Stock Market Behavior on Ex-Dividend Dates: The Case of Cum-Ex Transactions in Germany

Thiess Buettner, FAU[†] and CESifo
Carolin Holzmann, FAU
Felix Kreidl, FAU
Hendrik Scholz, FAU

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Abstract

This paper explores whether stock-market arbitrage exploits profit opportunities arising from tax fraud. We focus on so-called cum-ex trades. These trades rest on the issuance of withholding-tax certificates that can be used for a tax-credit or refund without previous withholding-tax payment. We provide a theoretical analysis showing that without false tax certificates cum-ex trades would be unprofitable. In addition, we show that if profit opportunities associated with the false tax certificates are exploited, cum-ex trading alters the price-drop ratio at the ex-dividend day. The empirical analysis provides evidence using data on daily stock prices and trading volumes for German stocks for the years 2009 to 2015. Our identification strategy exploits variation in the withholding-tax liability of dividends as well as differences in the withholding-tax procedure over time. The results indicate that price-drop ratios at ex-dividend days can be explained by cum-ex trades. Consistent with cum-ex trading, the data also shows large increases in trading volumes around ex-dividend dates.

Keywords: Dividend taxes; Capital gains taxes; Price-drop ratio; Ex-dividend dates; Tax clienteles; Tax compliance; Tax fraud; Withholding tax; Tax crediting

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[†] University Erlangen-Nuremberg, Lange Gasse 20, 90403 Nuremberg, Germany.
Email: thiess.buettner@fau.de, carolin.holzmann@fau.de, felix.kreidl@fau.de, hendrik.scholz@fau.de

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1 Introduction

A large literature discusses the effects of capital income taxes on the stock market, in particular, on the stock market behavior on ex-dividend dates (e.g., Elton and Gruber, 1970; Kalay, 1982; Michaely and Vila, 1995; McDonald, 2001). In this context, the literature typically focuses on statutory taxes on dividends and capital gains. Little attention has been paid to the administration of these taxes.[1] However, the procedures that determine how these taxes are collected and enforced have potentially important implications for arbitrage at stock markets. This is illustrated by so-called cum-ex trading, a specific type of stock trades around ex-dividend dates, which makes use of the issuance of withholding-tax certificates – even without previous withholding-tax payment. Allegedly, cum-ex trading caused major tax-revenue losses in Germany.[2]

Germany imposes a withholding tax of 25% on dividend payments and credits or even refunds the tax for German as well as foreign investors. Until January 2012, two separate parties were responsible for the tax collection and the issuance of tax certificates which entitled for a tax refund or tax credit. While the withholding tax was collected by the dividend-paying corporation, the issuance of withholding-tax certificates was the responsibility of the stock holder's depository bank. This separation of responsibilities created a lack of transparency in the withholding-tax system and opened up the opportunity for a specific type of arbitrage around dividend dates. A new form of cum-ex trades emerged which achieved issuance of withholding-tax certificates without previous withholding-tax payment. Since the tax certificates entitled the

[1] Johannesen (2014) illustrates some of the problems that are related to the enforcement of withholding taxes, particularly in case of interest income.

[2] For an overview see Spengel and Eisgruber (2015). The federal parliament in Germany (Deutscher Bundestag) has set up a committee of enquiry to clarify the precise circumstances of cum-ex trading as well as the revenue losses and the political responsibility.

owner either to a tax refund or a tax credit, the certified amount of withholding taxes created tax revenue losses for the public.[3]

This paper explores whether cum-ex trading exerted significant effects on the market for German stocks. We provide a theoretical discussion that shows how cum-ex trading may have affected stock prices. Our theoretical findings reveal that without false tax certificates cum-ex trades are unprofitable. In addition, we find that if associated profit opportunities are exploited, cum-ex trading alters the price-drop ratio at the ex-dividend day. We empirically test this prediction using a large data set including price and trading volume information on German stocks for the years 2009 to 2015. Our empirical identification strategy exploits differences in the withholding-tax liability of dividend payments and in the withholding-tax procedure over time. Dividends that are paid out of firms' current profits are subject to a 25% withholding tax (regular taxable dividends) and, therefore, principally suitable for cum-ex transactions. In contrast, dividends that are paid out of firms' capital reserves are withholding tax free and, thus, not suitable for cum-ex trading.

The empirical results show that during the cum-ex period, the ex-day price-drop ratio (PDR) in case of regular taxable dividends is, as theoretically predicted, significantly smaller than the PDR of withholding-tax-free dividends. In line with our theoretical model, we find the PDR of cum-ex suitable stocks to be 0.75 whereas the PDR of stocks not suitable for cum-ex trades is unity. Furthermore, we find a strong increase in trading volumes within a two-trading day window before the ex-day, the relevant time period for cum-ex trades. The increase is economically substantial: The trading volume increases due to cum-ex trading on the second day before the ex-day by around 23% and on the day prior the ex-day by approximately 61%. For dividend payments after January 2012, when the German legislator had fixed the withholding system that

[3] Despite the obvious fact that no withholding-tax payment was associated with the tax certificate, various agents held the opinion that the construction was legal (for an overview, see Spengel and Eisgruber, 2015).

enabled cum-ex trades, we do not find any statistically significant difference in trading volume around the ex-day that can be attributed to the difference in withholding-tax liability of the dividend.

This paper contributes to the literature on the effects of capital income taxation on stock prices and trading volumes at ex-dividend dates. The paper broadens the scope of relevant tax institutions by taking into account not only statutory taxation but also the administrative procedures that determine how taxes are collected. The paper's main contribution is to explore whether arbitrageurs exploit profit opportunities that arise from tax fraud and to empirically quantify the effect. The paper studies the German stock market where previous literature has established empirical evidence of statutory tax effects consistent with perfect arbitrage at ex-dividend dates (e.g. McDonald, 2001; Haesner and Schanz, 2013). For empirical identification, we use, besides changes in dividend taxation over time also differences in the withholding-tax liability of dividends. Our findings highlight the importance of administrative procedures of tax systems in the context of financial markets where tax sensitivities of investments are reportedly high (Slemrod and Gillitzer, 2014): Opportunities for tax fraud give rise to new forms of arbitrage that fully exploit associated profit opportunities.

The paper proceeds as follows. Section 2 provides background information on cum-ex trading. Section 3 derives theoretical implications of cum-ex trading for the capital market equilibrium. Section 4 describes the data. Section 5 develops the empirical approach. Section 6 presents the empirical results. Section 7 concludes.

2 Background withholding tax system and cum-ex trades

Until December 2011, Germany required German corporations to collect a withholding tax of 25% on dividend payments. Thus, in case of a dividend payment, the stock holder received

only 75% of the gross dividend[4] on her bank account. 25% of the gross dividend were withheld by the corporation and directly transferred to the German government on account of the stock holder. While the withholding tax was collected by the dividend-paying corporation, the stock holder's depository bank was responsible for issuing the withholding-tax certificate. This discrepancy created a lack of transparency in the withholding-tax system that made it vulnerable for fraudulent tax deals: A new form of cum-ex trades emerged, which achieved issuance of withholding-tax certificates without previous withholding-tax payment. These tax certificates were de facto cash-equivalent as they entitled their owner for a tax deduction or even a tax refund. Their value, therefore, opened up new profitable arbitrage opportunities for cum-ex trades. Since these tax certificates were issued without previous withholding-tax payment, the certified amount of withholding tax constituted tax revenue losses for the public.

