Spillovers of cum-ex and cum-cum trading with single stock futures *

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ABSTRACT

We examine single stock future (SSF) trading and respective underlyings around dividend ex-dates to study a specific form of dividend tax arbitrage, widely known as cum-ex and cum-cum trading, across Europe. Both strategies are designed to profit from illicit refunds of tax withheld from dividends. Our results document trading spillovers into more favorable tax regimes, while the excessive trading disappear in markets with enacted tax reforms. In cum-ex trades, SSF have been mispriced to share the realized gains between colluding parties. Ex-day stock price drops are largely unaffected. All findings are robust to controls, such as transaction cost, volatility and institutional ownership.

JEL classification: H26, G12, G13, G14, G15.

Keywords: Dividend stripping, Dividend arbitrage, Withholding tax arbitrage, Tax-motivated trading, Single stock futures, Mispricing, Ex-dividend price drop.

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1 Introduction

Investigations in several European countries have begun to uncover large-scale tax fraud in the wake of so-called *cum-ex* and *cum-cum* transactions. Both trading schemes describe an advanced form of a dividend-capture strategy with the sole purpose of avoiding tax payments on dividends. In this regard, cum-ex trades aim to retrieve multiple illicit tax reimbursements on a single dividend payment. Legal articles place the number of multiple tax refunds on a single dividend payment up to five times.[1] By contrast, cum-cum trades exploit tax differentials between domestic and foreign investors. Both schemes operate through collusion, using offsetting future positions to conceal the distribution of realized tax profits between transacting parties.[2] Recent estimates assume a tax loss in the double-digit billion range in Europe, accumulated over the past 25 years (Spengel, 2017; Spengel et al., 2017; Spengel and Peitzmeier, 2017; Cum-ex Files, 2020).

Given the prominence of the topic, our study explores the size of cum-ex and cum-cum trading in ten European countries with comparable dividend tax jurisdictions. Our rich database of Eurex single stock futures (SSF) (including pre-arranged OTC trades) offers a unique opportunity to track these specific transactions over time. The primary goal is to identify patterns of both dividend tax arbitrage strategies by analyzing abnormal trading and pricing behavior of SSF and their respective underlyings around ex-dividend days. Moreover, our study reviews the legislative intervention of each country and is thus of concern for tax authorities and legislators to combat tax fraud.

Traditional dividend-capture trading (or dividend stripping) is a widespread practice for short-term traders to collect the dividend at low risk and generate abnormal returns, see e.g., Dubofsky (1987); Grammatikos (1989); Karpoff and Walkling (1990); Henry and Koski (2017). In one version, corporations leverage tax differentials across borders and investor groups to additionally profit from tax arbitrage. In fact, McDonald (2001); Liljeblom et al. (2001); Christoffersen et al. (2003); Hodgkinson et al. (2006) present early evidence of cross-border tax arbitrage, later referred to as cum-ex and cum-cum trading. While the literature generally acknowledged these trading strategies in the past, it is now important to underline the collusive arrangements between contracting parties just for the purpose of tax evasion (Buettner et al., 2020). Although few respondents argued in favor

[1] See Rau, DStR 2010, 1267 and Rau, FR 2011, 366-373.

[2] See Cologne Tax Court, Judgment No. 2 K 2672/17, dated July 19, 2019 and Regional Court Bonn, Judgment No. 62 KLs - 213 Js 41/19 - 1/19, dated March 18, 2020. Other possibilities include swaps, forwards and options.

of these practices, the Federal Court of Germany (Bundesgerichtshof) and the Federal Ministry of Finance confirmed the illegality for cum-ex and cum-cum trades recently.[3]

Under the European tax system, domestic and overseas entities are able to request a (full or partial) refund of the withholding tax on dividends (WHT). The shareholder's custodian bank usually issues a tax certificate for this purpose. In the case of cum-ex transactions, high short-selling activity contributed to multiple exchanges of stocks with *cum* and *ex*-dividend entitlements. The corresponding time-lagged settlement masked the actual shareholder at the time of dividend distribution, which allowed multiple investors to (i) receive the tax certificate and (ii) be reimbursed for taxes that were only withheld once.[4]

In contrast, cum-cum transactions involve a temporary transfer of stocks before the ex-dividend date to a location with tax-favorable jurisdiction. This results in (i) tax-exempt investors collecting the dividend payment untaxed, and (ii) original stock owners converting the dividend to (tax-free) capital gains (if specific double taxation agreements apply). Most importantly, transacting parties are found to enter offsetting future positions to distribute profits and hedge against market risk.

Both trading schemes likely emerged in Germany around 1990, when taxation law exhibited a loophole, see Subsection 2.2. It was effectively closed in 2012 for cum-ex trades. Later, in 2016, the German government also prohibited cum-cum transactions.[5] While general estimates suggest that these transactions have affected Germany on an unprecedented scale, investigations by state authorities and media find evidentiary documents on cum-ex and cum-cum trading in other European countries as well.[6]

Consequently, most countries reformed their tax codes to make both practices illegal. However, new measures and actions took place at different times. Moreover, they also vary in severity, and it is worth investigating the effectiveness of these implemented tax reforms. In addition, recent reports prepared by external experts and legal opinions argue about continued cum-ex and cum-

[3]See Spengel/Eisgruber DStR 2015, 785 and the landmark decision of the Federal Court Germany (Bundesgerichtshof), Judgment No. 1 StR 519/20, dated July 28, 2021 and Federal Ministry of Finance (Bundesministerium für Finanzen) document 2021/0726914, dated 9 July 2021.

[4]The settlement process of equities is usually conducted within two business days (T+2). Off-exchange trading does not necessarily have to follow this convention.

[5]See European Parliament's information document on the cum-ex files dated September 26, 2018.

[6]A network of 39 reporters from European media outlets discovered the multiple WHT claim schemes in several European countries. The investigation, formally known as the Cum-ex files, covers 180,000 pages of documents and is available at `https://cumex-files.com/en/`.

cum operations despite the introduction of legislative frameworks.[7]

We exploit the variation of tax regimes to investigate whether and how existing laws changed the dynamics of the markets, and the extent to which spillover effects were generated. More specifically, we argue that cum-ex and cum-cum activity spread to other countries when the German government changed their tax rules in 2012 and 2016. The investigation takes a threefold approach: first, we determine if and when a specific regulatory change was enacted for each country. Based on this research, we form three major periods that capture whether cum-ex and cum-cum trading is restricted or unrestricted in each country. A difference-in-differences test helps us then to identify changes in SSF trading activity, from which we infer spillover effects of cum-ex or cum-cum trading to neighboring countries. Second, we study the degree of SSF mispricing before ex-dividend dates to investigate collusive behavior between market participants, specifically for cum-ex trading. Third, we examine the underlying stocks and compare ex-day price drops between time periods and countries to explore whether investors' tax differentials are impounded in stock prices.

Recent studies examine the trading pattern of equities and relate the findings of above-average trading volumes to cum-ex activity in Germany (Spengel et al., 2017; Buettner et al., 2020). Wagner et al. (2020) observe a similar pattern after 2013 in neighboring European countries. In addition, a recent report by the European Securities and Markets Authority, (ESMA, 2020), discusses high cyclical peaks in securities lending and relates this pattern to cum-ex trading.[8] Our baseline results confirm the extraordinary stock trading around the ex-dividend days, albeit not for all countries.

Contrary to previous studies, we conjecture that trading volume in equity markets provides only little insight into cum-ex and cum-cum activity, and may result in selection bias. First, not all listed stocks were traded cum-ex or cum-cum.[9] Second, traders use derivatives to overcome microstructure constraints on the spot market (Ang and Cheng, 2005a; Brooks et al., 2006; Pan, 2008; Aggarwal and Thomas, 2019). SSF contracts represent an ideal instrument for this purpose.

[7]Among the German government's investigative committee, (Spengel, 2017) argues that cum-ex transactions are still possible due to a decentralized organizational structure: taxes are paid to state authorities, but are refunded by federal authorities. This makes it particularly vulnerable to criminal exploitation. See Public Hearing of the Subcommittee on Tax Matters of the European Parliament on the Cum-Ex/Cum-Cum Scandal, dated February 21, 2021, and as well.

[8]The report analyzes daily aggregated data on securities lending between 2014 and 2019 and shows that high cyclical peaks disappear in European markets mostly after 2015. Securities lending in Austria, Denmark, Germany, Finland, Sweden, Poland and Portugal declined markedly in recent years, while in Belgium, France, Italy and the United Kingdom it continues at high levels. The report concludes that high peaks of equity lending around ex-dividend dates may indicate dividend arbitrage trading; however, it does not necessarily point to cum-ex activity.

[9]See Buettner et al. (2020) for evidence on the German (HDAX) market.

Futures contracts lock stock prices in time while hedging out the market risk. The low margins permit the holder of futures contracts to leverage their position with only limited capital lockup. Most importantly, futures do not impose short-selling restrictions like the spot market and represent an alternative to security lending or borrowing. Danielsen et al. (2009); Benzennou et al. (2018); Gagnon (2018); Jiang et al. (2019) document the increased use of SFF after the short-sale ban for securities. Bialkowski and Jakubowski (2012) argue that SSF facilitates dividend stripping and affirm high trading activity for Eurex SSF around ex-dividend dates.

Therefore, our analysis relies on the SSF market and we expect to give a more detailed and complete picture of the illicit dividend tax reclaim schemes. Our key variable is open interest, the sum of open future contracts on a stock including both short and long positions. However, we also investigate the volume of stocks that are underlying instruments for the Eurex SSF contracts. This selection of SSF traded stocks includes the most liquid stocks that likely receive the highest investor attention (Ang and Cheng, 2005b; Bialkowski and Jakubowski, 2012).

In addition to exchange trading, we also examine OTC trades for both futures and underlying stocks. OTC futures are pre-arranged contracts traded on a minimal regulatory venue. As such, they allow tailored trading strategies for a less transparent channel. Similarly, stocks from off-exchange venues do not need to meet minimum requirements or file with the exchange supervisory authorities. To differentiate between OTC future and OTC stock markets, we refer to the later as off-exchange trading throughout the paper.

Our sample consists of 935,505 transactions, centered in 50 days over the ex-dividend events, of which 35.49% are traded OTC. All trades arose from 8,221 SSF contracts on 439 underlying securities in ten European markets, including Austria, Belgium, Finland, France, Germany, Italy, Luxembourg, the Netherlands, Spain and Switzerland. The time period of the transaction data covers almost 15 years, from October 2005 to August 2019.

We find that SSF trading activity around ex-dividend dates significantly decreases in Germany following the two landmark tax law changes in 2012 and 2016. Simultaneously, SSF trading increases after 2012 in Austria, Belgium, and France, suggesting spillover effects to more favorable tax regimes. The trading spillovers appear again in Belgium, France, Finland, and Spain after 2016. These findings suggest continued cum-ex or cum-cum trading in these countries. In Austria and Switzerland, the high trading activity around ex-days disappears when the governments change

their tax codes. Our difference-in-difference analysis does not find significant changes in SSF trading behavior for Italy and the Netherlands. We interpret this result as an indication that ex-day trading levels remain relatively stable over time with no trading spillover effects. Including controls in our analyses allow us to infer which stocks are likely to be traded in the future market. We find that high SSF trading activity covaries positively with high spot market activity of the respective stocks. Moreover, we document a concave relationship with foreign institutional ownership, suggesting high tax heterogeneity between investors and limited short sales in the spot market.

Next, we study SSF mispricing for 51,283 transactions that occurred within 20 days before ex-dividend dates to evidence cum-ex trading. The Regional Court of Bonn, Germany highlights the importance of derivatives, specifically SFF, in the construction of cum-ex schemes. The court states that the futures, which have been used for cum-ex trades, exhibit significant price deviations from their fair market value. This mispricing is a result of profit shifting between colluding parties.[10] To observe such mispricing, we derive fair futures values using intraday stock prices from the cost of carry model. The mispricing is then defined as the difference between actual and theoretical prices relative to the dividend. We call this ratio the dividend level, which shows the percentage of dividend that has been priced in SSF. Our results support the findings described in the court decision. During the cum-ex period in Germany, we observe dividend levels of 86% on average, which represents a significant overpricing in SSF during the cum-ex period. This effect disappears after the tax law change in 2012 in Germany. While we are able to show mispriced SSF for Germany, the availability of pricing data restricts us from studying SSF mispricing in other European countries.

Finally, we investigate the ex-day price decline to dividend ratio (PDR) of SSF underlying securities to explore the influence of cum-ex or cum-cum trading on stocks. In theory, ex-day prices should decline exactly by their dividend amount, i.e. $PDR = 1$ (Miller and Modigliani, 1961).[11] The large ex-dividend literature, however, documented mean PDR values consistently greater or less than one (Campbell and Beranek, 1955; Ainsworth et al., 2020). While many hypotheses developed over time to explain this anomaly (see Kalay (1982); Michaely and Vila (1995, 1996); Koski and Scruggs (1998) among many other studies), there is also evidence that the differential tax treatment of dividends and capital gains is reflected in asset prices (Elton and Gruber, 1970;

[10] see Regional Court of Bonn, Judgment No. 62 KLs - 213 Js 41/19 - 1/19, dated March 18, 2020.
[11] See Allen and Michaely (2003) for a literature review.

