(1-s_d)\sum_j n(j)D(j) \tag{4}$$

The condition $s_k = s_z$, which implies that the tax rates on capital gains and interest coincide, holds in all tax systems we consider. In order to see how the futures price changes when there is a change in the dividend payment of firm j, n(j)D(j), we can take the derivative with respect to n(j)D(j). This yields

$$\frac{\partial F^*}{\partial[n(j)D(j)]} = s_d e^{r(T-\tau(j))} - s_k \frac{1-s_d}{1-s_k} \tag{5}$$

From this it follows that when $s_k > s_d$, an increase in dividends decreases the futures price. If $s_k = s_d$ the effect is positive, but small (namely, $e^{r(T-\tau(j))} - 1$).

Tax Regimes and the Marginal Investor

The German tax system underwent two major reforms during our sample period. Until 2000 an imputation system, the **Vollanrechnungsverfahren (VOLL)** was in place. Good descriptions of this tax regime can be found in Röder and Bamberg (1994) and Kempf and Spengel (1993). The main principle of the imputation system was to tax every individual's capital income at her personal marginal tax rate. In this system the taxes paid at the corporate level were credited to the investor in form of a tax credit. Depending on whether her personal tax rate was above or below the corporate rate, the investor then either had to pay additional taxes or received a tax refund.

In 2001, the half-income system **Halbeinkuenfteverfahren (HEV)** was introduced (see Weber (2004, 2005) for a more detailed description). The imputation tax credits of the former imputation system were abolished. Dividends were now taxed both at the corporate and at the personal level. However, personal taxes were only levied on one half of the gross-dividend.

In 2009, the half-income system was succeeded by a flat withholding tax system **Abgeltungssteuer (ABG)** (see Scheffler (2012) for a detailed description.). It stipulates a flat tax rate of 25%, irrespective of the investor's tax bracket.[7]

The short description above disregards the fact that different taxation rules apply for private and institutional investors, and that different investors can be in different tax brackets. In principle, we could derive the willingness to pay for a futures contract for each investor type. However, we are interested in the equilibrium price. This price, in turn, will depend on the identity (and, more specifically, the tax rate) of the marginal investor. Private investors face severe restrictions when engaging in futures arbitrage. They are subject to high margin requirements, they face substantially higher transaction costs than financial institutions, and they face restrictions which make it difficult to establish a short position in the spot market. The advent of ETFs and other structured products in later years of our sample period may have relaxed these restrictions (Bamberg and Dorfleitner (2002)), but they did not eliminate them. We therefore argue that the marginal investor is not a private investor but rather a domestic (financial) institution.

Under both the Halbeinkuenfteverfahren and the Abgeltungssteuer the taxation of dividends received by financial institutions depends on whether the shares are held as a long-term investment (and are thus held in the banking book) or as a short-term investment (held in the trading book). While dividends received on short-term investments are fully taxed, only 5% of the dividends received on long-term investments are taxed. This is referred to as the dividend privilege.[8] Table 2 shows the details of the taxation for long- and short-term investments in all three tax regimes.

However, because arbitrage positions in the futures market are short-term in nature (and are held in the trading book), we assume the short-term financial institution to be the marginal investor.[9] In the following we therefore only describe the taxation of a short-term institutional investor. We note that the distinction between a short-term and a long-term financial institution is not relevant under the imputation tax system. At the same time the bulk of our empirical analysis relates to the imputation tax system. Consequently, the assumption we are making here on the identity of the marginal investor is inconsequential for much of our empirical analysis.

[Insert Table 2 about here]

Under the imputation system the tax rates on interest income, dividends and capital gains for the marginal investor were equal at $s = s_z = s_k = s_d = 0.583$. However, the tax on dividends was split into two components. First, when a firm paid a dividend the dividend was taxed (at a rate of 36%, later reduced to 30%). This is also the rate that was assumed in the construction of the index. The investor receiving the dividend had to pay additional taxes whenever his individual tax rate was higher than the rate at which the dividend had already been taxed (which was the case for the marginal investor). We denote the tax rate differential by s_d^*.[10, 11] s_d^* is the relevant rate to be used in formulas (3) to (5). Since $s_d^* < s_k$, it follows from (5) that dividend payments decrease the futures price.

To illustrate the magnitude of the valuation effect we use formula 3 and make further simplifying assumptions. In particular, we assume a futures contract with a time to maturity of $T = 1$ year, we assume that all dividend payments occur at time t=1/2, and that r is not the continuously compounded interest rate but rather the discrete rate relating to the time interval $[0, T]$ (i.e. the one-year rate). Furthermore, we use numerical values that are representative for the period during which the imputation system was in effect. Specifically, we use historical median values for the part of our sample period in which the imputation tax system was in effect. We assume a dividend yield of 1.78% , an interest rate of 4.04% p.a. and an index level of 2,625 points. Under these assumptions we obtain

$$F^* = S_0 \left[1 + r\left(\frac{1-s_z}{1-s_k}\right)\right] - \left[s_k - s_d^* - \frac{r}{2} s_d^* (1 - s_z)\right] \frac{1}{1-s_k} D$$
$$= 2625[1.0404] - [0.583 - 0.3484 - 0.0404 * 0.5 * 0.3484 * 0.417] * 2625 *$$

$0.0178 * 2.4$

$= 2731 - (0.2346 - 0.00293) * 2625 * 0.0178 * 2.4 = 2731 - 25.98 = 2705.8$

Thus, the fair futures price F* is about 26 index points (or 0.95 %) below the theoretical futures price F obtained from the simple cost-of-carry formula 2. Under the imputation system the theoretical effect of dividend taxation on futures prices is thus substantial.