The cum-ex trader instigates the cum-ex trade through a short-sale of a stock cum-dividend at price P_{CUM} one or two days before the ex-dividend date. The exact timing of the short-sale is important for cum-ex trades. As German stock market guidelines oblige the actual delivery of the stock within a two-trading-day window, the cum-ex trader achieves through this timing an ex-dividend delivery of the stock. The ex-dividend delivery at price P_{EX} is an essential part of cum-ex trades and necessary for the trades to be profitable.[5]

Once the stock sale is completed, the short-buyer becomes the legal owner of the cum-dividend stock and is entitled to receive a dividend payment at the ex-day. However, the stock will be physically delivered to the buyer's depository account only at the end of the ex-day (or one trading day later). Without further ado, the buyer will not receive a dividend payment. In order to ensure correct dividend distribution, a so-called dividend clearing is carried out.

[4] The gross dividend is the dividend after corporate taxes.

[5] German stock-exchange rules require no coverage of the short-sale under the condition that delivery is completed within this two-trading-days window (§4 II Bedingungen für Geschäfte an der Frankfurter Wertpapierbörse), *i.e.* cum-ex transactions require no stock borrowing.

Important in the context of cum-ex trading is that the dividend clearing of German stocks is based on the dividend after withholding tax. In the clearing process, the short-buyer receives a "three-part delivery" of the stock: The cum-ex trader delivers the stock ex-dividend at the price P_{EX} and pays a dividend compensation equal to the dividend after withholding tax, $(1-\tau_d)D$. Further, the short-buyers' depository bank issues a withholding-tax certificate that confirms the payment of a withholding tax of $\tau_d D$. Hence, the short-buyer is indifferent between the delivery of stocks cum-dividend or the "three-part delivery" in the clearing process.

In the clearing process, the counter party, *i.e.* the cum-ex trader, makes only a "two-part delivery". According to the withholding-tax rules at the time, the short-buyer's depository bank issues a withholding-tax certificate for the short-seller which discharges the cum-ex trader from the obligation to fully deliver the value of the stocks cum-dividend. Assuming a price-drop at the ex-day in the share price that corresponds to the gross dividend D, the cum-ex trader earns a gross return equal to the withholding tax on the dividend payment, $\tau_d D$.

The issuance of withholding-tax certificates by depository banks for dividend compensation payments without actual withholding-tax payments is the consequence of a substantial flaw in the withholding-tax system at the time. Core of the problem is the fact that the withholding-tax system made different parties responsible for the tax-withholding (the dividend-paying corporation) and for the issuance of the tax certificate (depository banks). For depository banks it was, consequently, not transparent whether the underlying transaction was a cum-ex trade (without previous withholding-tax payment) or an ordinary transaction (with previous tax payment). In both cases, the depository banks issued withholding-tax certificates. Cum-ex traders exploited this issuance. Presumably, organized large-scale cum-ex trading potentially caused large tax revenue losses for the German government between 2009 and 2011.

In January 2012, the German dividend withholding-tax system was fundamentally reformed to prevent cum-ex trading. Most importantly, the discrepancy between the party withholding the dividend tax and the party issuing the tax certificate was eliminated. Since 2012, German depository banks are responsible for both the levying of the dividend withholding tax and the issuance of the withholding-tax certificate.

3 Theory

In this section, we derive an equilibrium model in which the trading behavior of different investor classes with heterogeneous tax rates is consistent with the expected price drop at the ex-day (see, e.g., Allen and Michaely, 1995). We follow the approach by Kalay (1982) and McDonald (2001) and use a costly arbitrage framework to derive no-arbitrage conditions under which different risk-neutral investor classes do not have explicit arbitrage opportunities neither by buying the stock cum-dividend and selling it ex-dividend (long arbitrage strategy), nor by shorting cum-dividend and closing the short position ex-dividend (short arbitrage strategy). Selling and buying at the stock market come at a transaction cost, c. The tax treatment enters with two tax instruments, a dividend tax, τ_d, and a tax on realized capital gains, τ_g. Besides explicit arbitrage, we follow McDonald (2001) and consider also the case of implicit arbitrage where investor classes may accelerate or decelerate planned transactions in order to capture or avoid dividend payments. Note that in this case, transaction cost is considered irrelevant.[6] The model enables us to establish a theoretical prediction of the equilibrium ex-day price-drop ratio both in presence and absence of cum-ex transactions.[7]

[6] We consider implicit strategies for small dividend yields when explicit arbitrage can be unprofitable due to relatively high transaction cost.

[7] For the model's derivation, we consider the applicable tax rules for the time period from January 2009 to December 2015.

3.1 Long- and short arbitrage with fully taxable investors

At the stock market, investors that consider selling, meet investors that consider buying the stock. We start with the derivation of general no-arbitrage conditions for investors. The expected return of an investor following a long-arbitrage strategy, which is buying a stock cum-dividend and selling the stock ex-dividend, is $(E[P_{EX}] - P_{CUM} - 2c)(1-\tau_g) + D(1-\tau_d)$. The long-arbitrage strategy yields an expected return that is smaller or equal to zero if the price-drop ratio exceeds or equals $\frac{P_{CUM}-E[P_{EX}]}{D} \geq \frac{1-\tau_d}{1-\tau_g} - \frac{2c}{D}$.

The alternative strategy is short-arbitrage. This consists of borrowing and selling a stock cum-dividend and purchasing and returning the stock ex-dividend. This strategy yields an expected return of $(P_{CUM} - E[P_{EX}] - 2c))(1-\tau_g) - (1+\gamma)(1-\tau_d)D$. With this strategy, the net dividend is foregone, and, in addition, a fraction $\gamma > 0$ of the net dividend has to be paid as a price for borrowing. The expected return is non-positive if the price-drop ratio is below or equal $\frac{P_{CUM}-E[P_{EX}]}{D} \leq (1+\gamma)\frac{1-\tau_d}{1-\tau_g} + \frac{2c}{D}$. Note that the equation represents the price-drop ratio in case of a *covered short-arbitrage strategy* as the short position is covered by the borrowed stock at the cost of the fraction γ of the net dividend.

We use both equations to derive a general condition that ensures the absence of profitable trading opportunities around dividend dates in the market:

$$\frac{1-\tau_d}{1-\tau_g} - \frac{2c}{D} \leq \frac{P_{CUM} - E[P_{EX}]}{D} \leq (1+\gamma)\frac{1-\tau_d}{1-\tau_g} + \frac{2c}{D}. \tag{1}$$

German fully taxable investors face equal tax rates on dividends and realized capital gains, $\tau_g = \tau_d$.[8] Arbitrage strategies are unprofitable if the price-drop is within the interval

$$1 - \frac{2c}{D} \leq \frac{P_{CUM} - E[P_{EX}]}{D} \leq (1+\gamma) + \frac{2c}{D}. \tag{2}$$

Under the assumption of an equivalence of the tax rates on dividends and capital gains, the same conditions as established in equation 2 hold for foreign fully taxable investors.