McDonald, 2001; Haesner and Schanz, 2013). In this respect, cum-ex and cum-cum trading provides us an ideal setting to study whether tax advantages explain ex-day price movements. Our study finds support for the dynamic dividend clientele model, although neither cum-ex nor cum-cum had systematic influence on the PDR.

The remainder of this paper is organized as follows. Section 2 briefly reviews cum-ex and cum-cum transactions and discusses country-specific tax regimes. Section 3 presents data and descriptive statistics. Section 4 develops results and concludes.

2 Dividend tax arbitrage strategies and regulation

2.1 The basic setup

Dividend payments can be exempt from taxation in two general ways: either by a tax relief at source, or through a tax refund. The first option depends on whether the dividend-paying company uses its capital reserves to pay out dividends. If it does, the shareholder receives a dividend free of WHT (tax-free dividend) regardless of residency or investor status. The second option is fully or partly reserved for institutional investors, depending on where the investor resides and whether a specific double tax treaty exists. The process works as follows:

The dividend-paying corporation has to deduce a certain percentage on dividend distribution and forward it to the respective tax office (apply WHT at source). The shareholder can claim a tax exemption afterwards by applying for a refund. A refund request will be granted, if securities are held in the investor's account at the end of the last cum-dividend day, i.e., usually one business day before the ex-dividend date. Furthermore, domestic (or EU-resident) shareholders qualify for a full tax recovery (0%), if they meet certain holdings rules, for example, by having direct investments above specific thresholds. Foreign investors rely on specific reciprocity rules that allow them to levy lower tax rates (0-15%) if their home country is subject to a double tax treaty. If applicable, the taxes will be refunded fully or partially, or credited against foreign corporate tax. It is not possible to claim dividend taxes for retail investors.

The differential treatment of taxes incentivizes dividend stripping: *tax-exempt* or *low-tax* investors capture the nominal dividend while *high-tax* investors likely forgo the dividend payment to escape taxes. Cum-cum trading works identically, with the noteworthy exception that two in-

stitutional investors make an arrangement beforehand. In this scheme, the high-tax investor lends or sells their securities shortly before the dividend payment to transfer temporary ownership to a tax-exempt investor. Stock prices are hedged by futures which deviate from their fair market value to let the high-tax investor participate in the tax refund.[12]

Cum-ex trades are more aggressive because of the opportunity for multiple dividend tax refunds. Most often, they involve three types of traders to perform this strategy. Figure 1 shows the profits and losses for the following exemplary trade.

[Figure 1 about here]

Arbitrageur A buys a large number of stocks from short-seller B before the stock goes ex-dividend. Short-seller B borrows the stocks ex-dividend, and delivers them ex-dividend at the event date to A. Because short-seller B is legally obliged to deliver cum-dividend by contract, a compensation payment equal to the net value of the dividend will be carried out (tailor-made dividend). Since arbitrageur A obtained stock ownership before the dividend event date, their depository bank provides them with a tax certificate with which they will request a tax refund. Simultaneously, the original owner of the stocks C collects the actual net value dividend payment and receives a tax certificate from their depository bank for the WHT to submit to tax authorities. Although only the beneficial owner C possesses legitimate ownership of the stock and dividend, both agents A and C have the taxes reimbursed, doubling the WHT refund of the same single dividend payment.

Moreover, if collusion is at play, arbitrageur A and short-seller B will enter an offsetting future position (before the ex-dividend date) to hedge price risks and redistribute the profit. In particular, short-seller B will buy an overpriced SSF on the stock from arbitrageur A. Subsequently, the profit (as a percentage of the illicit tax reimbursements) is shifted from short-seller B to arbitrageur A.

This example is highly simplified to the basic features of the cum-ex transactions. Further investigation and legal cases reveal the possibility of multi-agent coordination and the creation of

[12] see Regional Court Bonn, Judgment No. 62 KLs - 213 Js 41/19 - 1/19, dated March 18, 2020. Moreover, by converting the dividend into capital gains, the high-tax investor can also receive the dividend payment tax-free if country-specific double taxation rules apply.

special investment vehicles or investment funds, especially for cum-ex/cum-cum trading.[13]

2.2 Tax laws governing cum-ex and cum-cum trading in Europe

Cum-ex and cum-cum trading likely emerged in Germany around 1990, when there was a loophole in the taxation law.[14] Previously, German legislation allowed WHT reclamation for both dividends and dividend compensation payments. Moreover, the bank that deducted tax on dividends was not the same bank that issued tax certificates. This made it particularly difficult to trace the true beneficiary of a stock. A new reform in 2007 excluded the compensation payment from tax relief, however, only for domestic banks. Thus, cum-ex schemes continued through the submitting of tax certificates of foreign depository banks. In 2012, Germany finally amended the law to authorize only domestic banks to centralize both activities. Currently, only domestic depository banks are responsible for dividend tax collection and issuance of reimbursement certificates. In 2016, Germany prohibited transaction schemes with the sole aim of dividend tax avoidance, impeding any cum-cum activity.[15]

Investigations by state authorities and the media find evidence on cum-ex and cum-cum schemes in neighboring markets as well. To prevent the trading schemes of multiple taxation refunds, several countries changed in their tax codes. Information on legislative changes in Europe is obtained from ESMA (2020), the German Parliament (Bundestag document No. WD 4 - 3000 - 073/16), and manual research. Table 1 presents a summary of tax law changes and practices taken against cum-ex and/or cum-cum trading for each country.

[Table 1 about here]

[13] See Legal articles by Rau, DStR 2010, 1267 and Rau, FR 2011, 366-373. The author discusses an exemplary trading strategy with one original owner with two short-sellers and four arbitrageurs shifting shares temporarily in a circle. All transactions took place one or two days before the ex-dividend events in chronological order, and reverse on the event date. Moreover, each transaction is between different parties to impede its traceability. As a result, shares are credited multiple times in multiple depository accounts. Each of the four arbitrageurs is provided with a tax certificate in addition to the share owner.

[14] The German government published a series of reports describing cum-ex and cum-cum transactions in detail while elaborating on the German tax system from 1999 to 2012. See Bundestag No. 18/7601 dated February 18, 2016, Bundestag hib 215/2016 dated April 14, 2016, Bundestag No. 18(30)99, political position: Stellungnahme Desens dated September 29, 2016, Bundestag No. WD 4 - 3000 - 073/16 dated December 21, 2016, Bundestag No. 18/11978 dated April 18, 2017, Bundestag No. 18/12700 dated June 20, 2017, Bundestag No. 19/7006 dated January 15, 2019, Bundestag No. 19/12690 dated August 23, 2019. See also European Parliament resolution of November 29, 2018 on the cum-ex scandal: financial crime and loopholes in the current legal framework (2018/2900(RSP)).

[15] See the European Parliament's information document on the on the cum-ex files dated September 26, 2018.

Note that during our investigated time span (2005-2019) tax laws, effective dates, target and scope all differ across countries. For example, Austria stopped all payments of dividend tax refunds during the second half of 2013. As of 2014, the Austrian government requires proof of stock ownership at the actual settlement date. Germany and Switzerland moved to prohibit the issuance of tax certificates for dividend compensation payments in 2007 and 2008. While it is unclear whether the measure affected Switzerland, the case of foreign banks' tax certificates illustrates that traders in Germany found a workaround. Belgium recently imposed a 60-day holding requirement on any shares which have to be held in full ownership.[16] Finland and Luxembourg now follow the OECD guidelines to improve transparency through the new requirement of disclosing information on the stock beneficiary.

France, which applies custom tax rates on WHT, is a special case. This makes it more difficult for French tax authorities to trace illicit tax refunds. In 2019, the French government introduced an amendment that requires the taxpayer to prove the purpose of transactions if they apply for a refund of dividend tax. Until the end of 2020, we find no tax reforms related to cum-ex or cum-cum in Netherlands and Spain.

3 Data and descriptive statistics

3.1 Data sources and sample formation

This paper sets out to study cum-ex and cum-cum activity in ten European countries and is based on a rich data set that covers SSF transaction data on the Eurex Exchange. In addition, we compiled information on the underlying stocks from multiple sources. All sources are listed in Table A1. All variables are defined in Table A2.

The Eurex Exchange is the largest market for European-based derivatives.[17] Ever since SSF were first introduced in October 2005, trading has multiplied substantially, yet with a significant year-to-year variability. Starting with 740,068 open interest in 2005, trading grew continuously

[16] We found Belgian newspapers that report on investigations related to cum-ex trades on October 14, 2014 in representative offices of foreign banks, see e.g. De Tijd, Verloor België meer dan 200 miljoen aan 'duivelse geldmachine'?, dated October 20, 2018. Furthermore, ESMA (2020) reports about further investigations in Belgium by the Financial Services and Markets Authority (FSMA) in 2015. While we suspect that these measures could have affected SSF trading activity, regression analysis shows no effects.

[17] As of 2020, the trading volume at Eurex reached 1.9 billion contracts in total, see Eurex Exchange, Full year and December 2020 figures at Eurex, 2021.

over the years until its first peak in 2012. Following a plateau between 2013 and 2016, the market volume increased sharply again until 2019, to 417 million open interest.

[Figure 2 about here]

The transactions data on SSF are anonymous and include prices and open interest, from October 2005 to August 2019.[18] Moreover, the dataset discloses information on whether the future contracts were OTC trades. It leaves us with 935,505 trades from 8,221 future contracts, of which 35.49% are traded pre-arranged. The trades arise from 439 different securities that have a market capitalization of over €6.03 trillion (August 31, 2019).

All information on the dividends, i.e., gross and net dividend amount, ex-dates and tax rates, for all underlying securities and the entire sample period were extracted from the Thomson Reuters database. Additionally, we hand-collected company announcements on dividends and verified the dividend information using the website www.boersen-zeitung.de (January 31, 2021), because dividend data are prone to errors and omissions.[19]

Our initial sample is based on regular dividend event dates. We include interim, extra and special dividends in the data set when these special event types happen on a regular dividend event date.[20] These multiple dividend types for a single stock with the same ex-date are combined into a single observation. This procedure results in a total of 5,275 dividend ex-dates, of which only 2,751 ex-dates match with the SSF trading data. All dividend event types are ordinary cash dividends, omitting stock dividend events and zero-dividend paying events. Moreover, we remove every observation with tax-free dividends.[21] As we use a 50-day window surrounding each dividend event, there are 3,563 calendar dates during this period.

The analysis is based on split-adjusted data. We also retrieve daily data on stock prices, market capitalization, and volume (for both public and off-exchange stock markets) from Thomson

[18] The sizes of contracts include mostly 100 and 1,000 shares. The tick size is 0.0001 for most SSF.

[19] Ince and Porter (2006) draw attention to coverage and classification issues in the Thomson Reuters database that can influence statistical inferences.

[20] Thomson Reuters distinguishes between extra and special dividends to determine the source of payment. Special dividends originates from the company's extraordinary profits, while extra dividends are paid from the company's regular net profits or reserves.

[21] Tax-free dividends are dividends free of withholding tax. Thomson Reuters declares dividends "tax-free", if the dividend is paid out of (i) 27 KStG Leistungen aus dem steuerlichen Einlagenkonto, (ii) 27 Corporation Tax Act (Korperschaftsteuergesetz, KStG), (iii) contributions or reserves other than nominal capital, (iv) unappropriated net income or net earnings from tax deposit account. France is an exceptional case where this definition does not apply. The Thomson Reuters database has flagged all available ex-dividend events of French shares as "dividend free of tax" since 2004. This is because France applies custom tax rates.

Reuters.[22] All information is converted to €. The natural logarithm of the market capitalization serves as a proxy for company size. Transaction costs are measured by the bid-ask spread (the difference between ask and bid price measured in bps). For companies included in our sample, the bid-ask spread is, on average, 19 bps. Companies' past performance is defined by a rolling average of six-month log-return calculated from daily closing prices. We use annualized stock volatility to measure risk. The mean and median are 0.29 and 0.26. 76% of all underlying securities pay an annual dividend. We measure the dividend yield as the amount of gross dividend as a percentage of the daily closing price. The dividend yield ranges between 0.05% to 60.15%, with an average of 2.34%.

We further retrieve intraday stock prices from the Refinitiv Tick History database to calculate the mispricing of SSF by matching intraday stock prices with the SSF transaction timestamp (in seconds). For the cost of carry model, we use Euribor rates which are obtained from Bloomberg.