Under both the half-income system and the withholding tax system, the tax rates on interest income, dividends and capital gains are again equal for the marginal investor. Under these tax systems the rate at which dividends are taxed is equal to the rate which is assumed in the construction of the index. However, if we assume that the marginal investor is a short-term investor, as proposed in Table 2, the investor has to additionally tax the dividends at rate s_d. To illustrate the valuation effect we again use formula 3 and assume numerical values that are representative for the period during which the half-income system and the withholding tax system were in place. Specifically, we assume a dividend yield of 2.33% for the half-income system (3.4% for the withholding tax system), an interest rate of 3.35% (1.32%), and an index level of 5030 (5957) points. As before we assume a futures contract with one year to maturity, and we assume that all dividends are paid after six months.

For the half-income system we obtain

$$F^* = S_0\left[1 + r\left(\frac{1-s_z}{1-s_k}\right)\right] - \left[s_k - s_d - r(T-\tau_j)s_d(1-s_z)\right]\frac{1}{1-s_k}D$$

$$= S_0[1+r] - [-0.0335 * (0.5)0.375(0.625)] * 5030 * 0.0233 * 1.6$$

$$= S_0[1.035] + 0.0041 * 5030 * 0.0233 * 1.6$$

$$= 5201 + 0.77 = 5202$$

The corresponding value under the withholding tax system is

$$F^* = S_0\left[1 + r\left(\frac{1-s_z}{1-s_k}\right)\right] - \left[s_k - s_d - r(T-\tau_j)s_d(1-s_z)\right]\frac{1}{1-s_k}D$$

$$= S_0[1+r] - [-0.0132(0.5)0.2544(0.7456)] * 5957 * 0.034 * 1/0.7456$$

$$= S_0[1.0132] + 0.0013 * 5957 * 0.034 * 1/0.7456$$

$$= 5957 + 0.35 = 5957$$

The fair futures price F* thus is less than one index point above the theoretical futures price F from the simple cost-of-carry model (0.77 points under the half-income system and 0.35 points under the withholding tax regime).[12] Thus, under both tax regimes the effect of dividend taxation on futures prices is negligible. In our empirical analysis we will therefore focus on a comparison between the imputation system on the one-hand side and the half-income system and the withholding tax regime on the other-hand side. We will not make an attempt at empirically differentiating between the latter two.

3 Hypotheses

In this section we build on the theoretical pricing relation introduced above and derive testable hypotheses. We define *mispricing* as the relative difference between the actual futures price and the theoretical price according to the simple cost-of carry-relation (2).[13]

$$\frac{FDAX_t^{empirical} - DAX_t e^{r(T-t)}}{DAX_t e^{r(T-t)}} \quad (6)$$

We have argued above (and Bühler and Kempf (1995) have shown empirically) that, under the imputation system, futures prices are expected to be significantly below the prices predicted by the cost-of-carry relation. We do not expect significant mispricing under the other two tax regimes. We thus have

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Hypothesis 1: The mispricing (i.e. the difference between the actual futures prices and the prices predicted by the simple cost-of-carry relation) is negative under the imputation system. There is no mispricing under the half income and withholding tax regime.

As noted previously German firms pay dividends once a year, and most firms do so in the second quarter of the year. Consequently, when analyzing the nearest-to-delivery contract we expect that the mispricing is most pronounced in the June contract.[14] By the same argument, when analyzing the second-nearest-to-delivery contract we expect that the mispricing is more pronounced in the June and September contracts than in the March and December contracts.

Hypothesis 2: The mispricing of the nearest-to-delivery contract under the imputation tax system is more pronounced for the June contract than for the three other contracts. Similarly, the mispricing of the second-nearest-to-delivery contract under the imputation tax system is more pronounced for the June and September contracts than for the March and December contracts.

The expected mispricing obviously depends on the magnitude of the dividend payments relative to the value of the index. We therefore expect

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Hypothesis 3: The mispricing under the imputation tax system is more pronounced in years with higher dividend yields.

The first three hypotheses refer to the average mispricing per contract. Besides that we can also derive predictions on the dynamics of future prices. In particular, the mispricing should be reduced with every dividend payment occurring during the lifetime of the contract. Once there is no dividend payment left to be made until maturity, the mispricing should disappear. We thus have

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Hypothesis 4: The mispricing under the imputation tax system is reduced with every dividend payment and approaches zero when there are no dividend payments left to be made until the maturity date of the contract.

From the pricing formulas (3) and (4) it follows that the mispricing depends on the time to maturity of the futures contract even after controlling for the timing of dividend payments. This relation is consistent with empirical evidence reported in Cakici and Chatterjee (1991) and MacKinlay and Ramaswamy (1988). These authors have documented that the absolute value of the deviation between actual and theoretical futures prices increases in the time to maturity of the contract. We therefore hypothesize

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Hypothesis 5: The mispricing under the imputation tax system is more pronounced for contracts with longer time to maturity.