3.2 Cum-ex traders

We model cum-ex traders as a specific subgroup of fully taxable investors. Cum-ex traders follow an arbitrage strategy that exploits the issuance of a tax certificate without previous withholding-tax payment arising from a flawed withholding tax system that is vulnerable against tax fraud. To take advantage of the issuance of tax-certificates, it is crucial that a short-sale of stocks takes place within a two-trading-days window before the ex-day. Importantly, German stock-exchange rules require no coverage of the short-sale under the condition that delivery is completed within this two-trading-days window, *i.e.* cum-ex transactions require no stock borrowing. The cum-ex trader closes the short position with two transactions, first, the delivery of the stock ex-dividend at ex-dividend day (or one day later) to the buyer, second, as the requirement is delivery of a stock cum-dividend, the payment of a dividend compensation to the buyer. In accordance with the stock exchange clearing guidelines at the time, the dividend compensation payment equals the net-of-tax dividend, $(1-\tau_d)D$. The (gross) return from the arbitrage

[8] Fully taxable domestic investors are broker dealers, institutional investors (e.g., financial institutions and insurers), corporate investors, and individual investors. In case of individual investors, independent from the investment horizon, both capital gains and dividends are subject to a flat tax. German corporations benefit from basically tax-free dividends and capital gains in the years between 2009 and 2012. In this case, 5% of dividends and capital gains was declared as non-deductible expenses. Consequently, 95% of dividends and capital gains were tax-free (Scheffler, 2012). Institutional investors' and broker dealers' income from dividends and capital gains is subject to the standard corporate tax rate.

is $P_{CUM} - E[P_{EX}] - (1-\tau_d)D - 2c$. Regardless of the tax imposed on the return, arbitrage is unprofitable for the cum-ex trader if

$$\frac{P_{CUM} - E[P_{EX}]}{D} \leq (1-\tau_d) + \frac{2c}{D}. \tag{3}$$

Under ordinary conditions, *i.e.* without false tax certificates, cum-ex trades would always generate negative returns for the buyer. In fact, without false tax-certificates, the buyer would participate in a cum-ex trade only, if the compensation exceeds price drop and transaction cost $(1-\tau_d)D > P_{CUM} - E[P_{EX}] + 2c$. Hence the buyer would only be willing to participate in cum-ex trades if

$$\frac{P_{CUM} - E[P_{EX}]}{D} < (1-\tau_d) - \frac{2c}{D}. \tag{4}$$

Comparison of equation (4) with (3) shows that without false tax-certificates, there is no constellation of dividends, stock prices and transaction cost consistent with cum-ex trading. Hence, without false tax certificates cum-ex trades are either unprofitable for the short seller or the buyer would incur a loss.

However, if the buyer obtains a tax-certificate in the amount of $\tau_d D$, the buyer would find a cum-ex trade profitable, if $D > P_{CUM} - E[P_{EX}] + 2c$. Hence, cum-ex deals are profitable for the buyer as long as

$$1 - \frac{2c}{D} > \frac{P_{CUM} - E[P_{EX}]}{D}. \tag{5}$$

Even if the no-arbitrage condition (3) holds with equality, *i.e.* cum-ex traders have exploited all arbitrage opportunities, condition (5) is still fulfilled. This is intuitive, since, the buyer would gain from the illegitimate tax certificate.

3.3 Capital market equilibrium

The capital market equilibrium determines the ex-dividend day behavior of stock prices considering the derived no-arbitrage conditions of the investor classes. Under the assumption that the cum-ex trader is the marginal investor in the market, the model allows us to make predictions for the effect of cum-ex trading on the equilibrium price-drop ratio for German stocks. In general, cum-ex trading may cause a decline in the equilibrium price-drop ratio. More specifically, in absence of cum-ex trading, if a fully taxable investor is the marginal trader, the model predicts an ex-day price-drop ratio more or equal to one (equation (2)), if γ is negligible and c is small. In contrast, if the cum-ex trader is the marginal investor, according to equation (3), the expected ex-day price-drop ratio is 0.75.

Figure A3 depicts the no-arbitrage conditions, equations (2) and (3). The expected ex-day price drop in percent is plotted against the gross dividend yield. For a given dividend yield, an upward movement in the figure represents an increase in the price drop, a downward movement a decrease in the price drop, respectively. Concerning trading strategies, an increase in the price drop for a given dividend yield suggests decreasing (increasing) profits for long (short) arbitrage strategies. For simplicity, we assume that the stock loan fee is negligible $\gamma = 0$.[9]

The parallel lines AB and CE depict the explicit no-arbitrage conditions for fully taxable investors (with transaction cost $c > 0$). Below AB, the relative price-drop is smaller than the gross dividend payment. This would imply that the long-strategy would offer profitable arbitrage op-

[9] In practice, the stock loan fee γ is a small percentage of the tax saving that is realized through the stock lending that results from differential between the standard and the preferred tax rates. The assumption $\gamma = 0$ should, therefore, have no substantial impact on our analysis of the the capital market equilibrium.

portunities. Hence, German or foreign investors could follow a long strategy and capture the dividend by purchasing the stock cum-dividend and selling it ex-dividend. Hence, this cannot be an equilibrium. Above CE, the relative price-drop is larger than the gross dividend payment. Hence, investors would find it profitable to follow a short strategy and avoid the dividend by selling the stock cum-dividend and repurchasing it ex-dividend. Also this is not consistent with an equilibrium.

An equilibrium where arbitrage opportunities from long- and short arbitrage are exploited is found only in the area ABEC, where transaction cost associated with explicit arbitrage exceeds potential arbitrage profits. Still, fully taxable German and foreign investors might follow implicit arbitrage strategies. In this case, transaction cost are irrelevant ($c = 0$) and the area ABEC would collapse to the dotted line OH. Hence, a capital market equilibrium with implicit arbitrage and fully taxable investors would imply that the price-drop-ratio for each level of dividends is equal to the slope of OH.

More generally, in the absence of cum-ex trading, the equilibrium combination of dividend yields and ex-dividend price drops is represented by the slope of the parallel lines AB, CE and OH. Ignoring the indeterminacy associated with the transaction cost, the model predicts a marginal equilibrium price-drop ratio of one when German and foreign fully taxable investors capture or avoid dividends until marginal profits are zero.

The equilibrium is different with cum-ex trading. As noted above, profitable arbitrage opportunities emerge only if false tax certificates are issued. According to equation (5) arbitrage is possible if the price-drop ratio is below unity. In the figure A3, this condition is captured by the line AB. Hence, cum-ex trades are possible only for dividend/price-drop pairs below AB. The line CF depicts the no-arbitrage condition of cum-ex traders (3). For any point above CF the price-drop ratio is large enough to make these trades profitable. The cum-ex trader does not

trade dividend/price-drop pairs below CF, as they result in marginal losses. Cum-ex trades may be driving the market only to the right of the intersection point P with dividend/price-drop pairs in the rectangular area PFB that is spanned by the lines AB and CF.