Who trades stocks around ex-dividend days? We collect the monthly ownership structure for each traded company from the FactSet database. The ownership data is based on regulatory filings and company websites. We use the information provided on the percentage of domestic and foreign institutional ownership, i.e., the aggregated holdings of all reporting institutions divided by the shares outstanding. Domestic institutional ownership is on average 3.92%. It ranges between 0 and 56.77% during an ex-dividend event. The share of foreign institutional ownership is on average 27.76% and varies between 0 and 95.80% during ex-dividend events.

Other factors may influence cum-ex or cum-cum trading, yet we do not find considerable variation between specific underlying characteristics. A great portion of the underlying securities is listed on Xetra (24.54%), Euronext Paris (21.90%), and Six Swiss Exchange (9.50%). The highest concentrations of stocks are from the industrial (21.50%), financial (17.50%), the materials (10.25%) sectors. We find that the underlying securities are mostly listed on the DAX (25.86%), CAC40 (21.90%), and FTSE Italia All-Share (10.55%) indices.

[22] Thomson Reuters defines off-exchange trading as over the phone negotiated trades, broker to broker trades, dark trades and OTC Link system trades.

3.2 Descriptive statistics

Large spikes in volume surrounding the ex-dividend dates for companies with taxable dividends and strong yields are evidence of cum-ex and cum-cum trading activities. These high levels of trading volume are extreme deviations from usual trading levels around the ex-days. As an example, Figure 3 graphs daily contract volume of futures and equity of four German firms, Allianz AG, SAP SE, Muenchener Rueck, and Deutsche Post AG. While the first three firms pay taxable dividends, Deutsche Post AG issues WHT-free dividends for all investors groups, with an one-time exemption in 2008.

[Figure 3 about here]

The first three examples have contract volumes for futures roughly seven times higher than Deutsche Post AG between 2005 and 2011. Another striking feature is the extraordinary open interest of Deutsche Post AG in 2008. Excess trading activities of both futures and equities disappeared almost completely after the tax law was first changed in 2012.

A similar pattern can be observed for aggregated data for each country. Based on their legislative changes, we form three periods for each country and define the first period between October 2005 and December 2011 as the *cum-ex trading period*. We expect to see high trading activity around ex-dividend dates in Germany, since both cum-ex and cum-cum were still legal in this phase. The second period, between January 2012 and December 2015, may represent the first spillover effect into neighboring countries. In addition, this time marks also the sole *cum-cum trading period* for Germany. The third period - January 2016 to August 2019 - represents the second spillover period for all other countries, and at the same time, also the post-regulated tax regime for Germany.

To account for the country-specific law changes, we shorten the cum-ex period for Switzerland from 2005 to 2008, and the first spillover period for Austria from 2012 to 2014. Although we find legislative changes in Belgium, Finland, France and Luxembourg in 2019, our database does not allow us to investigate long-term changes in trading activity after the tax reforms. In 2016, Italy exempted foreign institutional investors (funds) from the dividend taxation. This could prevent cross-border tax arbitrage and, if the measure had any effect, we should be able to observe changes in trading activity after 2016.

Figure 4 shows the evolution of aggregated open interest over time. The red and blue lines show Germany's first and second changes in tax law targeting cum-ex and cum-cum trades in 2012 and 2016, respectively. The blue line shows the second tax law change against cum-cum trades in 2016. The green line emerged from the research summarized in Table 1 and shows the effective date of country-specific tax laws against cum-ex or cum-cum trading. Figure 5 shows the aggregated open interest in a 20-day window surrounding the ex-dividend event for the three defined periods: (i) cum-ex (2005-2011), (ii) cum-cum or first spillover (2012-2015), and (iii) post or second spillover (2016-2019).

[Figure 4 and Figure 5 about here]

Figure 4 depicts the significant increase in open interest in Austria, Belgium, Italy and Luxembourg precisely after Germany prohibited cum-ex trading in 2012. Some minor increases can be also observed in Finland and Switzerland after 2012. This provides initial evidence for the first spillover effect of cum-ex trading. The figure also shows sharp increases in open interest in Finland, France, Italy, the Netherlands, Spain and Switzerland after Germany made a second legislative change in 2016. This indicates the second spillover effect of cum-ex or cum-cum trading. Note that France, Italy and Switzerland exhibit slightly different types of peaks than all other countries, which are more widely shared around the ex-dividend dates.

Figure 5 is in line with these preliminary insights, and plots extremely large spikes of open interest one day before the ex-dividend event. Note that the sharp increase in open interest during the cum-ex period in Germany can be also observed in Austria, Spain and Switzerland. Moreover, the effects become more profound in Austria and Belgium after 2012. The distribution during the cum-cum period in Germany is larger and centered around -10 to + 10 days. The picture in Finland, France and the Netherlands is similar during the second spillover period.

Finally, Figure A1 in the appendix shows the evolution of stock trading on off-exchange venues centered around the ex-dividend day. Among all countries, only Austria, Belgium, and Germany exhibit a noticeable increase in stock volume five days before the ex-dividend event. This substantial amount of stock trading vanished after Germany made cum-ex activities illegal. The remaining countries do not display any clear pattern and are therefore excluded.

It may be possible that countries prevented cum-ex and cum-cum trades through related court

rulings. Although we identify legal cases related to cum-ex and cum-cum trading in the IBFD's Tax Research Platform, we do not observe significant changes in trading activity or ownership structure.[23]

4 Empirical analysis and results

Subsection 4.1 examines abnormal trading activity around ex-dividend days and derives trading spillovers from changing market dynamics. Subsection 4.2 investigates the pricing of SSF around ex-dividend days while Subsection 4.3 seek some clues of cum-ex and cum-cum trading in stock prices.

4.1 Trading activity around ex-dividend days

This section examines trading spillover effects of cum-ex and cum-cum trading in ten European countries. Our key explanatory variable is trading activity, which is measured by logarithmic open interest 50 days before and after the ex-dividend event ($OpenInterest_{t_{-50,+50}}$). The primary focus is to assess the magnitude of SSF trading in response to tax law changes. If cum-ex and cum-cum trading migrated to neighboring markets, then we expect to see high levels of open interest specifically after changes in Germany's tax laws. If countries take their own actions, we expect a decrease in open interest, resulting in negative coefficients after the respective law change. Additionally, we test for abnormal stock volume in exchange and off-exchange markets to corroborate our outcome.

Consistency of results is established by controlling for both market and asset characteristics, such as $OTCShare$ (the share of OTC future trades divided by the sum of future trades per day), $ForeignOS$ and $DomesticOS$ (the portion of shares owned by foreign or domestic institutional investors divided by the outstanding shares of a firm), transaction cost are displayed by

[23] For example, the French Supreme Administrative Court decided on the illegality of cum-cum activities in 2006, see Ministre de l'Economie, des Finances et de l'Industrie v Société Bank of Scotland on December 29, 2006, No. 9 ITLR 683. The case consists of a foreign investor who was interposed between a French subsidiary and its parent shareholder to seek a full refund of WTH on dividends. While the parent company was liable to pay taxes, the foreign investor was not. The court concluded that the transaction of shares was purely tax-motivated and denied reduced taxation on dividends. Likewise, a triangular relationship was arranged in the Netherlands. Despite the analogous setting, the Dutch court decided in favor of the foreign investor and allowed the reimbursement of tax under the double tax treaty, see Netherlands, HogeRaad (Supreme Court) on April 6, 1994, No. BNB 1994/217. Further court rulings are the Swiss Federal Tribunal on November 21, 2017, No. 2C_123/2016 and the Italian Supreme Administrative Court Decision on February 20, 2013, No. 4164.

BidAskSpread (the difference between ask and bid price as a percentage of the ask price), *Size* (logarithmic market capitalization), annualized $Volatility$ and $Momentum$ (a rolling average of past six-month returns). Table 2 presents descriptive statistics of all of the key variables in the final sample.

$$\begin{aligned} OpenInterest_{j,t} = \beta_0 &+ \beta_1 \cdot \sum_{t=-10}^{10} D_t \times CumExPeriod_t + \beta_2 \cdot \sum_{t=-10}^{10} D_t \times CumCumPeriod_t \\ &+ \beta_3 \cdot \sum_{t=-10}^{10} D_t + \beta_4 \cdot CumExPeriod_t + \beta_5 \cdot CumCumPeriod_t \\ &+ \beta_6 \cdot X_{j,t} + Firm_j + \epsilon_{j,t} \end{aligned} \tag{1}$$

Our empirical model in Equation 1 is estimated over all three tax regimes for each country separately. $X_{j,t}$ is a vector of controls. $Firm_j$ denotes stock-level fixed effects. Results are presented in Table 3 and Table 4.

Baseline results for Germany

As expected, Germany shows positive coefficients during the cum-ex and cum-cum periods. This clearly points to exceptionally high trading activity before the implementation of tax laws, supporting descriptive evidence in Figure 4 and Figure 5. Moreover, we find abnormal stock volume, with significantly higher trading levels in both exchange and off-exchange markets. As result, we interpret that cum-ex and cum-cum activities has effectively stopped in Germany after 2016.

[Table 3 about here]

Among the control variables, we find that SSF trading is closely related to spot market activities. Volatility and the past performance of a stock intensify open interest, indicating the use of momentum strategies or feedback trading. Moreover, investors are willing to trade futures when the underlying risk is high. Firm size plays only a minor role in trading SSF.[24]

Another string of studies suggests that abnormal trading volume around ex-dividend days is negatively related to transaction costs and positively related to dividend yield (Lakonishok and

[24] Although this relationship appears appealing and intuitive, it is inconsistent with Ang and Cheng (2005b); Vipul (2008); Danielsen et al. (2009); Bialkowski and Jakubowski (2012).

Vermaelen, 1986). This indicates the presence of short-term trading and dividend stripping. We test these findings for open interest, assuming that transaction costs are correlated with the bid-ask spread, and confirm the relation. Yet, the negative correlation between dividend yield and stock volume is unexpected.

The OTC coefficient documents that high levels of open interest are driven by a large share of OTC future trades. While the Regional Court Bonn elaborates that cum-ex and cum-cum were possibly traded public and OTC, our results show that both schemes were likely driven by pre-arranged OTC future and off-exchange stock trades.

Further research on ownership structure reveals that the level of institutional ownership has explanatory power for abnormal volumes during ex-dividend days (Michaely and Vila, 1995; Liljeblom et al., 2001; Le et al., 2020). However, the relationship is non-linear.[25] We follow Liljeblom et al. (2001), who split the information into shares of domestic and foreign institutional ownership. Moreover, we include squared terms to control for non-linearity. Since domestic investors typically enjoy more tax-advantages compared to foreign investors, domestic institutional ownership is expected to increase considerably. While we are consistent with the idea, we observe only negative effects on open interest and stock volume, however. Instead, our results are in line with Liljeblom et al. (2001); Dhaliwal and Li (2006), and point to a greater impact of foreign institutional ownership. Moreover, we support the findings that trading activity around ex-days is a concave function of institutional ownership.

Interestingly, Bialkowski and Jakubowski (2012) also find that institutional ownership has a negative impact on open interest. The authors conclude that institutional ownership serves as a proxy for short sale ability. Investors therefore trade SSF contracts less if they have the possibility to short sell a stock.

Country-by-country analysis

To consistently report positive coefficients for all other countries when abnormal SSF trading is present, we exchange the cum-ex/cum-cum periods in Equation 1 with the first (2012-2015) and

[25] Dhaliwal and Li (2006) argue that institutional ownership reflects the investor base and their tax heterogeneity. The investor base is similar if institutional ownership is either very low or very high. As such, tax preferences (on dividends or capital gains) are homogeneous. The variation of investor groups and tax preferences is the highest in between, and therefore correlates with ex-day trading.

second (2016-2019) spillover period.

[Table 4 about here]

We document increases in trading activity in Austria, Belgium and France after 2012, suggesting spillover effects to more favorable tax regimes. Note that Germany allowed cum-ex as well as cum-cum trading until 2012. Trading spillovers can therefore be related to both schemes. Further, comparing with the pre-spillover period, the amount of open interest increases further in Belgium, France, Finland and Spain after 2016. While we can not clearly distinguish between the two schemes in the data, the timing indicates that these increases in open interest are primarily spillover effects attributed to cum-cum trading.

Particular attention should be given to the legislative interventions in Austria and Switzerland. To account for those, we shorten the cum-ex period for Switzerland to 2005-2008, and the first spillover period for Austria to 2012-2014 by including a dummy for their post-regulated periods. If the law change was enforced effectively, then we should be able to observe a decrease in open interest for the post-regulated period. Indeed, Switzerland consistently records significant negative coefficients, indicating an effective measure after 2008. In Austria, trading in SSF decreased substantially from 2016.

Italy is a unique case because the government exempted foreign institutional investors from dividend taxation in 2016. This may motivate participation in simple dividend-capture trading rather than cum-ex or cum-cum strategies, which of course increases trading activity in turn. Regression analyses indicate no appreciable changes in SSF trading, however. Luxembourg reports negative coefficients in both spillover periods, suggesting a strong decrease in open interest. The Netherlands seems to remain at relatively stable levels of open interest through all three periods. We interpret these results as a minor influence on futures trading activity from Germany's tax law changes.