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4 Data and Summary Statistics

We use data on the DAX futures contract, the DAX index, and on dividend payments made by the constituent stocks of the DAX. Our sample period extends from 1992 to 2011.[15] DAX futures prices and DAX index values are obtained from Datastream. For each futures contract maturing between September 1992 and September 2011 we retrieve six months of data. We subdivide these six months into a three-months period during which the contract is the nearest-to-delivery (nearby) contract and a three-months-period during which the contract is the second-nearest-to-delivery contract. We calculate the average mispricing (as defined above) for each contract and each period.

Table 3 provides summary statistics on trading volume and open interest. When considering the nearby contract (first column) the June contract is slightly more actively traded than the other contracts, and it has much higher open interest. The observation that the June contract has markedly higher open interest but only slightly higher trading volume is consistent with the finding of Bamberg and Dorfleitner (2002) that the average holding period is longer for the June contract. Table 3 also reveals that the second-nearest-to-delivery contracts are much less liquid than the nearby contracts. The average trading volume is only about 6% and the average open interest is only about 11% of that of the nearby contract.

[Insert Table 3 about here]

We obtain the annualized DAX dividend yield from Datastream. It is based on the actual dividend payments made by the 30 constituent stocks. The average dividend yield over the entire sample period is 2.34% per year, with a minimum of 1.37% (in 2000) and a maximum of 4.16% (in 2009). The high dividend yield in 2009 is due to compressed share prices during the financial crisis. Besides the dividend yields we collect a complete list of all individual dividends paid by the constituent stocks of the DAX during the sample period. It contains the exact date and amount of the dividend payment. Figure 1 shows the number of dividend payments in each quarter. The clustering of dividend payments in the second quarter of the year is evident.

[Insert Figure 1 about here]

Finally we obtain money market interest rates for maturities between one day and three months. We interpolate these rates to obtain a rate that exactly matches the maturity of the futures contracts.[16]

5 Empirical Analysis

We start with an analysis of the average mispricing per contract (hypotheses 1 - 3). In a second step we then analyze the time series behavior of our mispricing measure on a daily basis (hypotheses 4 and 5).

5.1 Mispricing per Contract

Figure 2 shows the average mispricing for each contract during the three-months period in which the contract is the nearby contract. It is apparent from the figure that there is substantial mispricing in the early years of the sample period (which coincide with the imputation tax system). However, in contrast to hypothesis 1 the mispricing is not predominantly negative. After 2000 the mispricing appears to be (with the exception of the June 2001 and September 2008 contracts) much less volatile.

[Insert Figure 2 about here]

Hypothesis 2 states that the mispricing under the imputation tax system is more pronounced for the June contract. Table 4 reports the average mispricing of the March, June, September and December contracts under the three tax regimes. The average mispricing is positive in all but one case, and significantly so in nine cases. Only the mispricing of the June contract under the imputation tax system is negative (and significant at the 5% level). This is consistent with hypothesis 2. The table also confirms the visual impression from Figure 2 that the absolute levels of mispricing are largest under the imputation tax system and smallest under the withholding tax regime.

[Insert Table 4 about here]

So far we have only considered the nearby contract. However, hypothesis 2 also predicts that the mispricing of the second-nearest-to-delivery contract under the imputation tax system is more pronounced for the June and September contracts than for the March and December contracts. Table 5 shows the mispricing for the second-nearest-to-delivery contracts.

[Insert Table 5 about here]

The results are somewhat ambiguous. The mispricing under the imputation system is positive for each contract month. This is inconsistent with hypotheses 1 and 2. However, the mispricing is much smaller for the June and September contracts than for the March and December contracts. An additional analysis (results omitted) reveals that the difference is significant at the 1% level. Thus, while our hypothesis does not accurately predict the level of mispricing, it does correctly predict the time-series pattern of mispricing. Table 5 also reveals that the mispricing of the second-nearest-to-delivery contract under the half income system is of the same order of magnitude as the mispricing under the imputation system. In contrast, the mispricing under the withholding tax regime is markedly lower.

Hypothesis 3 predicts that the mispricing under the imputation tax system is more pronounced in years with higher dividend yields. Table 6 shows the average mispricing of the June contracts (for the three months during which the contract is the nearby contract) sorted by the dividend yield in the respective year. There is clear evidence that the mispricing increases (i.e. becomes more negative) as the dividend yield increases. The correlation between the two variables is -0.74. No such pattern is found for the two other tax regimes.