As a consequence, if cum-ex traders carry out cum-ex trades until all profit opportunities are exploited, the dividend/price-drop pairs will lie on the heavy dashed line in the section PF where the marginal profit from arbitrage for the cum-ex trader is equal to zero. With cum-ex trades, therefore, the market equilibrium to the right of the intersection point P is characterized by the line PF. Hence, in the presence of cum-ex trading, the model predicts an equilibrium marginal price-drop ratio of 0.75 for all dividend yields exceeding $\left(\frac{D}{P_{CUM}}\right)^*$.

The predictions to the left of the intersection point P depend on the whether the equilibrium is dominated by explicit or implicit arbitrage. With explicit arbitrage, capital market equilibrium requires dividend/price-drop pairs to be located in the area APZC. In case of implicit arbitrage, the indeterminacy vanishes and dividend/price-drop pairs are located on OH. Still, abstracting from the indeterminacy regarding implicit or explicit arbitrage, for dividend yields below $\left(\frac{D}{P_{CUM}}\right)^*$ the model predicts a marginal equilibrium price-drop ratio of one.

3.4 Empirical predictions

Our capital market model predicts the marginal ex-day price-drop ratio in the presence of cum-ex trading to be smaller than the marginal ex-day price-drop ratio in the absence of cum-ex trading, assuming that the cum-ex trader is the marginal investor.

H1: Cum-ex trading decreases the expected ex-day price-drop ratio of German stocks.

Considering the applicable tax rules for the years 2009 to 2012, the model, further, makes precise predictions with respect to the size of the marginal ex-day price-drop ratios in the pres-

ence and the absence of cum-ex trading, respectively. This leads us to the following two hypotheses:

H2: In the presence of cum-ex trading, the expected ex-day price-drop ratio of German stocks is 0.75.

H3: In the absence of cum-ex trading German stocks show an expected ex-day price-drop ratio of one.

4 Data

We analyze the effects of cum-ex trading on price-drop ratios and trading volumes of German stocks that were constituents of the German HDAX index between 2003 and 2015.[10] To ensure a stable tax environment for the empirical analysis, we focus with our analysis on the time period from 2009 to 2015, when Germany applied in all years a flat tax system for capital income taxation.

Information on absolute dividend payments and dividend payment dates is taken from the Thomson Reuters EIKON database. We focus on regular dividend payments, i.e. capital bonuses are excluded. We use information on withholding-tax liability of dividends from German corporations' annual official dividend announcements that are provided by the Bundesanzeiger.

We gather information on daily unadjusted closing prices, total return indices and the HDAX market index based on XETRA values from Thomson Reuters EIKON to calculate ex-day price-drop ratios. To analyze the effects of cum-ex trading on trading volumes, we use information on daily trading volumes in the years 2009 to 2015 which are provided by the Karlsruhe Institute of Technology (KIT) as part of the Karlsruher Kapitalmarktdatenbank (KKMDB). A feature of

[10] The HDAX index includes the 110 German stocks that are largest in terms of their free-float weighted market capitalization. It covers approximately 96% of the market capitalization of the German stocks listed in the broader CDAX.

the KIT database worth mentioning is that it includes comprehensive information on trading volumes at all German stock exchanges including OTC markets. Free-float weighted market capitalization is obtained from Thomson Reuters EIKON.

Table B1 provides descriptive statistics of the data set.

5 Methods

5.1 Empirical identification strategy

Our empirical strategy exploits the fact that only a part of German dividend-paying stocks is suitable for cum-ex trading. The German tax law does not subject all dividend payments to withholding taxes. Whereas dividends paid from firms' current profit are subject to a 25% withholding tax (in the following regular taxable dividends), dividends paid from firms' capital reserves[11] are withholding tax free (in the following withholding-tax-free dividends). We exploit this variation in the withholding-tax liability of dividends in our empirical strategy, as cum-ex trading is only profitable with stocks paying dividends from their current profits that are subject to withholding tax. Only in this case the cum-ex trader can achieve the issuance of a withholding-tax certificate. This enables us to use stocks paying withholding-tax-free dividends as control group to analyze the effect of cum-ex trading on capital market outcomes.

[11] Dividends paid out of a corporation's capital reserve are withholding tax free according to §27 KStG (Corporation Tax Act). Such dividend payments can be seen as a capital reduction. At the time of the disposal, the withholding-tax-free dividend reduces the initial purchasing price of the stock and, thereby, increases the investor's capital gain.

5.2 Regression analysis

We aim at estimating the effect of cum-ex trading on the ex-day price-drop ratio. For that purpose, we use linear regression models to estimate the following equation:

$$\text{relative price drop}_{it} = \beta_0 + \beta_1 \mathrm{I}_{\text{profit},it} + \beta_2 \mathrm{I}_{\text{profit},it} * \text{dividend yield}_{it} + \beta_3 \text{dividend yield}_{it} + \varepsilon_{it}. \tag{6}$$

The dependent variable, relative price drop$_{it}$, is the drop in stock i's price from the cum-day (day $t-1$) to the ex-day (day t), relative to the cum-day price.[12] $\mathrm{I}_{\text{profit},it}$ is a binary indicator that equals unity if the dividend source is the current profit and zero in case dividends are paid from capital reserves. The dividend yield, dividend yield$_{it}$, is the gross dividend relative to the cum-day price. We are interested in the coefficients β_2 and β_3. The latter captures the marginal price-drop ratio in the absence of cum-ex trading. We estimate β_3 from a group of dividends that are withholding tax free and, therefore, not suitable for cum-ex trading. β_2 describes the difference in the marginal price-drop ratio that results from cum-ex trading. We derive the estimate β_2 from dividends that are subject to withholding tax and, therefore, principally suitable for cum-ex trading. The sum $\beta_2 + \beta_3$ is the marginal price-drop ratio in the presence of cum-ex trading. The coefficient β_0 is the intercept of the regression equation for withholding-tax-free dividends. β_1 measures the deviation in the intercept between the two groups. ε_{it} is an idiosyncratic error.

Besides the effects on market prices, cum-ex trading should lead to increased trading activity at stock exchanges around the ex-day. We expect the cum-ex traders to execute a large number of short-sales within a two-day window before ex-dividend day of a stock. Through the timing of the short-sales within the two-day window, the cum-ex trader ensures an ex-dividend

[12] To prevent bias due to market developments, we adjust the cum-price by the expected daily return according to Elton et al. (2005). The expected daily return is estimated using a market model. The estimation period covers a time window of 130 days around the ex-day, where 10 days before and 10 days after the ex-day are excluded.

delivery of the stock which is crucial for the trade to be profitable. Notably, there are alternative theories such as the dynamic trading clientele theory (Michaely and Vila, 1995) that also predict increased trading activity around the ex-dividend day. To distinguish the general increase in trading volume around the ex-day from the cum-ex effect, we, again, refer to our control group of stocks paying withholding-tax-free dividends: We use linear regression models to estimate the following equation:

$$\log \text{number}_{it} = \lambda_0 + \lambda_1 \mathrm{I}_{\text{profit},it} + \lambda_2' T_t + \lambda_3' T_t * \mathrm{I}_{\text{profit},it} + \varepsilon_{it} \tag{7}$$

The dependent variable, $\log \text{number}_{it}$, describes the natural logarithm of the number of stocks i traded at day t, where t is a day within a 130-day window around i's ex-day (days $\{-65;65\}$). Again, $\mathrm{I}_{\text{profit},it}$ is a binary indicator that equals unity if the dividend source is the current profit (regular taxable dividend) and zero in case dividends are paid from capital reserves (withholding-tax-free dividend). T_t is a vector of indicators that mark each of the ten days before and after the ex-day (days $\{-10;10\}$).