4.2 Mispricing of single stock futures

To complement our analysis, we study the mispricing of SSF transactions before ex-dividend days. We follow the decision of the Regional Court of Bonn which documents significant price deviations

in SSF. The mispricing represents the shifting of profit between colluding parties.[26] The main variable of interest is the level of SSF mispricing ν, calculated as the difference between the actual $F_{t,T}$ and theoretical SSF price $F^*_{t,T}$ relative to the dividend. Theoretical future prices are derived from the cost of carry model,

$$F^*_{t,T} = (S_t - D_t\nu)e^{r(T-t)}, \tag{2}$$

where S_t is the spot price, D_t is the present value of the gross dividend at time t, r is the interpolated Euribor rate and $T-t$ is the remaining time to maturity. The SSF mispricing ν shows the percentage of the gross dividend that is priced in SSF. We call ν the dividend level, assuming that the actual future price corresponds to its fair value, $F_{t,T} = F^*_{t,T}$, when the dividend is fully priced in the cost of carry model, $\nu = 1$. A dividend level below (above) one increases (decreases) future prices and creates a positive (negative) deviation from the fair value ($\nu = 1$).

The main objective of our analysis is to examine the degree of SSF mispricing, computed as implied dividend levels, in Germany. The level of mispricing for cum-cum trades is too small to be recognizable. For this reason, we compare only two periods, i.e., 2005-2011 and the post-regulation period (2012-2019), to evidence cum-ex trading. Data restrictions do not allow us to examine SSF mispricing in neighboring countries when trading spillovers are present. Our transaction data are limited to 20 days before the ex-dividend date ($t_{-20,-1}$) and include only events that have a minimum of €1 gross dividend. We remove the outliers because small dividends lead to extreme dividend levels. Ultimately, our sub sample consists of 51,283 stock prices within the same second of the SSF transaction.

Supporting the abnormal SSF trading during the cum-ex period, descriptive statistics in Figure 6 and Figure 7 shows implied dividends levels of around 80% to 90% on average. The dividend levels below one indicate a positive SSF mispricing, with the most profound effect four days before ex-dividend date. This effect vanishes after the tax reform in 2012.

[Figure 6 and Figure 7 about here]

Our regression analysis include controls to rule out unobserved heterogeneity issues. We control

[26] See Cologne Tax Court, Judgment No. 2 K 2672/17, dated July 19, 2019 and Regional Court Bonn, Judgment No. 62 KLs - 213 Js 41/19 - 1/19, dated March 18, 2020. Other possibilities include swaps, forwards and options.

for future characteristics, such as $TradeSize$, the logarithmic number of traded SSF contracts per transaction, $TimeToMaturity$, the days count until the SSF contract expires, $TransactionTiming$, the number of day between the transaction date and the ex-dividend date, and finally, OTC, a dummy variable that flags one when the SSF was traded over-the-counter. Moreover, literature suggests to include stock market characteristics, such as annualized $Volatility$, $Size$, $DividendYield$, $BidAskSpread$, and institutional ownership, i.e. $ForeignOS$ and $DomesticOS$.

$$\nu_{j,t} = \beta_0 + \beta_1 \cdot CumExPeriod_t + \beta_2 \cdot X_{j,t} + Firm_j + \epsilon_{j,t} \tag{3}$$

Our empirical model in Equation 3 is estimated over two periods. $X_{j,t}$ is the vector of controls and $Firm_j$ denotes stock-level fixed effects. Results are presented in $Table$ 5.

Results for Germany

On average, the dividend level during the cum-ex period is 13.4% lower than after the tax law change in 2012. This estimate is in line with the insider information that has been detected by the Regional Court of Bonn. It was stated that approximately half of tax refund (26.4% of the dividend) was transferred to the counterpart with SSF.

[Table 5 about here]

Further, the level of mispricing becomes larger for block trades and especially for OTC trades that have been performed shortly before the dividend ex-date. The remaining time until the future contracts expires has only little effect on the mispricing. Moreover, the mispricing becomes more prominent for stocks with a higher dividend yield. This result is robust to transaction cost, volatility, and institutional ownership.

Interestingly, literature finds more efficiently priced SSF for developed countries, see (Ang and Cheng, 2005b; Danielsen et al., 2009; Shastri et al., 2008; Bialkowski and Jakubowski, 2012), while there is evidence of SSF underpricing in emerging markets, see Vipul (2005, 2008); Pathak et al. (2017); Shankar et al. (2018). Against this backdrop, we find substantial overpricing of SSF around ex-dividend dates, controlling for multiple asset and market factors, when traders are actively involved in dividend capture trading. We argue that the distorted future prices mirror the profit

shifting of cum-ex traders.

4.3 Ex-dividend stock price declines

Theory and evidence on the behavior of ex-day prices conflict and results remain inconclusive to date. In theory, ex-day prices should decline by their dividend amount, i.e. ex-day price decline to dividend ratio (PDR) should equal one. Empirical research, however, documented mean PDR values constantly greater or less than one. One explanation for this anomaly may be that asset prices reflect the differential tax treatment of dividends and capital gains (Elton and Gruber, 1970).[27] Contrary to the tax explanation, the short-term trading hypothesis argues that dividend stripping eliminates any tax effect on prices because arbitrageurs ensure price efficiency.[28] The ex-day price drop will be close to the dividend after adjusting for transaction costs Kalay (1982) or underlying's risk Michaely and Vila (1995).

According to the dynamic dividend clientele model, ex-day price changes are composed of multiple trading decisions of investors with different tax statuses, i.e. high tax heterogeneity Michaely and Vila (1996). The PDRs therefore vary with the average tax preference of all investors.[29] While this view has gained acceptance over recent years, it is unclear how and in which direction tax heterogeneity influences ex-day prices.

Our study contributes to this large ex-dividend literature by studying the PDR during the cum-ex, cum-cum and spillover periods in ten European countries. Cum-ex and cum-cum trading are strongly motivated by tax considerations because both strategies create a tax differential by

[27] When dividends are subject to more beneficial tax treatment than capital gains, the price drop will be higher than the dividend amount for higher dividend-paying stocks, i.e. $PDR > 1$. This relationship reverses when capital gains are more tax-advantaged, resulting in a $PDR < 1$ for higher dividend-paying stocks. While the literature mostly reviews markets that disfavor dividends and find $PDR < 1$, McDonald (2001) is one of the few studies that examines a tax regime where dividends are not disadvantaged. Germany's imputation system prior to 2001 allowed domestic institutional investors to receive a tax credit, which ultimately resulted in untaxed dividend payments. This differential tax treatment was reflected in greater price declines on the ex-day dividend days, which exceeded the net dividend by almost two times on average. The author concludes that domestic corporate traders dominate the stock prices on the ex-dividend days.(Green and Rydqvist, 1999; Florentsen and Rydqvist, 2002) provide additional evidence for Swedish and Danish lottery bonds.

[28] Koski and Scruggs (1998) argues that the price drop is expected to exceed the dividend ($PDR > 1$), if short-term traders (short) sell the stock cum-dividend, and buy ex-dividend to gain a profit. Conversely, if the price drop is expected to be less than the dividend ($PDR < 1$), short-term traders will buy the stock cum-dividend, and sell it afterwards.

[29] Alternative explanations for the ex-day price drop behavior include business cycles (Gordon and Bradford, 1980; Eades et al., 1994) and market microstructure effects (Dubofsky, 1992; Bali and Hite, 1998; Frank and Jagannathan, 1998). Frank and Jagannathan (1998) find PDRs less than one in a market with no taxation on capital gains or dividends, suggesting no tax effect on ex-day prices.

means of the extra benefit in the dividend tax refund. In a similar setting, Le et al. (2020) analyze the ex-day price drops of franking credits in the Australian market. Imputation or franking credits create a tax differential by design since only domestic investors receive a dividend tax advantage. The authors show that the PDR increases when tax heterogeneity, captured by holdings or trading of domestic investors, increases. While we control for institutional stock ownership, we derive tax heterogeneity from the cum-ex/cum-cum and trading spillover periods.

In this context, if the degree of tax heterogeneity increases, trading increases, and we should be able to observe dividend clienteles, paired with a higher pricing of cum-day stocks and a more intense price decline on ex-days, i.e., $PDR > 1$. This effect is particularly acute at times when the tax advantage matters, and reverses when it is removed. If the tax heterogeneity is on average low, trading decreases, and we anticipate noticeably smaller ex-day price declines, i.e. $PDR = 1$.

To assess these hypotheses, we calculate the ratio of the ex-day price drop to gross dividend ratio for each ex-dividend event by using the price difference between the cum-dividend closing price and ex-dividend day opening price. Note that the calculation has three serious drawbacks: firstly, the use of net or gross dividend makes a difference in statistical inference; secondly, price changes of too-small dividends will eventually result in excessive ratios; and thirdly, ex-day price declines are subject to overnight market movements. In order to address these problems, we follow Elton and Gruber (1970) and derive the PDR from an investor's choice equilibrium. This implies the use of the gross dividend.[30] Figure A2 in the appendix displays the evolution of the actual (gross and net) PDR and the theory implied PDR over time. On average, ex-day price declines are smaller than the gross dividend, although the figures are quite volatile.

Extreme outliers are winsorized at a 1% level (i.e., 60 dividend events are excluded).[31] Moreover, we adjust the cum-dividend closing price for overnight market risk using our estimate of expected daily returns $E[r_j]$ following Liljeblom et al. (2001); Elton et al. (2005); Lasfer (2008).

[30] If tax rates determine ex-day prices, an investor will be indifferent to selling on cum-dividend or ex-dividend day when $P^{Cum} - \tau_g(P^{Cum} - c) = P^{Ex} - \tau_g(P^{Ex} - c) + D \cdot (1 - \tau_d)$, where τ_g is capital gains tax rate, τ_d dividend tax rate, D is the gross dividend and c is the transaction cost. Rearranging the equation gives the following relationship: $PDR = \frac{(1-\tau_d)}{(1-\tau_g)}$.

[31] Graham et al. (2003); Elton et al. (2005); Zhang et al. (2008) use thresholds to account for this problem. Lasfer (2008); Haesner and Schanz (2013) winsorize their PDR data. Another issue for consideration could be the aggregation across firms since the investor base likely differs on the firm-level, which makes it impossible to infer a reasonable marginal investor's tax bracket Ainsworth et al. (2020).

$$PDR_{j,t} = \frac{P_{j,t}^{CumClose} \cdot \big(1 + E[r_j]\big) - P_{j,t}^{ExOpen}}{d_{j,t}}, \tag{4}$$

where d_j is the net dividend for stock j at event t and $E[r_j]$ is estimated by Equation 5.

$$E[r_j] = \hat{\beta}_{0_j} + \hat{\beta}_{1_j} R_m^{CI} \tag{5}$$

R_m^{CI} is the realized stock return on the ex-day of a value-weighted stock market index.[32]

We use a similar identification strategy as in Subsection 4.2. $X_{j,t}$ is a vector of controls, including information on ownership, $ForeignOS$ and $DomesticOS$, information on transaction cost, $BidAskSpread$, and the $DividendYield$. In addition, we also account for the underlying's risk profile, including systemic risk, β_j, and idiosyncratic risk, $\frac{\sigma_{e_j}}{\sigma_{Rm}}$, which we estimate from the market model in Equation 5. The constant shows the mean value. Regression results are presented in Table 6.

$$PDR_{j,t} = \beta_0 + \beta_1 \cdot CumEx_t + \beta_2 \cdot CumCum_t + \beta_3 \cdot X_{j,t} + \beta_4 \cdot \beta_j + \beta_5 \cdot \frac{\sigma_{e_j}}{\sigma_{Rm\,j}} + \epsilon_{j,t} \tag{6}$$

Overall, results are mixed and we believe further investigation is warranted. Contrary to expectation, mean PDR in Germany remains close to unity despite changes in tax heterogeneity. Although the result supports the findings of Buettner et al. (2020), who investigated German HDAX stocks during 2005 and 2015, we reject that tax-induced trading impounds tax heterogeneity in stock prices.

[Table 6 about here]

Likewise, we do not find systematic changes in PDRs attributed to differences in the tax heterogeneity in other countries. The final result is that ex-day price declines are mostly negatively related to high-beta stocks, suggesting lower trading activity for greater uncertainty. This result is in line with the dynamic dividend clientele model.