[Insert Table 6 about here]

5.2 Time-Series Analysis

In this section we turn from an analysis of the average level of mispricing per contract to a time-series analysis of the daily level of mispricing. Hypotheses 4 and 5 predict that the mispricing decreases with each dividend payment and decreases as maturity approaches. To test these hypotheses we regress the daily mispricing on the amount of dividends outstanding until the maturity date of the contract, the days to maturity, and several control variables. We use two specification for the dependent variable. The first (denoted model 1) is the mispricing measured in index points,

$$FDAX_t^{empirical} - DAX_t e^{r(T-t)}. \tag{7}$$

We exclude cases in which the mispricing amounts to more than two percent of the DAX index value. In the second specification (denoted model 2) we use the relative mispricing

$$\frac{FDAX_t^{empirical} - DAX_t e^{r(T-t)}}{DAX_t e^{r(T-t)}} \tag{8}$$

The explanatory variables suggested by hypotheses 4 and 5 are the days to maturity (we exclude the maturity date of the contract) and the amount of dividends outstanding. The latter variable is defined as the weighted sum of the dividends paid by the component stocks of the DAX until the maturity date of the contract where the weight for each stock is the weight of the stock in the index.[17] Note that this variable implicitly controls for the dividend yield - in years with higher dividend yields the amounts of dividends outstanding will be higher. The valuation formulas (3) and (4) imply that, everything else equal, the actual value of the futures contract is decreasing in the amount of dividends outstanding and in the time to maturity. We thus expect a negative coefficient for both variables. We have documented earlier that dividend payments are concentrated in the second quarter. We therefore include two interaction terms such that the coefficient on the amount of dividends outstanding is allowed to be different in the second quarter of the year.[18]

We include as controls dummy variables that identify the June, September and December contracts. We further include the natural logarithm of trading volume and the lagged mispricing to account for serial correlation in the dependent variable. Finally, in the specification in which the dependent variable is the mispricing measured in index points we further include the level of the DAX index because we expect higher values of the dependent variable when the index level is higher. The sample period is 1992-2000 (the imputation tax system). All equations are estimated using OLS with heteroscedasticity-consistent standard errors. In an unreported robustness check we estimated separate models for the nearest-to-delivery and second-nearest-to-delivery contracts. The results were qualitatively similar to those reported below.

The results are shown in Table 7. The explanatory variables explain 10.2% of the variation in the mispricing variable in model 1 and 6.8% in model 2. The coefficient on the amount of dividends outstanding is negative (as predicted) but insignificant in model 1. The corresponding coefficient in model 2 is positive and even significant at the 5% level. The latter result is at odds with our hypothesis. However, the coefficient captures the average effect of outstanding dividends in the first, third and fourth quarter, that is, in those quarters in which few dividends are paid. The effect in the second quarter is captured by the interaction terms. The respective coefficients are negative and highly significant in both model specifications, and their numerical values are larger than the value of the coefficient for the other three quarters. We can thus conclude that in the second quarter, in which most dividends are paid, a higher amount of dividends outstanding results in lower futures prices relative to the simple cost-of-carry valuation model. This finding is in line with hypothesis 4.

The coefficient on days to maturity is positive and, despite its small size, significant. This is inconsistent with hypothesis 5.[19] The coefficients on the control variables imply that both mispricing variables are serially correlated, and that prices of the June contract are lower (relative to the cost-of-carry benchmark) even after controlling for our explanatory variables. Trading volume does not have significant impact on the deviations from the cost-of-carry relation.

6 Conclusion

In this paper we have analyzed the effect of dividend taxation on futures pricing. Before 2001 Germany operated a full imputation tax system. Under the reasonable assumption that the marginal investor is an institution, futures prices under the imputation system should be lower than suggested by the simple cost-of-carry relation. Further, the deviation from the cost-of-carry relation should increase in the amount of dividends outstanding and the time to maturity.

Our empirical results are not very encouraging. Futures prices under the imputation tax system were often above, rather than below, the cost-of-carry benchmark. Thus, dividend taxation is unable to explain the level of deviations from the cost-of-carry relation. On the positive side, it does have explanatory power for the time series patterns of these deviations. We observe lower futures prices in years with higher dividend yields, and prices of the June contract (which is the nearest-to-delivery contract in the quarter in which most German firms pay their dividends) are lower than those of the March, September and December contracts. Multivariate regressions confirm the finding that dividend taxation affects futures prices in the second quarter. It seems fair to conclude, though, that additional research is required to fully understand the subtle effects of taxation on futures prices.

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Footnotes

[1] Cornell and French (1983a) document that US stock index futures were underpriced in the early 1980s. They offer an explanation which is based on the taxation of capital gains. While investors in the spot markets have the option to defer capital gains taxes, investors in the futures markets do not have this option. However, Cornell (1985) reconsidered the issue and concluded that "the timing option is not an important factor in pricing stock index futures" (p. 89). We will therefore not pursue this issue.

[2] Several papers analyze the relation between spot and futures prices and try to infer the value of dividend tax shields or imputation tax credits, e.g. McDonald (2001), Cannavan et al. (2004) and Cummings and Frino (2008).

[3] Bamberg and Dorfleitner (2002) also argue that prices of the June contract are most heavily affected by dividend taxation. They further document that the average holding period of the June contract is significantly longer than average holding periods for March, September and December contracts.

[4] The exact definition depends on the tax regime. Roughly, it is the dividend net of corporate taxes.

[5] Cornell and French (1983a,b) assume a perfect capital market without taxes, transaction costs or other frictions such as short sale restrictions or indivisibility issues. They further assume that the borrowing and lending rates are equal, and that dividends are paid continuously. Further necessary

assumptions are that interest rates and dividends are non-stochastic, that there are no margin requirements, that there is no reinvestment risk, and that the composition of the index does not change during the lifetime of the futures contract.