Based on the comparison with our control group of withholding-tax-free dividends, we estimate the abnormal trading volume caused by cum-ex trading in the days around the ex-day. For the control group of withholding-tax-free dividend payments, the coefficients in the vector λ_2 show the difference in trading volume at the 20 days around the ex-day compared to ordinary trading days. The coefficients in the vector λ_3 capture the cum-ex effect on the trading volume (relative to the control group) for each of the 20 days around the ex-day. λ_0 is a constant term. λ_1 measures the average difference in trading volume between the two groups of stocks on ordinary trading days while we define ordinary trading days to be within a 130-day window around the ex-day excluding the 10 days before and the 10 days after the ex-date ($\{-65;-11\} \cup \{11;+65\}$). ε_{it} is an idiosyncratic error.

We apply pooled OLS regressions to estimate both regression equations. Robust standard errors are clustered at the level of the stock to take account of heteroscedasticity in the linear regression models and to allow for possible within-correlation in the error. The key identifying assumption for our pooled OLS regressions is that the estimated difference in price-drop ratios/ trading volume is entirely attributable to cum-ex trading. To strengthen this assumption, we run regressions, besides for the cum-ex period from 2009 to 2011, also for the post period from 2012 to 2015 where we do not expect to find any statistically significant difference in the price-drop ratios/ trading volumes that results from differences in the withholding-tax-liability of dividends.

6 Empirical results

6.1 Ex-day price-drop ratios

This subsection presents empirical evidence on the question of whether cum-ex-trading affects the ex-day price-drop ratio. Table B2 reports the OLS estimation results for the marginal price-drop ratios for the cum-ex period (2009-2011) and the post period (2012-2015). The first column presents estimates for the marginal price-drop ratios for the cum-ex period. In the absence of cum-ex trading under the tax system at the time, we expect the marginal price-drop ratio to be equal to one. To test this theoretical prediction, we exploit the fact that withholding-tax-exempt stocks are not suitable for cum-ex trading. The point estimate for the price-drop ratio of withholding-tax-exempt stocks is 1.20. It is not significantly different to one (F-test with p-value = 0.177). In the presence of cum-ex trading, we expect the marginal price-drop ratio with 0.75 to be significantly smaller than one. At a price-drop ratio of 0.75 the cum-ex trader makes zero marginal profit. The point estimate of the marginal price-drop ratio of cum-ex suit-

able stocks is 0.74. Importantly, the point estimate is statistically significantly different from one (F-test with p-value = 0.002).

Column 2 of Table B2 presents as a robustness check the results for the period after January 2012, when the German legislator prevented cum-ex trading with a reform of the tax law. For withholding-tax exempt dividend payments we still expect for the post period a price-drop ratio of one. For regular taxable dividends, however, we expect a marginal post price-drop ratio of 0.72. This price-drop ratio results from a change in dividend taxation of marginal investors that are fully taxable corporate investor, e.g. banks and financial institutions, without strategic shareholding (less than 10% of the free-float shares). Their dividends are in the post-period no longer exempt from dividend tax but subject to the full German corporate tax rate of about 30%[13] In contrast, their capital gains are still tax exempt. Consequently, this implies an expected marginal price-drop ratio of 0.72. In line with our theoretical expectations, for regular taxable dividend stocks, we get a point estimate for the price-drop ratio of 0.72 (column 2 of Table B2) that is significantly smaller than one (F-test with p-value = 0.000). The mean price-drop ratio for withholding-tax-exempt stocks is 0.85 and not significantly different to one (F-test with p value = 0.145).

6.2 Trading volumes

Table B3 reports evidence on how cum-ex trading affects the trading volumes at German stock exchanges around the ex-day. Column 1 presents OLS regression results for the abnormal trading volume at each day within a twenty-day window around the ex-dividend day during the cum-ex period. The dependent variable is defined as the natural logarithm of the daily number of stocks traded at all German stock exchanges. We, therefore, interpret the coefficients as

[13] The German corporate tax burden of approximately 30% comprises a 15 percentage points federal corporate tax plus a 15 percentage points local corporate tax (assuming a representative local business tax multiplier (*Gewerbesteuerhebesatz*) of 400% and a solidarity surcharge of 5.5% of the 15% corporate tax.)

marginal changes in trading volume in %. For dividends that are withholding-tax exempt, the point estimates generally indicate that the trading volume statistically significantly increases by 29% and 33% the two days before dividend payment and by 43% the ex-day itself. Interestingly, stocks that are cum-ex suitable even exceed these increases precisely at the two days prior to the ex-day. The two-day window before the ex-day is crucial for cum-ex trading. Within this two-day window, the cum-ex traders shorten the stocks at the cum-dividend price. Cum-ex trading, therefore, increases the trading volume on day -2 by approximately 23%, on day -1 by approximately 61%, both effects are highly statistically significant. At the ex-day itself the trading volume of cum-ex relevant stock is 21% (p-value=0.116) higher as compared to stocks that are not cum-ex suitable. Hence, the largest part of cum-ex trading happens on the day prior to the ex-day.

In the literature, it has so far not been entirely clear how cum-ex traders closed their open positions (for a discussion see, e.g., Deutscher Bundestag, 2014). Interestingly, our regression results show no statistically significant difference in trading volumes on the days subsequent to the ex-day. This indicates that cum-ex traders seem not to close their positions with stock purchases at the stock exchanges but rather choose alternatives. This may be OTC derivatives, for instance.

Column 2 in Table B3 provides further results that strengthen the validity of our identification strategy. In the post period, the point estimates show basically no difference in the increase in trading volumes around the ex-day that can be attributed to differences in withholding-tax liability of dividends. This finding is reassuring, as it indicates that our identification strategy does not pick up a general difference in trading volumes around ex-days between our treatment and control group.

7 Conclusion

This paper analyzes whether stock market arbitrage exploits profit opportunities that arise from tax fraud. We provide a theoretical discussion that shows how so-called cum-ex trades could have substantially impacted the capital market. Our theoretical results show that without false tax certificates cum-ex trades are unprofitable. In addition, we show that if associated profit opportunities are exploited, cum-ex trading alters the price-drop ratio at the ex-dividend day. Furthermore, cum-trades are associated with a substantial positive effect on the trading volumes around the ex-dividend day.

We empirically test the theoretical predictions using a data set which includes price and trading volume information on German stocks for the years 2009 to 2015. Our empirical identification strategy exploits differences in the withholding-tax liability of dividend payments. Dividends that are paid out of firms' current profits are subject to a 25% withholding tax (regular taxable dividends) and, therefore, principally suitable for cum-ex transactions. In contrast, dividends that are paid out of firms' capital reserves are under the tax law at the time withholding tax free and, thus, not suitable for cum-ex trading.