[32] Amsterdam Exchanges Index, Austrian Traded Index, BEL 20 Index, CAC 40 Index, DAX Index, FTSE Italia All-Share Index, IBEX 35 Index, Luxembourg SE LuxX Index, Swiss Market Index

5 Conclusion

This article reports on the spillover effects of cum-ex and cum-cum trading by using a rich data set of Eurex single stock futures (SSF). Cum-ex and cum-cum trades are two trading strategies around the ex-dividend date that are designed to profit from (multiple) illicit dividend tax refunds. Legal articles and cases have found that investors collude with each other by passing shares with *cum* and *ex*-dividend entitlements with SSF. This increased trading activity creates the illusion of multiple investors paying dividend tax, although it is only withheld once.

Germany is generally assumed to be the most affected market, which is why it serves as a reference country to infer the characteristics of these trades. Moreover, Germany introduced regulatory changes to prevent cum-ex trades and cum-cum trades in 2012 and 2016, respectively. These changes caused trading spillovers to neighboring countries, which are the subject of our study. For our analysis, we determine if and when a specific legislative change was enacted for each country. The different tax law regimes make identifying the spillover effects in a multiple-country setting ideal.

Our results document cum-ex and cum-cum trading spillovers to more favorable tax regime markets, such as Austria, Belgium and France, after 2012. The trading spillovers appear again in Belgium, France, Finland and Spain in 2016. These findings suggest continued cum-ex or cum-cum trading in these countries. In Austria and Switzerland, the high trading activity around ex-days disappeared when the governments changed their tax codes. Results for Italy, Luxembourg and the Netherlands are ambiguous. Despite descriptive evidence, our regression analysis shows only moderate or negative changes in SSF trading over time. We interpret this result as no cum-ex or cum-cum trading spillovers occurring in these countries.

Prior research and descriptive evidence indicate that cum-ex and cum-cum trades seem to be concentrated around ex-dividend dates with strong yields. We document additionally high open interest one day before the stocks go ex-dividend, accompanied by a high share of pre-arranged OTC trades. Foreign institutional ownership is positively related to trading activity. More specifically, it is described by a concave function, suggesting high tax heterogeneity between investors and limited short-selling opportunities. While we are consistent with the idea that domestic institutional ownership should increase, our data is not sufficiently granular to study the effects.

We further find substantial overpricing in SSF contracts traded within 20 days before ex-dividend dates during the cum-ex period in Germany. On average, SSF have been overpriced by 13.4% of the stock's gross dividend, approximately the half of the withholding tax refund. This mispricing is more pronounced for block trades and especially for OTC trades shortly before the dividend ex-dates. The effect disappear after Germany's tax rule change in 2012. We argue that this result evidence the profit shifting of cum-ex traders.

Analyzing the price drop ratios (PDR) of the SSF underlying securities reveals that tax advantages are not reflected in stock prices. Chances in tax heterogeneity therefore has no effect on asset prices, but risk decreases price declines on ex-dates.

References

Aggarwal, N. and Thomas, S. (2019). When stock futures dominate price discovery. *Journal of Futures Markets*, 39(3):263–278.

Ainsworth, A., Lee, A. D., and Walter, T. (2020). Can firm-specific dividend drop-off ratios be used to infer shareholder marginal tax rates? *Accounting & Finance*, 60(1):507–534.

Allen, F. and Michaely, R. (2003). Payout policy. In *Handbook of the Economics of Finance*, volume 1, pages 337–429. Elsevier.

Ang, J. S. and Cheng, Y. (2005a). Financial innovations and market efficiency: The case for single stock futures. *Journal of Applied Finance*, 15(1).

Ang, J. S. and Cheng, Y. (2005b). Single stock futures: Listing selection and trading volume. *Finance Research Letters*, 2(1):30–40.

Bali, R. and Hite, G. L. (1998). Ex dividend day stock price behavior: Discreteness or tax-induced clienteles? *Journal of Financial Economics*, 47(2):127–159.

Benzennou, B., Gwilym, O. A., and Williams, G. (2018). Are single stock futures used as an alternative during a short-selling ban? *Journal of Futures Markets*, 38(1):66–82.

Bialkowski, J. and Jakubowski, J. (2012). Determinants of trading activity on the single-stock futures market: Evidence from the Eurex Exchange. *Journal of Derivatives*, 19(3):29–47.

Brooks, C., Davies, R. J., and Kim, S. S. (2006). Cross hedging with single stock futures. Working paper.

Buettner, T., Holzmann, C., Kreidl, F., and Scholz, H. (2020). Withholding-tax non-compliance: The case of cum-ex stock-market transactions. *International Tax and Public Finance*, pages 1–28.

Campbell, J. A. and Beranek, W. (1955). Stock price behavior on ex-dividend dates. *Journal of Finance*, 10(4):425–429.

Christoffersen, S. K., Reed, A. V., Geczy, C., and Musto, D. K. (2003). The limits to dividend arbitrage: Implications for cross border investment. Working paper.

Cum-ex Files (2020). Cum-ex: Internationale Aspekte und juristische Aufarbeitung.

Danielsen, B. R., Van Ness, R. A., and Warr, R. S. (2009). Single stock futures as a substitute for short sales: Evidence from microstructure data. *Journal of Business Finance & Accounting*, 36(9-10):1273–1293.

Dhaliwal, D. and Li, O. Z. (2006). Investor tax heterogeneity and ex-dividend day trading volume. *Journal of Finance*, 61.

Dubofsky, D. A. (1987). Hedging dividend capture strategies with stock index futures. *Journal of Futures Markets*, 7(5):471–481.

Dubofsky, D. A. (1992). A market microstructure explanation of ex-day abnormal returns. *Financial Management*, pages 32–43.

Eades, K. M., Hess, P. J., and Kim, E. H. (1994). Time-series variation in dividend pricing. *Journal of Finance*, 49(5):1617–1638.

Elton, E. J. and Gruber, M. J. (1970). Marginal stockholder tax rates and the clientele effect. *The Review of Economics and Statistics*, 52(1):68–74.

Elton, E. J., Gruber, M. J., and Blake, C. R. (2005). Marginal stockholder tax effects and ex-dividend-day price behavior: Evidence from taxable versus nontaxable closed-end funds. *The Review of Economics and Statistics*, 87(3):579–586.

ESMA (2020). Final report on Cum/ex, Cum/cum and withholding tax reclaim schemes. Report No. ESMA 70-155-10272.

Florentsen, B. and Rydqvist, K. (2002). Ex-day behavior when investors and professional traders assume reverse roles: The case of Danish lottery bonds. *Journal of Financial Intermediation*, 11(2):152–175.

Frank, M. and Jagannathan, R. (1998). Why do stock prices drop by less than the value of the dividend? Evidence from a country without taxes. *Journal of Financial Economics*, 47(2):161–188.

Gagnon, L. (2018). Short sale constraints and single stock futures introductions. *Financial Review*, 53(1):5–50.

Gordon, R. and Bradford, D. (1980). Taxation and the stock market valuation of capital gains and dividends: Theory and emphirical results. *Journal of Public Economics*, 14(2):109–136.

Graham, J. R., Michaely, R., and Roberts, M. R. (2003). Do price discreteness and transactions costs affect stock returns? Comparing ex-dividend pricing before and after decimalization. *Journal of Finance*, 58(6):2611–2636.

Grammatikos, T. (1989). Dividend stripping, risk exposure, and the effect of the 1984 tax reform act on the ex-dividend day behavior. *Journal of Business*, pages 157–173.

Green, R. C. and Rydqvist, K. (1999). Ex-day behavior with dividend preference and limitations to short-term arbitrage: The case of Swedish lottery bonds. *Journal of Financial Economics*, 53(2):145–187.

Haesner, C. and Schanz, D. (2013). Payout policy tax clienteles, ex-dividend day stock prices and trading behavior in Germany: The case of the 2001 tax reform. *Journal of Business Finance & Accounting*, 40(3-4):527–563.

Henry, T. R. and Koski, J. L. (2017). Ex-dividend profitability and institutional trading skill. *Journal of Finance*, 72(1):461–494.

Hodgkinson, L., Holland, K., and Jackson, R. H. G. (2006). Dividend valuation, trading and transactions costs: The 1997 partial abolition of dividend tax credit repayments. *Accounting and Business Research*, 36(4):253–270.

Ince, O. S. and Porter, R. B. (2006). Individual equity return data from Thomson Datastream: Handle with care! *Journal of Financial Research*, 29(4):463–479.

Jiang, G. J., Shimizu, Y., and Strong, C. (2019). Back to the futures: When short selling is banned. Working paper.

Kalay, A. (1982). The ex-dividend day behavior of stock prices: A re-examination of the clientele effect. *Journal of Finance*, 37(4):1059–1070.

Karpoff, J. M. and Walkling, R. A. (1990). Dividend capture in NASDAQ stocks. *Journal of Financial Economics*, 28(1-2):39–65.

Koski, J. L. and Scruggs, J. T. (1998). Who trades around the ex-dividend day? Evidence from NYSE audit file data. *Financial Management*, pages 58–72.

Lakonishok, J. and Vermaelen, T. (1986). Tax-induced trading around ex-dividend days. *Journal of Financial Economics*, 16(3):287–319.

Lasfer, M. (2008). Taxes and ex-day returns: Evidence from Germany and the UK. *National Tax Journal*, 61:721–742.

Le, N. N. A., Yin, X., and Zhao, J. (2020). Effects of investor tax heterogeneity on stock prices and trading behaviour around the ex-dividend day: The case of Australia. *Accounting and Finance*, 60(4):3775–3812.

Liljeblom, E., Löflund, A., and Hedvall, K. (2001). Foreign and domestic investors and tax induced ex-dividend day trading. *Journal of Banking & Finance*, 25(9):1687–1716.

McDonald, R. L. (2001). Cross-border investing with tax arbitrage: The case of German dividend tax credits. *The Review of Financial Studies*, 14(3):617–657.

Michaely, R. and Vila, J.-L. (1995). Investors' heterogeneity, prices, and volume around the ex-dividend day. *Journal of Financial and Quantitative Analysis*, 30(2):171–198.

Michaely, R. and Vila, J.-L. (1996). Trading volume with private valuation: Evidence from the ex-dividend day. *Review of Financial Studies*, 9(2):471–509.

Miller, M. H. and Modigliani, F. (1961). Dividend policy, growth, and the valuation of shares. *Journal of Business*, 34(4):411–433.

Pan, E. J. (2008). Single stock futures and cross-border access for US investors. *Stanford Journal of Law, Business and Finance*, 14:221.

Pathak, R., Verousis, T., and Chauhan, Y. (2017). Information content of implicit spot prices embedded in single stock future prices: Evidence from Indian market. *Journal of Emerging Market Finance*, 16(2):169–187.

Shankar, R. L., Sankar, G., and Kiran, K. K. (2018). Mispricing in single stock futures: Empirical examination of Indian markets. *Emerging Markets Finance and Trade*.

Shastri, K., Thirumalai, R. S., and Zutter, C. J. (2008). Information revelation in the futures market: Evidence from single stock futures. *Journal of Futures Markets: Futures, Options, and Other Derivative Products*, 28(4):335–353.

Spengel, C. (2017). Kollektivversagen: Cum/Cum, Cum/Ex und Hopp! *Wirtschaftsdienst*, 97(7):454–455.

Spengel, C., Dutt, V., and Vay, H. (2017). Schätzung des durch Cum/Ex-Geschäfte mit Leerverkäufen entstandenen Steuerschadens. Working paper, University of Mannheim.

Spengel, C. and Peitzmeier, J. (2017). Schätzung des durch Cum/Cum-Geschäfte entstandenen Steuerschadens. Working paper, University of Mannheim.

Vipul (2005). Temporal variation in futures mispricing. *Vikalpa*, 30(4):25–38.

Vipul (2008). Mispricing, volume, volatility and open interest: Evidence from Indian futures market. *Journal of Emerging Market Finance*, 7(3):263–292.

Wagner, M., Wei, X., et al. (2020). Cum-ex trading–the biggest fraud in history? Working paper.

Zhang, Y., Farrell, K. A., and Brown, T. A. (2008). Ex-dividend day price and volume: The case of 2003 dividend tax cut. *National Tax Journal*, pages 105–127.

Figure 1: Exemplary cum-ex transaction
The figure shows the profit and loss (in % of total dividend) for each agent in an exemplary cum-ex transaction. The numbers are illustrative only. It works as follows:
On cum-dividend day:
(1) Arbitrageur A buys a large number of stocks from short-seller B before the stock goes ex-dividend (i.e. for €15,000).
On ex-dividend day:
(2) Company pays a dividend to shareholders who are registered in the company's record before the ex-dividend date (i.e. net dividend of €375).
(3) Short-seller B borrows the stocks ex-dividend (i.e. for €14,500), (4) and delivers them to A ex-dividend on the event date (i.e. for €14,500). Because short-seller B is legally obliged to deliver cum-dividend by contract, a compensation payment equal to the net value of the dividend (i.e. €375) will be carried out (tailor-made dividend). Since arbitrageur A obtained stock ownership before the dividend event date, the depository bank will provide a tax certificate with which A will request a tax refund (i.e. of €125). Simultaneously, the original owner of the stocks C collects the actual net value dividend payment (i.e. €375) and receives a tax certificate from their depository bank, which C submits to the tax authorities (i.e. €125). Although only the beneficial owner C legitimately owns the stock and dividend, both agents A and C receive tax reimbursements, doubling the WHT refund of the same single dividend payment. Moreover, if collusion is at play, Arbitrageur A and short-seller B will enter an offsetting future position (before the ex-dividend date) to hedge price risks and redistribute the profit. In particular, short-seller B will buy an overpriced SSF on the stock from arbitrageur A. Subsequently, the profit (as a percentage of the illicit tax reimbursements) is shifted from short-seller B to arbitrageur A.