[6] Further refinements of the simple cost-of-carry model, obtained by relaxing the perfect market assumptions, can be found in Janssen and Rudolph (1995). They consider additional risks and costs to arbitrage. Janssen and Rudolph (1995) model transaction costs (short-sale costs, fees, liquidity costs) and interest rate taxation. Furthermore, they take into account capital gains taxation which could reduce profits from arbitrage and therefore the band in which arbitrage is profitable. The focus of our paper lies on taxes and therefore transaction costs are not considered.

[7] Investors with a personal tax rate below 25% are taxed at their personal tax rate. For them, the effective tax rate is thus below the withholding tax rate of 25%.

[8] The objective of this rule is to avoid double-taxation. Without the dividend privilege the dividend would be taxed once when the corporation receives it and once when it passes it on to its shareholders.

[9] A similar argument is brought forward by Weber (2005).

[10] The calculation of s_d^* is shown in Table 2.

[11] If the investor was a foreign (rather than a domestic) corporation, the tax rate difference might be even larger because foreign investors usually did not receive the tax credit (see McDonald

(2001)).

[12] We note that in both cases the results would differ significantly if the marginal investor was a financial institution that holds the position in the banking book. In this case the dividend privilege would apply, and the fair futures price would be 66.8 (65.6) points below the price obtained from the simple cost-of-carry formula. However, as argued above, arbitrage positions are usually held in the trading book, and in this case the dividend privilege does not apply. Therefore, we stick to our assumption that the marginal investor is a short-term investor.

[13] Our measure of (relative) mispricing is similar to the measures used by MacKinlay and Ramaswamy (1988), Cakici and Chatterjee (1991), Bühler and Kempf (1995) and Roll et al. (2007).

[14] Bühler and Kempf (1995) and Röder and Bamberg (1994) document that there are more arbitrage opportunities in June contracts than in other contracts.

[15] Trading in DAX futures contracts started in November 1990. Several papers (e.g. Röder and Bamberg (1994); Bühler and Kempf (1995)) have shown that there were substantial arbitrage opportunities in 1991. We therefore decided to start our sample period in 1992.

[16] In a robustness check we simply use the one-month rate. The results are similar and are therefore omitted.

[17] Because the DAX index weights are not available for the entire sample period we approximate the monthly index weights of the DAX constituent stocks by dividing the market capitalization of

each component stock by the aggregate market capitalization of the index.

[18] We interact the dividend outstanding variable with two dummy variables. The first dummy takes on the value 1 for observations from June contracts when the June contract is the nearest-to-delivery contract. The second dummy takes on the value of 1 for observations from September contracts whenever a September contract is the second-nearest-to delivery contract.

[19] Note that the result is not necessarily in contrast with the empirical evidence reported in Cakici and Chatterjee (1991) and MacKinlay and Ramaswamy (1988). These authors analyze the absolute value of the mispricing while we analyze signed mispricing.

7 Figures and Tables

Figure 1: Dividend Payments Days per Nearest-to-Delivery Contract (1992-2011).

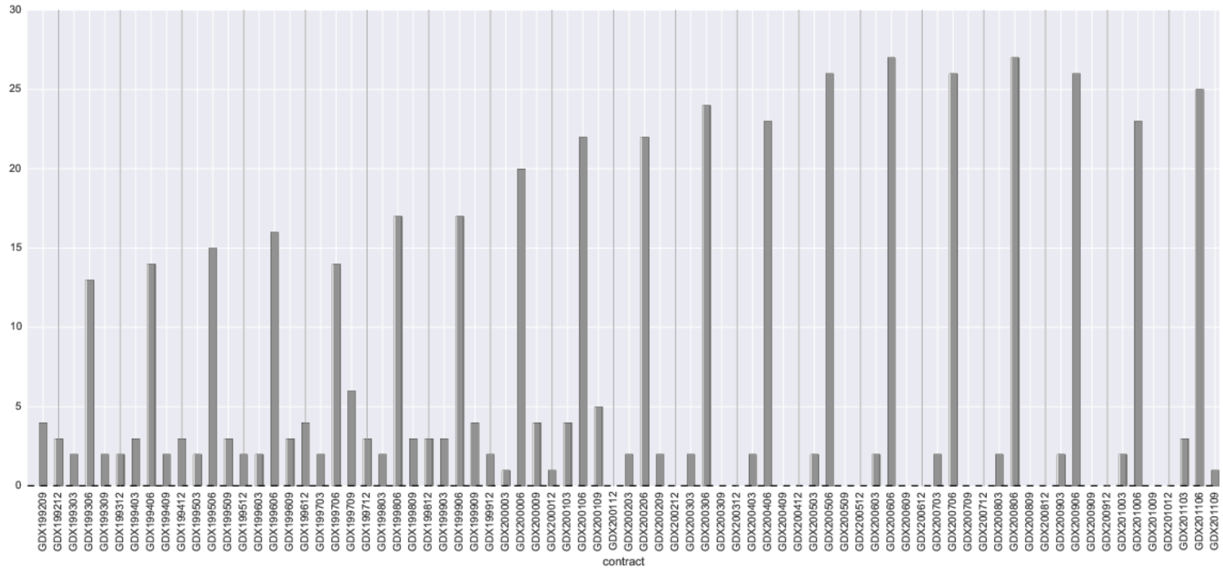

Figure 2: Average Mispricing $\frac{FDAX_t^{empirical} - DAX_t e^{r(T-t)}}{DAX_t e^{r(T-t)}}$ per Nearest-to-Delivery Contract under the Three Tax Regimes: *Vollanrechnungsverfahren (1992-2000), Halbeinkuenfteverfahren (2001-2009), Abgeltungssteuer (2009-).*