The empirical results show that during the cum-ex period, the ex-dividend day price-drop ratio in case of regular taxable dividends is, as theoretically predicted, significantly smaller than the price-drop ratio of withholding-tax-free dividends. In line with our theoretical model, we find the price-drop ratio of cum-ex-suitable stocks to be statistically not significantly different from 0.75. At the same time, in line with the theory, the price-drop ratio of stocks which are not suitable for cum-ex trades is not statistically significantly different from one. To ensure that cum-ex trades are profitable, cum-ex traders have to instigate the trades within a two-day window before the ex-day. This implies that trading volumes on these days should be increased. Our results in fact show a statistically highly significant increase in trading volume just the two

days before the ex-day. The increase is economically substantial: The trading volume increases due to cum-ex trading on the second day before the ex-day by 23% and on the day prior the ex-day by almost 61%. For dividend payments after the 2012 tax reform, we do not find any statistically significant difference in trading volume around the ex-day that can be attributed to the difference in withholding-tax liability of the dividend. In general, the zero findings for the post period are reassuring, as they indicate that our identification strategy does not pick up general differences in trading volumes around the ex-day between our treatment and control group.

Previous studies on the effects of taxation on stock prices and trading volumes at ex-dividend dates focus on statutory taxation. We broaden the scope of relevant tax institutions by taking into account also the administrative procedures that determine how taxes are collected. Our findings show the importance of administrative procedures of tax systems in the context of financial markets where tax sensitivities of investments are reportedly high (Slemrod and Gillitzer, 2014). Our findings strikingly show that stock-market arbitrage fully exploits profit opportunities arising from tax fraud.

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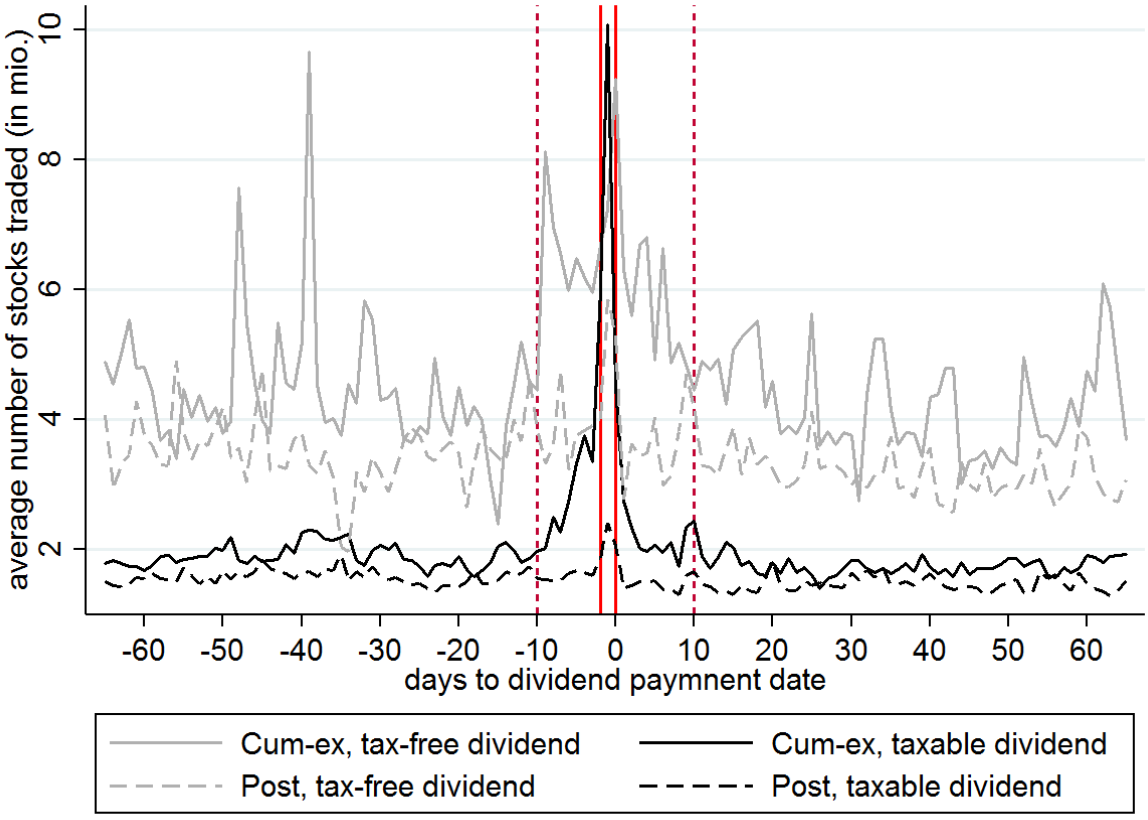
Appendix

Supplementary material for

"Stock Market Behavior on Ex-Dividend Dates: The Case of Cum-Ex Transactions in Germany"

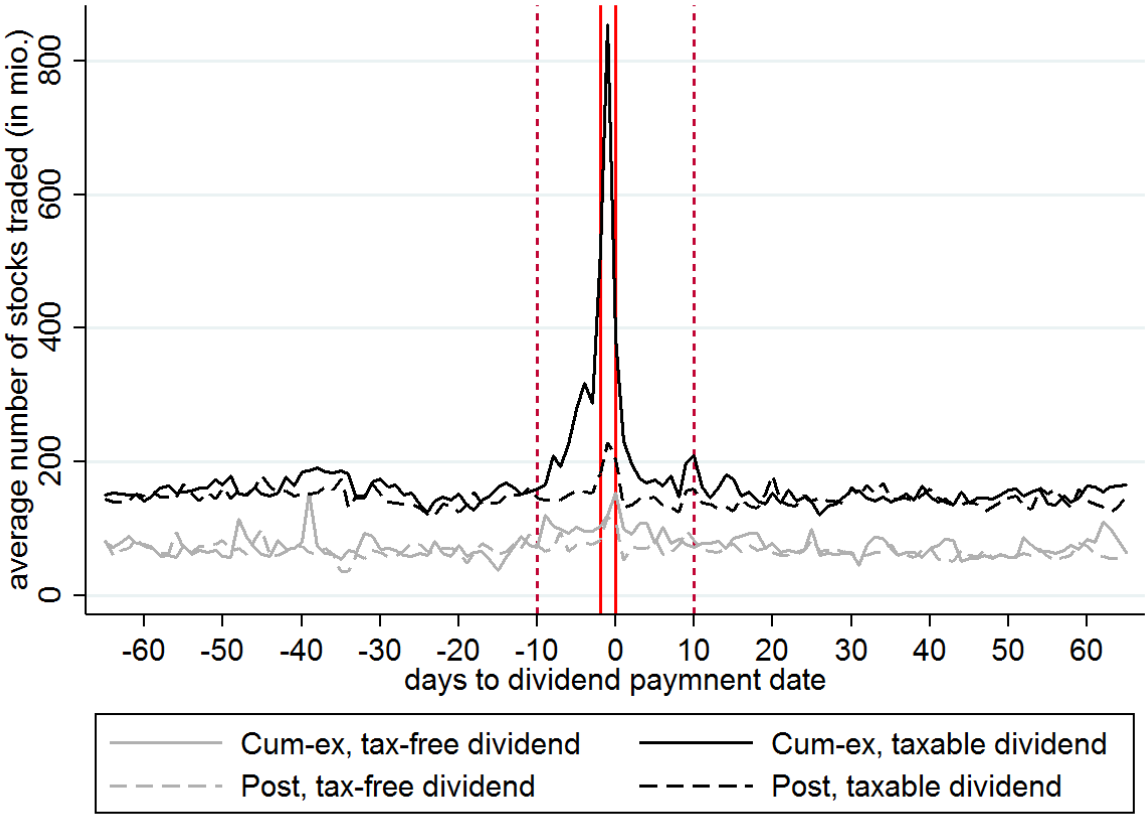
A Figures

Figure A1
Daily average number of stocks traded *per stock* (all German stock exchanges, 2009 - 2015)