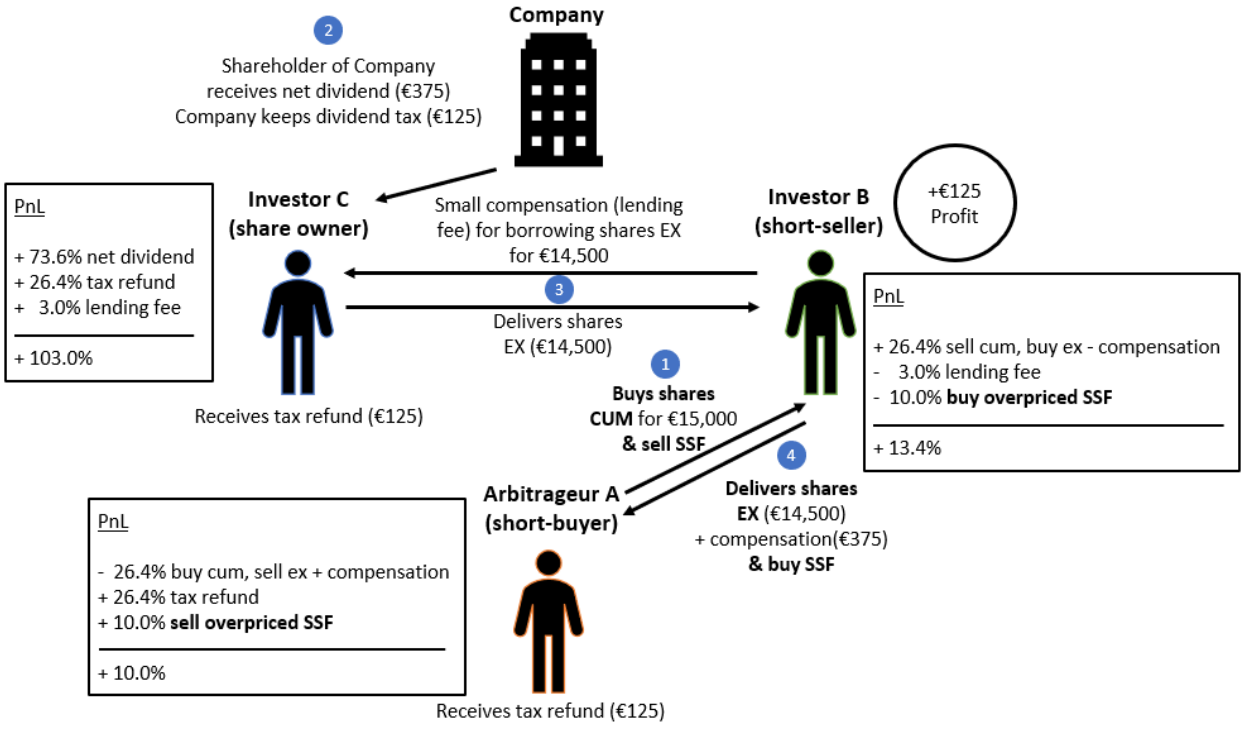

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Figure 2: Total open interest on Eurex Exchange
The figure shows the evolution of aggregated open interest on the Eurex Exchange, starting from the first SSF trade in October 2005 until the end of 2020. The red line shows the average open interest per year. Trading in SSFs has multiplied significantly from 740,068 in 2015 to 417 million open interest in 2020, yet with significant year-to-year variability. Trading grew continuously over the years, reaching a peak in 2012. After stagnation during 2013-2016, the market volume grew again substantially until 2019 before it dropped rapidly in 2020, by 86%.

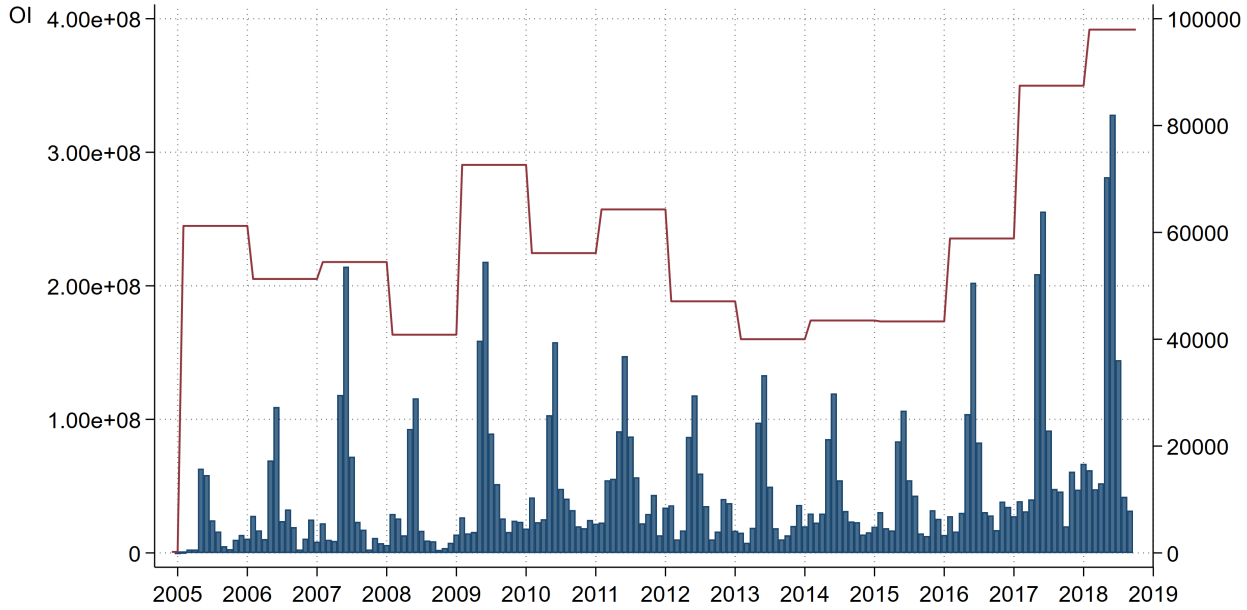
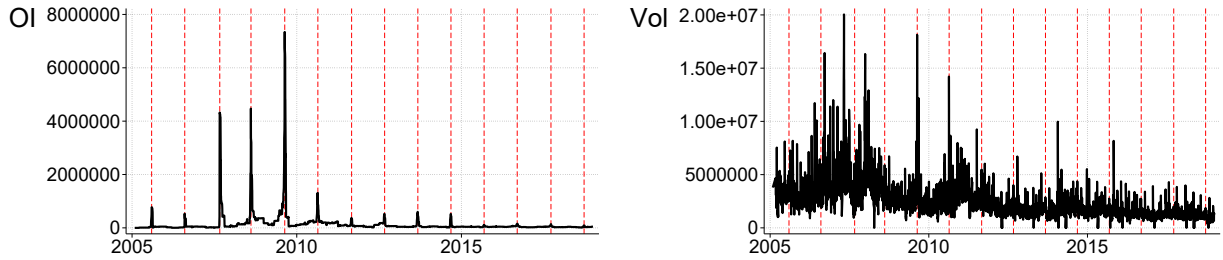
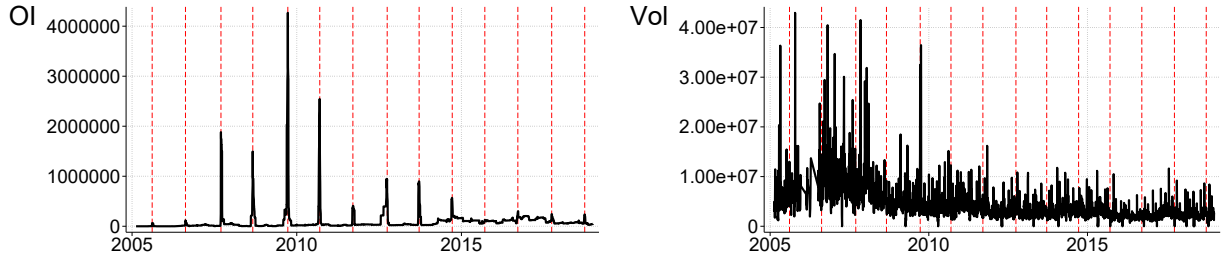


Figure 3: Open Interest and Volume: Some examples
The figure shows the evolution of open interest and volume for four German companies over time: (a) Allianz AG, (b) SAP SE, (c) Munich RE AG and (d) Deutsche Post AG. The first three examples ((a)-(c)) pay out taxable dividends, while the last firm (d) pays tax-free dividends except for in 2008. The red vertical lines in red indicate the ex-dividend dates.

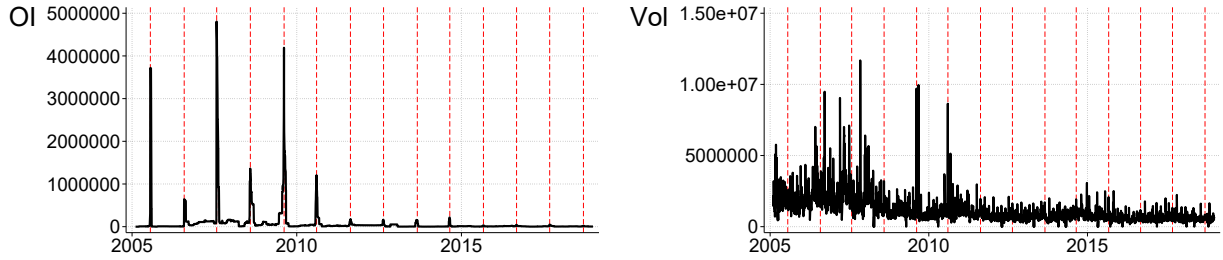
(a) Allianz



(b) SAP



(c) Munich RE



(d) Deutsche Post

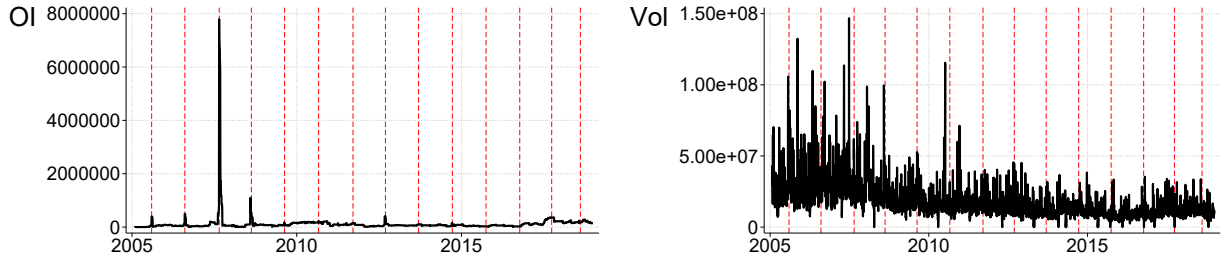
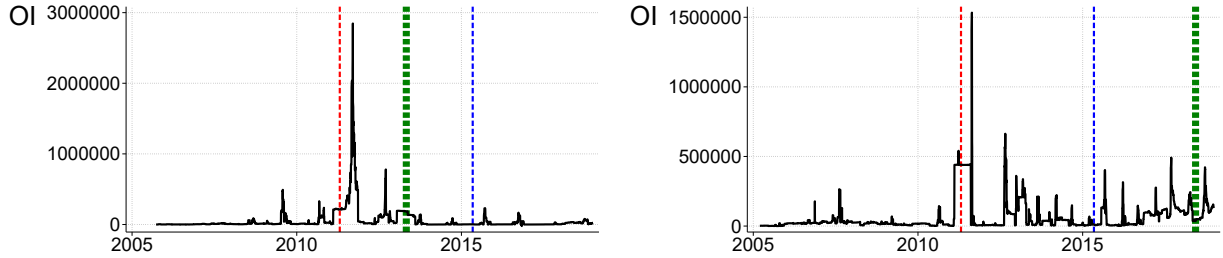


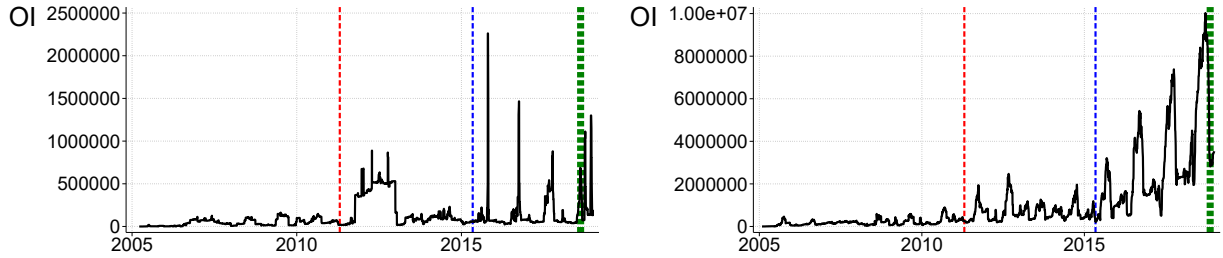
Figure 4: Open Interest

The figure shows the evolution of aggregated open interest for each country. The red line shows the first cum-ex law being introduced in Germany on January 1, 2012. The blue line shows the second law amendment regarding cum-cum activity in 2016. The green line emerges from the research summarized in Table 1 and shows the effective date of country-specific tax law changes enacted against cum-ex or cum-cum trading.