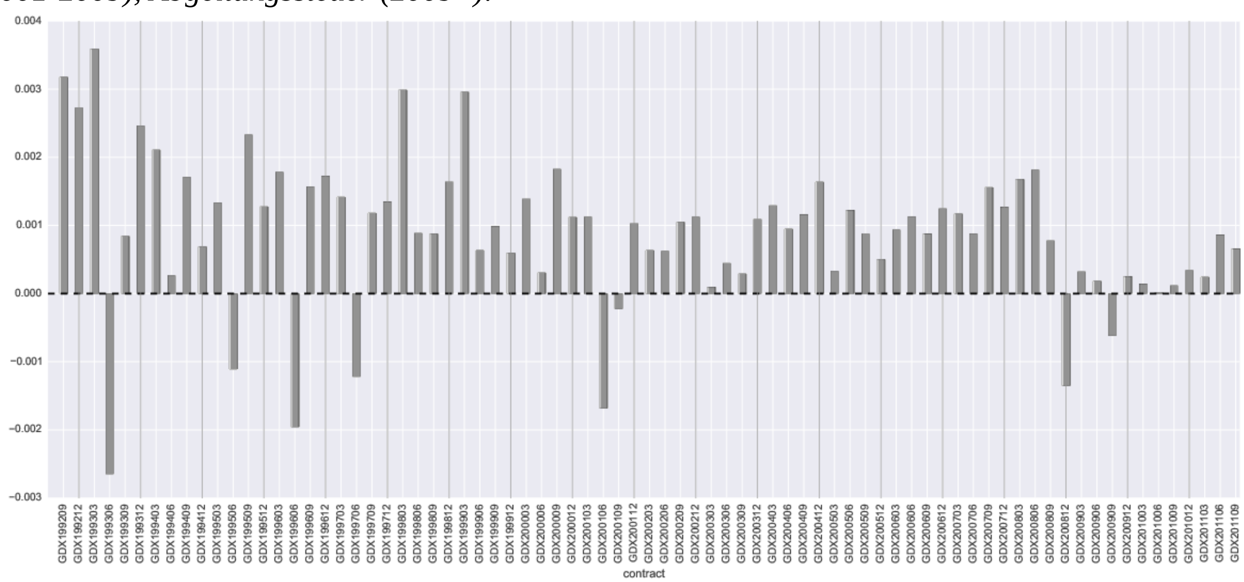

Table 1: No-Arbitrage Table to Derive the Fair Futures Price.

In this table (Bamberg and Dorfleitner (2002) use a similar no-arbitrage table to derive the futures price for the Halbeinkuenfteverfahren), we derive the fair futures price F^* with no-arbitrage arguments. The no-arbitrage arguments are based on a cost-of-carry strategy that involves initial investment into a portfolio of stocks that replicates the DAX index. This investment is financed with a credit in period $t = 0$. In the same period, the arbitrageur sells a DAX Futures contract short. Up to the maturity date of the futures contract the component stocks of the index pay dividends. The construction of the index assumes a lower tax rate than the actual rate paid by the arbitrageur. The arbitrageur has to finance the tax differences with supplementary credits up to maturity. We assume taxation at the end of the period.

Position	t=0	$t = \tau_j$	t=T
DAX portfolio long	$\underbrace{-\sum_{i=1}^{30} n(i)p_0(i)}_{=:-S_0}$	$(1 - s_d)\sum_j n(j)D(j)$	$\sum_{i=1}^{30} n(i)p_T(i) - \underbrace{s_k \sum_{i=1}^{30} n(i)[p_T(i) - p_0(i)]}_{Capital\ gains\ tax}$
FDAX short	± 0		$(F - S_T)(1 - s_k)$
Loan	$+S_0$		$-[S_0e^{rT} - (S_0e^{rT} - S_0)s_z] = -S_0[e^{rT} - e^{rT}s_z + s_z]$
Supplementary loan		$s_d \sum_j n(j)D(j)$	$-s_d \sum_j [n(j)D(j)e^{r(T-\tau(j))} - [n(j)D(j)e^{r(T-\tau(j))} - n(j)D(j)]s_z]$ $= -s_d \sum_j n(j)D(j)[e^{r(T-\tau(j))} - e^{r(T-\tau(j))}s_z + s_z]$
Dividend re-investment		$\underbrace{-\sum_j n(j)D(j)}_{=:-\sum_j n(j)z(j)p_{ex}(j)}$	$\sum_j n(j)z(j)p_T(j) - \underbrace{s_k \sum_j n(j)z(j)[p_T(j) - p_{ex}(j)]}_{Capital\ gains\ tax}$
Sum	0	0	0 →Solve for F* to get fair futures price.

s_k = capital gains tax, s_z = interest tax, s_d = dividend tax, r=continuously compounded interest rate, j = dividend paying company, $n(j)$ is the weight of company j in the DAX index. $D(j)$ is the dividend of company j. p_{ex} is the ex-dividend price and $z(j)$ is the amount of stocks to be bought at p_{ex} to match the dividend.