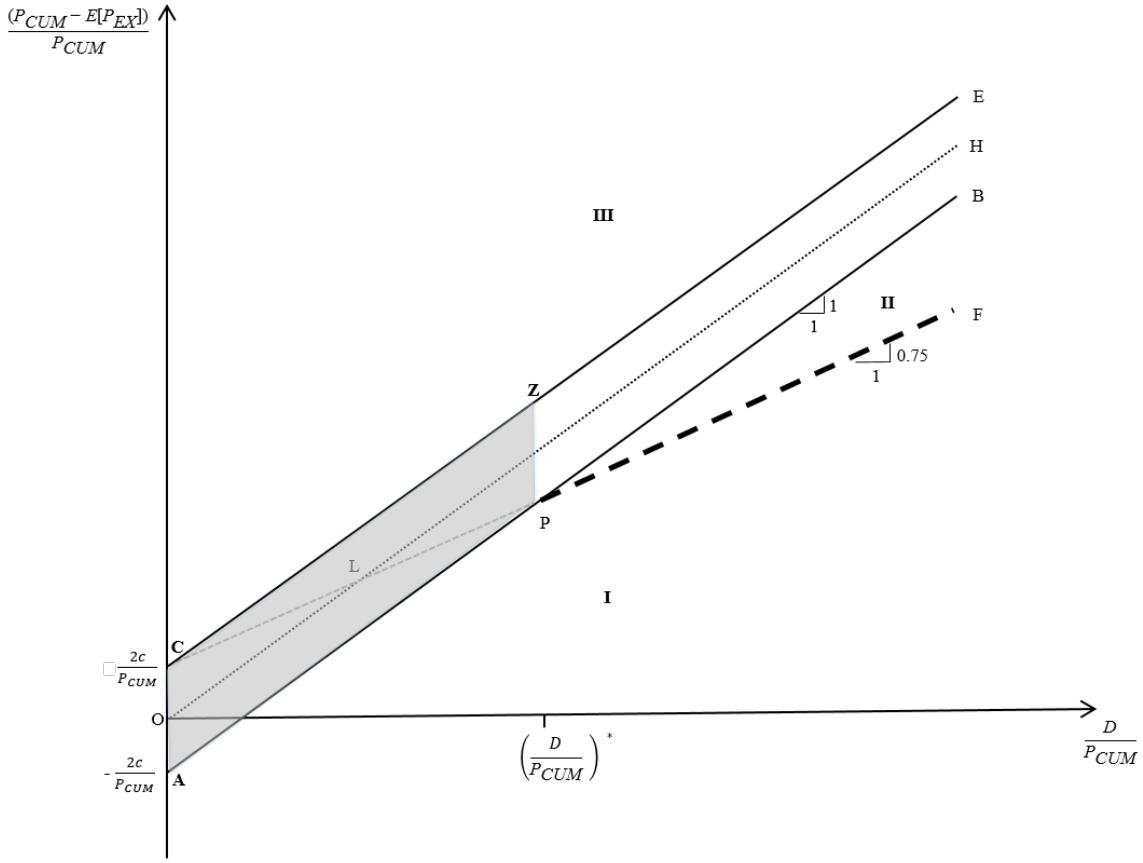
Note: The figure depicts the daily average number of stocks traded of one stock. We consider all German stock exchanges. The solid lines represent the number of stock trades during the cum-ex period from 2009 to 2011 and the dashed lines represent the post-period from 2012 to 2015, respectively. Dividends paid from current profit are subject to withholding tax (taxable dividends) and, therefore, suitable for cum-ex trading (black lines). Dividends from capital reserves are withholding tax free (tax-free dividends) and, thus, not suitable for cum-ex trading (gray lines). The vertical solid lines mark a two-day window prior to the ex-day. The vertical dashed lines mark a 10-day trading window around the ex-day.

Figure A2
Daily average *total* number of stocks traded (all German stock exchanges, 2009 - 2015)



Note: The figure depicts the daily average total number of stocks traded at German stock exchanges. The solid lines represent the total number of stock trades during the cum-ex period from 2009 to 2011 and the dashed lines represent the post-period from 2012 to 2015, respectively. Dividends paid from current profit are subject to withholding tax (taxable dividends) and, therefore, suitable for cum-ex trading (black lines). Dividends from capital reserves are withholding tax free (tax-free dividends) and, thus, not suitable for cum-ex trading (gray lines). The vertical solid lines mark a two-day window prior to the ex-day. The vertical dashed lines mark a 10-day trading window around the ex-day.

Figure A3
Capital market equilibrium and cum-ex trading



Note: The figure presents the no-arbitrage equilibrium for different investor classes in absence and presence of cum-ex trading. The expected ex-dividend price drop in percent is plotted against the gross dividend yield. The line OH illustrates the implicit arbitrage conditions for German and foreign fully taxable investors. The parallel lines AB and CE illustrate explicit arbitrage conditions for the fully taxable investors (equation (2)). In the absence of cum-ex trading, the equilibrium combination of dividend yields and ex-dividend price drops is represented by the slope of the parallel lines AB, CE and OH. The model predicts a marginal equilibrium price-drop ratio of one when German and foreign fully taxable investors capture or avoid dividends until marginal profits are zero. The line CF depicts the no-arbitrage condition of the cum-ex trader, equation (3). If the cum-ex trader characterizes the market equilibrium, the equilibrium dividend/price-drop pairs in the section PF on the heavy dashed line CF determine the marginal equilibrium price-drop ratio for dividend yields larger $(\frac{D}{P_{CUM}})^*$. In the presence of cum-ex trading the model predicts an equilibrium marginal price-drop ratio of 0.75.

B Tables

Table B1
Descriptives

	Cum-ex period		Post period	
	Current-profit dividend	**Capital-reserve dividend**	**Current-profit dividend**	**Capital-reserve dividend**
Number of dividend payments	289	49	406	82
Absolute dividend				
Mean (in euros)	1.53	0.36	1.49	0.58
Standard deviation	3.08	0.28	1.99	0.58
Dividend yield				
Mean (in %)	2.83	3.78	2.53	3.37
Standard deviation	1.90	2.06	1.66	2.34

Note: Descriptive statistics are presented in the cum-ex period from 2009 to 2011 and the post-period from 2012 to 2015, separately. Dividends from current profit are subject to withholding tax and, therefore, suitable for cum-ex trading. Dividends from capital reserves are withholding tax free and, thus, not suitable for cum-ex trading.