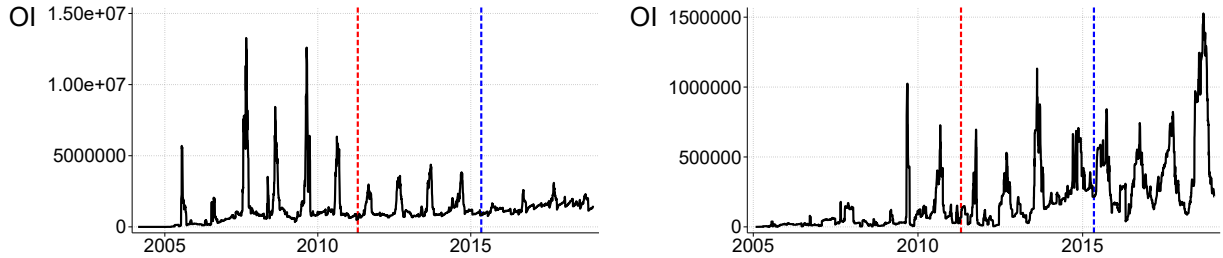
(a) Austria & Belgium



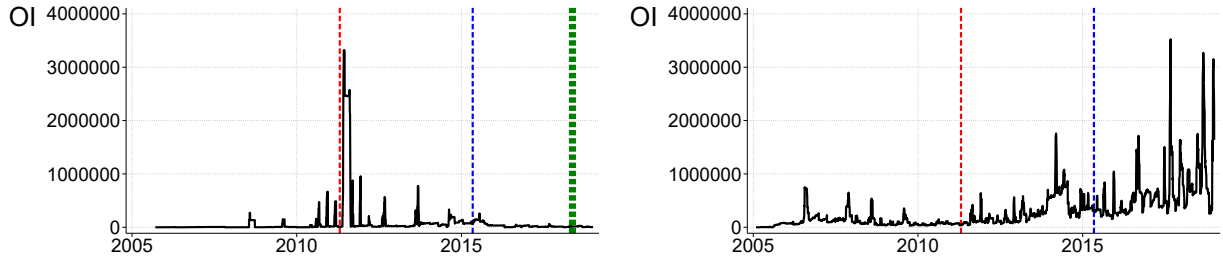
(b) Finland & France



(c) Germany & Italy



(d) Luxembourg & the Netherlands



(e) Spain & Switzerland

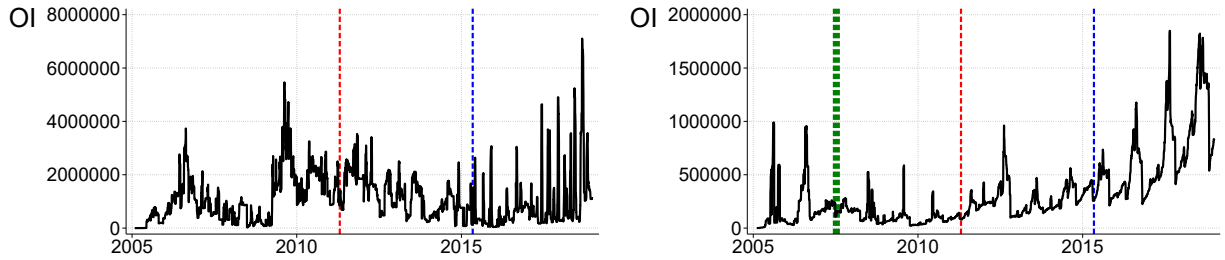
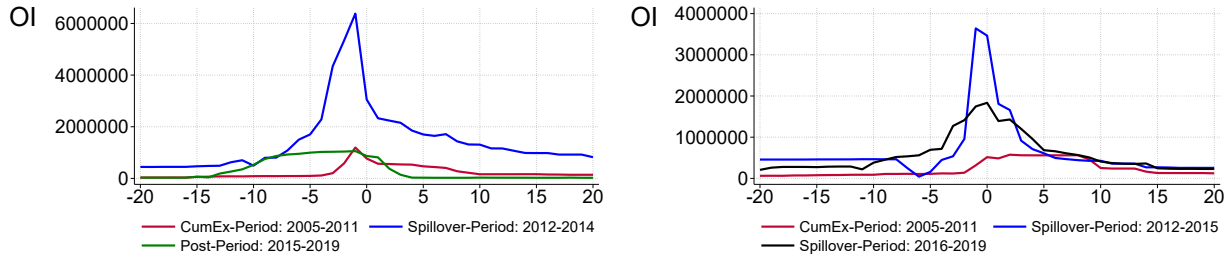
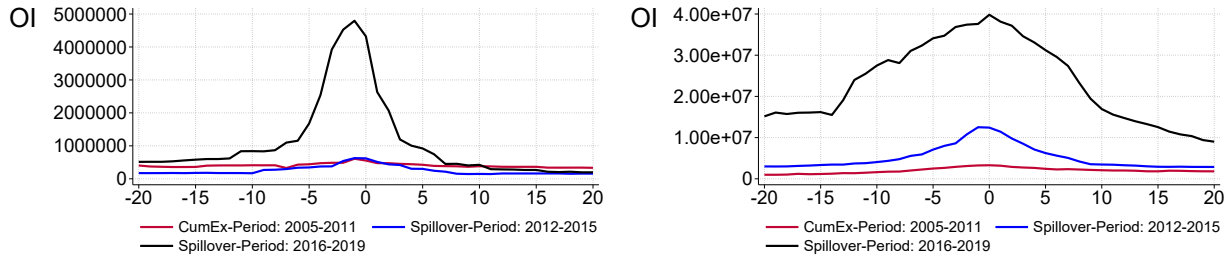


Figure 5: Open Interest: Event time
The figure shows open interest in a 20-day window surrounding the ex-dividend event (t_0). The data is aggregated for cum-ex (2005-2011), cum-cum/first spillover period (2012-2015), the post-regulated periods/second spillover period (2016-2019) for each country. Austria and Switzerland have shorter periods, as they implemented tax reforms. The country-specific periods emerged from the research summarized in Table 1.

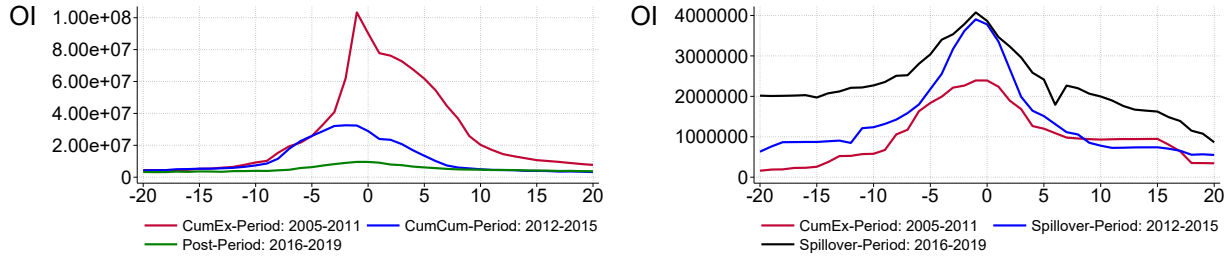
(a) Austria & Belgium



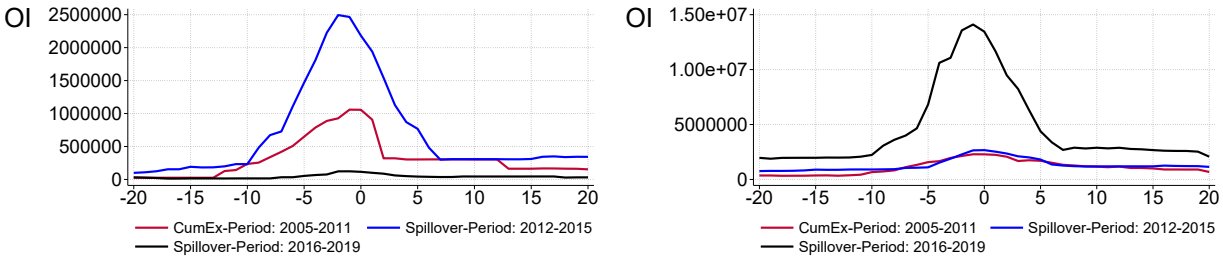
(b) Finland & France



(c) Germany & Italy



(d) Luxembourg & the Netherlands



(e) Spain & Switzerland

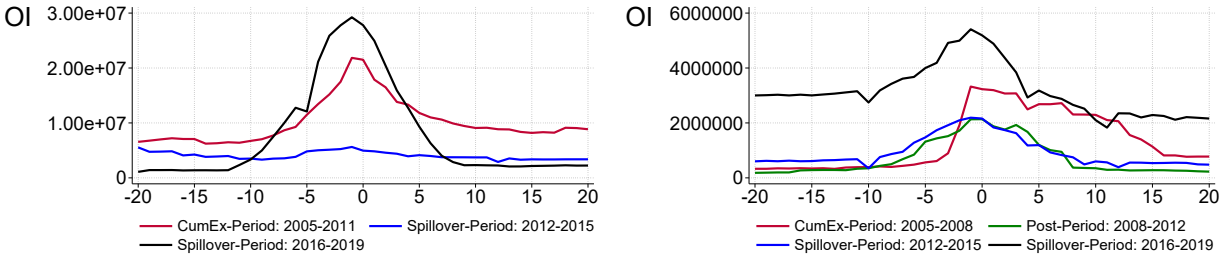
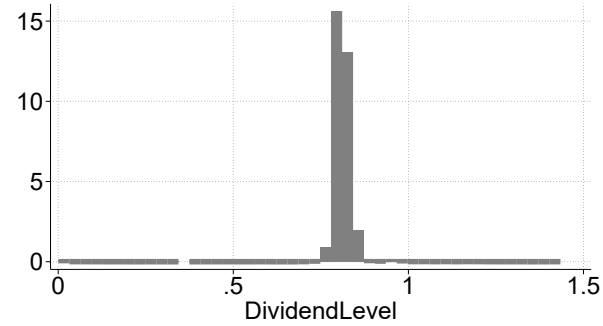


Figure 6: Implied dividend level
The figure shows the distribution of the implied dividend level for the cum-ex period (2005-2011) and the post-regulation period (2012-2019). The transaction data are restricted to 20 days before ex-dividend event.

(a) CumExPeriod: 2005-2011



(b) Post-Period: 2012-2019

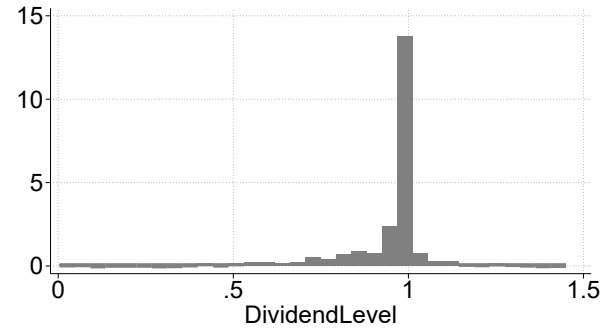
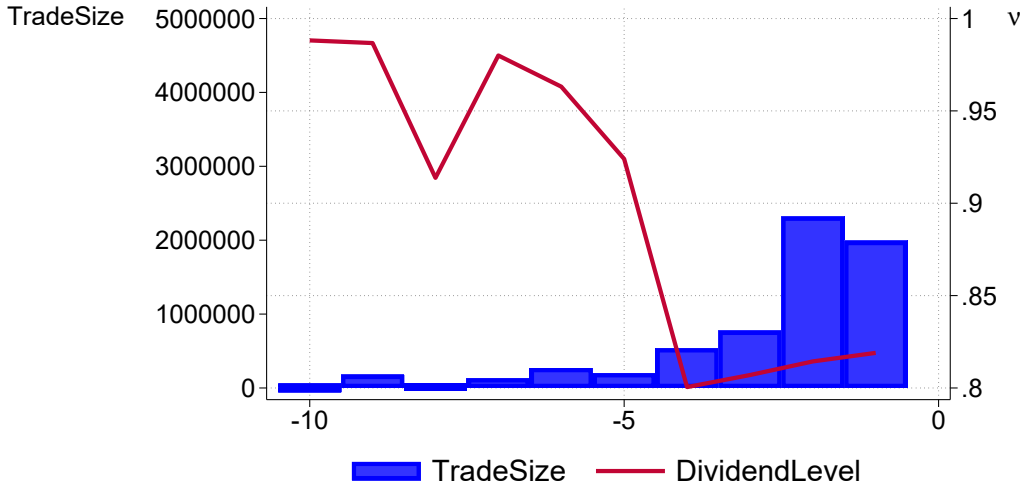


Figure 7: Implied dividend level: Event time
The figure presents average implied dividend level as well as aggregated SSF trade size in Germany for the last 10 days before ex-dividend events. Panel (a) and Panel (b) shows the distribution for the cum-ex period (2005-2011) and the post-regulation period (2012-2019).