Derivation of futures price F*:

$$
\begin{aligned}
0 = {} & (1 - s_k)\underbrace{\left[\sum_{i=1}^{30} n(i)p_T(i) + \sum_j n(j)z(j)p_T(j)\right]}_{=:S_T} \\
& +(F - S_T)(1 - s_k) - S_0[e^{rT} - e^{rT}s_z + s_z] + s_k \underbrace{\sum_{i=1}^{30} n(i)p_0(i)}_{=:S_0} \\
& -s_d \sum_j n(j)D(j)[e^{r(T-\tau(j))} - e^{r(T-\tau(j))}s_z + s_z] + s_k \sum_j n(j)D(j)
\end{aligned}
$$

$$
\begin{aligned}
F *= {} & S_0([e^{rT} - e^{rT}s_z + s_z] - s_k)\frac{1}{(1-s_k)} \\
& -[s_k \sum_j n(j)D(j) - s_d \sum_j n(j)D(j)[e^{r(T-\tau(j))} - e^{r(T-\tau(j))}s_z + s_z]]\frac{1}{(1-s_k)} \\
= {} & S_0(e^{rT}(1 - s_z) + s_z - s_k)\frac{1}{(1-s_k)} \\
& -[s_k \sum_j n(j)D(j) - s_d \sum_j n(j)D(j)[e^{r(T-\tau(j))}(1 - s_z) + s_z]]\frac{1}{(1-s_k)}
\end{aligned}
$$

Table 2: Marginal Investors and Tax Rates in the Three Tax Regimes Vollanrechungsverfahren (VOLL), Halbeinkuenfteverfahren (HEV), and Abgeltungssteuer (ABG).

In this table we show two exemplary investors and their tax rates in the three tax regimes under consideration. Similar tables are used in Kempf and Spengel (1993) and Spengel and Zinn (2010). We follow Weber (2005) and incorporate the Corporate Tax II (GST) into the total corporate tax rate s. Furthermore, we ignore an additional tax on the corporate tax, a solidarity surcharge tax which was introduced after German reunification.

VOLL	Financial Institution	
Corporate Tax (KST_{pout}) in case of dividend payout	0.36/0.3	
Corporate Tax (KST)	0.5/0.45	
Corporate Tax II (GST)	GST=0.05*400%=0.2	
Corporate Tax Total (=s)	$s = KST + \frac{GST(1-KST)}{(1+GST)} = 0.583$ or $s = 0.5417$	
Interest tax (s_z)	$s_z = s$	
Capital gains tax (s_k)	$s_k = s$	
Dividend Tax (s_d^*)	$s_d^* = 0.3484/0.2839$ §	
HEV	Financial Institution, long-term	Financial Institution, short-term
Corporate Tax (KST)	0.25	0.25
Corporate Tax II (GST)	GST=0.05*400%=0.2	0.2
Corporate Tax Total (=s)	$s = KST + \frac{GST(1-KST)}{(1+GST)} = 0.375$	$s = 0.375$
Interest tax (s_z)	$s_z = s$	$s_z = s$
Capital gains tax (s_k)	$s_k = s$	$s_k = s$
Dividend Tax (s_d^*)	$s_d = s$ (levied on $0.05D$)⊗	$s_d = s$
ABG	Financial Institution, long-term	Financial Institution, short-term
Corporate Tax (KST)	0.15	0.15
Corporate Tax II (GST)	GST=0.035*400%=0.14	0.14
Corporate Tax Total (=s)	$s = KST + \frac{GST(1-KST)}{(1+GST)} = 0.2544$	$s = 0.2544$
Interest tax (s_z)	$s_z = s$	$s_z = s$
Capital gains tax (s_k)	$s_k = s$	$s_k = s$
Dividend Tax (s_d^*)	$s_d = s$ (levied on $0.05D$)⊗	$s_d = s$

§ the effective dividend tax rate is $s_d = s$. This rate is split into two components in the imputation system. First, when a firm pays a dividend the dividend is taxed (at a rate of 36%, later reduced to 30%). The institution receiving the dividend has to pay additional taxes whenever its effective tax rate is higher than the rate at which the dividend has already been taxed. This additional rate is denoted as s_d^* and is calculated according to $D(1-s_d^*) = D^+(1-s)$, where $D = (1-KST_{pout})D^+$. D^+ is the untaxed capital gain to be distributed by the dividend paying company

⊗ Dividend-Privilege of Corporations. Only 5% of dividends are taxed. In case of losses, the taxes are not deductible.

Table 3: Average Daily Trading Data (Trading Volume and Open Interest) per Nearest-to-Delivery and Second-Nearest-to-Delivery Contract.