Table B2
Regression results: Ex-dividend day price-drop ratios

Mean price-drop ratio (PDR)	**Cum-ex period**	**Post period**
Dividend source: Current profit	**0.74**	**0.72**
95% confidence interval	[0.58;0.90]	[0.58;0.86]
(p-value, H0: Mean PDR = 1)	(0.002)	(0.000)
(p-value, H0: Mean PDR = 0.75)	(0.896)	(0.682)
Dividend source: Capital reserves (§27 KStG)	**1.20**	**0.85**
95% confidence interval	[0.91;1.50]	[0.64;1.05]
(p-value, H0: Mean PDR = 1)	(0.177)	(0.145)
(p-value, H0: Mean PDR = 0.75)	(0.003)	(0.370)
Observations	338	488

Note: The table includes mean ex-day price-drop ratios of stocks that pay dividends either from current profit or from capital reserves. Mean price-drop ratios are presented in the cum-ex period from 2009 to 2011 and the post-period from 2012 to 2015, separately. Dividends from current profit are subject to withholding tax and, therefore, suitable for cum-ex trading. Dividends from capital reserves are withholding tax free and, thus, not suitable for cum-ex trading. The mean price-drop ratios describe the relation between the relative ex-day price drop, defined as $\frac{P_{CUM}-P_{EX}}{P_{CUM}}$ and the stock's dividend yield. P-values are presented in parentheses. Standard errors are clustered at the stock-level. The sample includes all stocks that are constituents of the HDAX index between 2003 and 2015.

Table B3
Regression results: Abnormal trading volume around the ex-dividend day

		Cum-ex period		Post period	
Day	**Dividend type**	**Coef.**	**p-value**	**Coef.**	**p-value**
-10	Dividend source: Current profit	.1396	(0.257)	.0334	(0.702)
	Dividend source: Capital reserves (§27 KStG)	-.1430	(0.164)	.0268	(0.714)
-9	Dividend source: Current profit	.1678	(0.287)	-.1088	(0.219)
	Dividend source: Capital reserves (§27 KStG)	-.2679	(0.072)	.0626	(0.249)
-8	Dividend source: Current profit	.2266	(0.228)	-.1909	(0.079)
	Dividend source: Capital reserves (§27 KStG)	-.1153	(0.507)	.0786	(0.353)
-7	Dividend source: Current profit	.1154	(0.361)	-.0310	(0.729)
	Dividend source: Capital reserves (§27 KStG)	-.0688	(0.521)	.0509	(0.532)
-6	Dividend source: Current profit	.2267	(0.064)	.0110	(0.899)
	Dividend source: Capital reserves (§27 KStG)	-.0408	(0.711)	.0445	(0.547)
-5	Dividend source: Current profit	.1342	(0.424)	-.1808	(0.227)
	Dividend source: Capital reserves (§27 KStG)	.0018	(0.991)	.1463	(0.276)
-4	Dividend source: Current profit	.1696	(0.407)	-.0464	(0.617)
	Dividend source: Capital reserves (§27 KStG)	.0538	(0.785)	.1686	(0.043)
-3	Dividend source: Current profit	.0272	(0.829)	-.1828	(0.113)
	Dividend source: Capital reserves (§27 KStG)	.2357	(0.034)	.2063	(0.042)
-2	Dividend source: Current profit	.2337	(0.046)	-.0292	(0.756)
	Dividend source: Capital reserves (§27 KStG)	.2932	(0.001)	.2344	(0.007)
-1	Dividend source: Current profit	.6069	(0.002)	-.0088	(0.923)
	Dividend source: Capital reserves (§27 KStG)	.3304	(0.045)	.2873	(0.000)
0	Dividend source: Current profit	.2120	(0.116)	-.1330	(0.164)
	Dividend source: Capital reserves (§27 KStG)	.4257	(0.000)	.4310	(0.000)
1	Dividend source: Current profit	-.0029	(0.984)	.0769	(0.416)
	Dividend source: Capital reserves (§27 KStG)	.1437	(0.268)	-.0616	(0.422)
2	Dividend source: Current profit	.0025	(0.983)	-.1597	(0.077)
	Dividend source: Capital reserves (§27 KStG)	.1528	(0.133)	.0955	(0.146)

Note: Table continues on next page.

Table B3
Regression results: Abnormal trading volume around the ex-dividend day (cont.)

		Cum-ex period		Post period	
Day	**Dividend type**	**Coef.**	**p-value**	**Coef.**	**p-value**
3	Dividend source: Current profit	.0462	(0.741)	.0331	(0.720)
	Dividend source: Capital reserves (§27 KStG)	.0375	(0.769)	-.0543	(0.512)
4	Dividend source: Current profit	-.0469	(0.732)	-.0423	(0.552)
	Dividend source: Capital reserves (§27 KStG)	.1284	(0.310)	.0073	(0.903)
5	Dividend source: Current profit	.0412	(0.728)	-.1670	(0.107)
	Dividend source: Capital reserves (§27 KStG)	.0442	(0.607)	.1261	(0.180)
6	Dividend source: Current profit	-.1953	(0.459)	-.2235	(0.017)
	Dividend source: Capital reserves (§27 KStG)	.2127	(0.407)	.1608	(0.057)
7	Dividend source: Current profit	.3015	(0.170)	-.1304	(0.122)
	Dividend source: Capital reserves (§27 KStG)	-.2620	(0.217)	-.0024	(0.973)
8	Dividend source: Current profit	-.1604	(0.159)	-.0143	(0.865)
	Dividend source: Capital reserves (§27 KStG)	.1452	(0.119)	-.0682	(0.387)
9	Dividend source: Current profit	-.0053	(0.971)	-.0190	(0.848)
	Dividend source: Capital reserves (§27 KStG)	.0759	(0.512)	-.0381	(0.676)
10	Dividend source: Current profit	-.0608	(0.597)	-.0309	(0.736)
	Dividend source: Capital reserves (§27 KStG)	-.0204	(0.846)	-.0367	(0.668)
ordinary	Dividend source: Current profit	-.2892	(0.590)	-.6164	(0.151)
ordinary	Dividend source: Capital reserves (§27 KStG)	12.8547	(0.000)	13.2019	(0.000)
	Observations	39,157		60,045	

Note: The dependent variable is defined as the natural logarithm of a stock's daily traded number of stocks aggregated over all German stock exchanges. We distinguish stocks by dividend payment source. The stocks either pay dividends from current profit or from capital reserves. The cum-ex period comprises the years 2009 to 2011, the post-period the years 2012 to 2015. Dividends from current profit are subject to withholding tax and, therefore, suitable for cum-ex trading. Dividends from capital reserves are withholding tax free and, thus, not suitable for cum-ex trading. We compute an average ordinary trading volume per day within a 110-day ($\{-65;-11\}$ and $\{11;+65\}$) window around a stock i's ex-dividend day. A stock i's abnormal trading volume per day is defined as the difference between the actual observed trading volume per day and the calculated average ordinary trading volume for this stock. The abnormal trading volume per day is computed for a 20-day window around the stock i's ex-day. P values (based on robust standard errors clustered at the stock-level) from test on statistical significance are presented in parentheses. The sample includes all stocks that are constituents of the HDAX index between 2003 and 2015.