Future Contract	Trading Volume (Nearest-to-Delivery Contract)	Trading Volume (Second-Nearest-to-Delivery Contract)
March	84,057.72	4,540.01
June	86,551.66	6,359.89
September	81,938.49	5,102.85
December	82,312.02	4,967.20

Future Contract	Open Interest (Nearest-to-Delivery Contract)	Open Interest (Second-Nearest-to-Delivery Contract)
March	163,458.34	16,722.28
June	213,794.42	33,863.24
September	146,239.09	14,196.16
December	151,067.31	15,356.5

Table 4: Average Mispricing of Nearest-to-Delivery Future Contract in the Three Tax Regimes (Vollanrechnungsverfahren (VOLL), Halbeinkuenfteverfahren (HEV) and Abgeltungssteuer (ABG).

Tax System	Contract Months	Mispricing	T-Value	P-Value
VOLL	3	0.0022	8.84	0.00
	6	-0.0006	-2.58	0.01
	9	0.0016	7.30	0.00
	12	0.0015	6.93	0.00
HEV	3	0.0009	7.32	0.00
	6	0.0007	5.12	0.00
	9	0.0008	4.43	0.00
	12	0.0008	4.99	0.00
ABG	3	0.0002	1.38	0.17
	6	0.0004	3.26	0.00
	9	0.0001	0.39	0.70
	12	0.0003	2.43	0.02

Table 5: Average Mispricing of Second-Nearest-to-Delivery Future Contract in the Three Tax Regimes (Vollanrechnungsverfahren (VOLL), Halbeinkuenfteverfahren (HEV) and Abgeltungssteuer (ABG).

Tax System	Contract Months	Mispricing	T-Value	P-Value
VOLL	3	0.0039	17.61	0.00
	6	0.0020	8.03	0.00
	9	0.0018	8.19	0.00
	12	0.0036	15.78	0.00
HEV	3	0.0023	12.64	0.00
	6	0.0026	21.62	0.00
	9	0.0026	21.30	0.00
	12	0.0031	19.53	0.00
ABG	3	0.0000	-0.03	0.97
	6	0.0004	2.78	0.01
	9	0.0000	0.01	0.99
	12	-0.0012	-8.09	0.00

Table 6: Average Mispricing of Nearest-to-Delivery June Futures Contract in the Three Tax Regimes (Vollanrechnungsverfahren (VOLL), Halbeinkuenfteverfahren (HEV) and Abgeltungssteuer (ABG). The mispricing is sorted according to the annual dividend yield.

Tax System	Year	DY per Year	Mispricing	T-Value	P-Value
VOLL	2000	1.36	0.0003	0.70	0.49
	1998	1.37	0.0009	0.88	0.38
	1999	1.38	0.0006	1.15	0.26
	1997	1.46	-0.0012	-1.39	0.17
	1996	1.87	-0.0020	-3.50	0.00
	1994	1.90	0.0003	0.42	0.67
	1995	2.03	-0.0011	-1.96	0.05
	1993	2.27	-0.0026	-5.08	0.00
HEV	2001	1.95	-0.0017	-4.10	0.00
	2004	1.95	0.0009	1.92	0.06
	2002	2.22	0.0006	2.02	0.05
	2005	2.29	0.0012	3.47	0.00
	2006	2.40	0.0011	3.71	0.00
	2007	2.49	0.0009	4.03	0.00
	2003	2.57	0.0004	1.00	0.32
	2008	3.73	0.0018	8.35	0.00
ABG	2010	3.10	0.0000	0.08	0.93
	2011	3.22	0.0009	6.03	0.00
	2009	4.12	0.0002	0.86	0.39

Table 7: Daily Absolute and Relative Mispricing for Nearest-to-Delivery and Second-Nearest-to-Delivery Contracts in the Vollanrechnungsverfahren Tax Regime. The control dummy variables identify the June, September and December contract. Furthermore, the natural logarithm of trading volume and the lagged mispricing are included as well as the level of the DAX index.

	(1)	(2)
VARIABLES	Absolute_Mispricing	Relative_Mispricing
JUNE Contract	-4.687***	-0.00226***
	[-3.471]	[-5.555]
SEPTEMBER Contract	-0.786	-0.000417
	[-0.826]	[-1.585]
DECEMBER Contract	-1.078	-0.000385*
	[-1.376]	[-1.746]
Trading Volume	-0.473*	-6.74e-05
	[-1.839]	[-1.004]
Days to Maturity	0.0674***	1.71e-05***
	[3.672]	[3.346]
Absolute_Mispricing_lag	0.0410*	
	[1.676]	
Relative_Mispricing_lag		0.0452**
		[2.434]
DPS (Index weighted) to Maturity	-0.213	0.00199*
	[-0.0541]	[1.955]
DPS (Index weighted) to Maturity*NTD*JUNE Contract	-13.61***	-0.00410***
	[-3.421]	[-4.429]
DPS (Index weighted) to Maturity*SNTD*SEPTEMBER Contract	-11.15***	-0.00480***
	[-3.100]	[-5.096]
Dax Index	0.00221***	
	[13.38]	
Constant	1.177	0.00213***
	[0.405]	[2.661]
Observations	4,254	4,254
R-squared	0.102	0.068

Robust t-statistics in brackets
*** p<0.01, ** p<0.05, * p<0.1

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