(a) CumExPeriod: 2005-2011



(b) Post-Period: 2012-2019

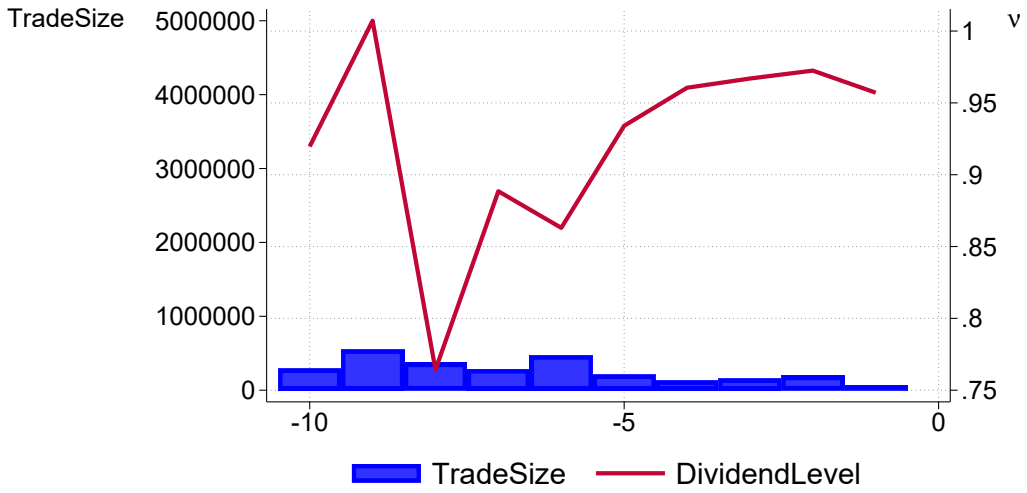


Table 1: Tax law changes and practices governing cum-ex and cum-cum trading
This table presents the tax law changes and practices enacted against cum-ex and/or cum-cum trading for each country. Information on legislative changes in Europe is obtained from ESMA (2020), the German Parliament (Bundestag document No. WD 4 - 3000 - 073/16) and manual research.

Country	Effective date	Action taken against cum-ex/ cum-cum	Sources
Austria	second half of 2013	Suspension of all dividend tax refunds payments.	Paper No. 8766/AB 9132/J (XXV.GP) (29. Jun 2016), Paper No. Reihe BUND 2018/35 (July 2018)
	01. Jan 2015	Tax reform: change of dividend refund procedure, disclosure of dividend beneficiary information.	Paper No. BMF-010203/0314-VI/1/2014 (18. Sep 2014)
Belgium	14. Oct 2014	Investigations of representative offices of foreign banks in Belgium regarding cum-ex trades.	De Tijd, Verloor België meer dan 200 miljoen aan 'duivelse geldmachine'? (20. Oct 2018)
	22. Jan 2019	Tax reform: Introduction of a sixty-day holding requirement for the beneficial owner to combat withholding tax evasion.	Loi du 11 janvier 2019 portant des mesures de lutte contre la fraude et l'évasion fiscales (11. Jan 2019)
Finland	01. Apr 2019/ 01. Jan 2021	Tax reform: The tax administration requires to disclose dividend beneficiary information. The law shall take effect from 01. Apr 2019 and apply to dividends paid on or after 01. Jan 2021.	Paper No. HE 282/2018 vp (05. Dec 2018), Paper No. EV 301/2018 vp (25. Mar 2019)
France	01. Jul 2019	Tax reform: The tax administration requires the beneficiary owner to prove the purpose of transaction.	LOI n° 2018-1317 du 28 décembre 2018 de finances pour 2019/ Finance law No. 2018-777, article 36 and 119 (28. Dec 2018)
Germany	01. Jan 2007	Tax reform: The shortseller's domestic custodian bank shall withheld the dividend tax and transmit the payment to the tax authority. However, the shortseller could avoid the dividend taxation by instructing a foreign bank.	§ 20 Abs. 1 Nr. 1 S. 4 EStG, § 44 Abs. 1 S. 3 EStG
	01. Jan 2012	Tax reform: Only domestic depositary institution are allowed to issue tax certificates and transfer applicable dividend taxes.	§ 44 Abs. 1 S. 3 EStG, Paper No. 18/12700 (20. Jun 2016)
	01. Jan 2016	Tax reform: A 45-day holding requirement for the beneficial owner before and after the dividend ex-date.	§§ 36a und 50j EStG, Paper No. 19/7006 (15. Jan 2019)
Italy	01. Jan 2016	Tax reform: full exemption from WHT on dividends for foreign investment funds	Law No. 178 of 30. Dec 2020 (2021 Budget Law)
Luxembourg	01. Jan 2019	The government adopts the OECD and European Union's tax avoidance measures into domestic law (ATAD Law) (21. Dec 2018)	Tax transparency and fight against aggressive tax planning (08. Feb 2021)
Netherlands	–		
Spain	–		
Switzerland	01. Apr 2008	The tax authority requires a tax certificate from the shareholder's custodian bank. The issuance of tax certificates for compensation payments (tailor-made dividends) are prohibited.	Kreisschreiben 21 der ESTV (01. Apr 2008)

Table 2: Descriptive summary
This table presents descriptive statistics for the full sample of 8,221 SSF contracts. All sources are listed in Table A1. All variables are defined in Table A2.

	N	Min	Mean	Median	Max	Std. Dev.
$OpenInterest$	206,529	0	7.9	7.8	16	2.5
$OTCShare$	45,458	0	.8	1	1	.37
$Volume$	265,464	0	14	14	21	2
$OffExchangeVolume$	62,498	-2.3	6.7	6.4	18	2.4
$ForeignOS$	259,762	0	28	26	96	15
$DomesticOS$	255,090	0	4.6	2	57	5.9
$Size$	266,116	18	23	23	26	1.2
$Volatility$	266,585	.076	.29	.26	1.8	.13
$Momentum$	266,490	-.86	.02	.018	1.5	.16
$DividendYield$	266,408	.036	2.6	2.2	32	1.8
$BidAskSpread$	263,034	-6.3	.19	.084	21	.52
$DividendLevel$	51,283	-1	.81	.81	3	.11
$TradeSize$	51,283	0	2.7	2.7	13	1.6
OTC	51,283	0	.017	0	1	.13
$TransactionTiming$	51,283	-20	-2.2	-2	0	1.6
$TimeToMaturity$	51,283	1	19	18	346	9.2
$GrossDividend$	2,657	.013	3.8	.9	823	35
$NetDividend$	2,657	.01	3.1	.74	644	28
PDR^{gross}	2,657	-1.8	.71	.77	2.9	.56
PDR^{net}	2,657	-2.1	.86	.91	3.5	.69
$ImpliedPDR$	2,657	.71	.99	1	1.3	.13
β_j	2,657	-.096	.92	.9	2.4	.3
$\frac{\sigma_{e_j}}{\sigma_{Rm}}$	2,657	.044	.32	.35	.48	.092

Table 3: Cum-ex and cum-cum trading in Germany
This table presents OLS regression results for Equation 1. The dependent variable is the logarithmic open interest one day before the ex-dividend event. All variables are defined in Table A1. t-statistics are given in parentheses. ***, **, * indicate significance at the 1%, 5% and 10% levels.

	TradingActivity		
	OpenInterest	Volume	OffExchangeVolume
$CumExPeriod \times D_{-1}$	2.445***	0.226***	4.000***
	(14.14)	(3.86)	(14.24)
$CumCumPeriod \times D_{-1}$	1.798***	0.005	0.134
	(8.17)	(0.09)	(0.46)
$OTCShare$	0.378***		
	(11.73)		
$ForeignOS$	0.038***	0.045***	0.044***
	(6.58)	(43.02)	(5.93)
$ForeignOS^2$	-0.000***	-0.000***	-0.001***
	(-5.10)	(-32.70)	(-5.86)
$DomesticOS$	-0.024	0.117***	-0.008
	(-1.41)	(38.64)	(-0.38)
$DomesticOS^2$	0.001	-0.004***	0.001
	(1.26)	(-29.98)	(1.13)
$Size$	0.017	-0.248***	-0.370***
	(0.49)	(-35.98)	(-8.63)
$Volatility$	1.800***	0.781***	0.686***
	(17.01)	(31.16)	(4.36)
$Momentum$	-0.434***	-0.129***	0.267***
	(-6.05)	(-8.24)	(2.93)
$DividendYield$	0.120***	-0.005*	-0.009
	(9.40)	(-1.78)	(-0.52)
$BidAskSpread$	-0.008***	-0.005***	
	(-5.74)	(-29.07)	
Observations	13943	62583	16489
R^2	0.668	0.914	0.558
Firm FE	Yes	Yes	Yes

Table 4: Cum-ex and cum-cum trading spillovers to neighboring countries
This table presents OLS regression results for Equation 1. The dependent variable is the logarithmic open interest one day before the ex-dividend event. All variables are defined in Table A1. t-statistics are given in parentheses. ***, **, * indicate significance at the 1%, 5% and 10% levels.

	logOpenInterest								
	AT	BE	FR	FI	IT	LU	NL	ES	CH
*Spillover*2012 × D_{-2}	1.446**	2.782***	1.236***	0.901	0.377	-1.511	-0.015	-1.068*	-0.852*
	(2.36)	(2.98)	(4.68)	(1.19)	(0.83)	(-1.26)	(-0.03)	(-1.87)	(-1.84)
*Spillover*2012 × D_{-1}	0.716	2.564***	0.867***	1.173*	-0.237	-2.379*	-0.072	-0.867*	-1.033**
	(1.36)	(4.61)	(3.52)	(1.93)	(-0.28)	(-1.81)	(-0.15)	(-1.81)	(-2.13)
*Spillover*2016 × D_{-2}		2.061**	0.865***	1.504***	-0.448	-3.224***	0.182	1.365**	-1.759***
		(2.22)	(3.35)	(3.34)	(-1.02)	(-2.66)	(0.41)	(2.48)	(-3.93)
*Spillover*2016 × D_{-1}	-2.814**	0.858	0.455*	1.907***	-0.825	-4.130***	0.312	0.308	-2.078***
	(-2.29)	(1.45)	(1.87)	(4.17)	(-0.98)	(-2.61)	(0.73)	(0.62)	(-4.43)
*PostRegulation*2008 × D_{-2}									-0.888*
									(-1.70)
*PostRegulation*2008 × D_{-1}									-0.904*
									(-1.73)
*PostRegulation*2014 × D_{-2}	0.954								
	(0.88)								
*PostRegulation*2014 × D_{-1}	0.415								
	(0.25)								
Observations	696	1013	13859	1146	2808	450	3172	1846	3914
R^2	0.565	0.609	0.671	0.675	0.749	0.840	0.603	0.686	0.777
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 5: SSF mispricing
This table presents linear regression results for Equation 3. The dependent variable is the implied dividend level, the percentage of gross dividend that is priced in SSF. The transaction data are limited to 20 days before the ex-dividend date and include only events that have a minimum of €1 gross dividend. t-statistics are given in parentheses. ***, **, * indicate significance at the 1%, 5% and 10% levels.

	DividendLevel	
	(1)	(2)
CumExPeriod	-0.134***	-0.118***
	(-59.70)	(-43.85)
TradeSize		-0.003***
		(-9.13)
OTC		-0.226***
		(-55.08)
TransactionTiming		-0.026***
		(-68.08)
TimeToMaturity		-0.000***
		(-3.19)
DomesticOS		-0.006***
		(-11.94)
ForeignOS		0.003***
		(10.01)
Size		-0.081***
		(-14.40)
Volatility		-0.252***
		(-19.57)
DividendYield		-0.006***
		(-4.37)
BidAskSpread		-0.001***
		(-5.44)
Constant	0.940***	2.907***
	(429.17)	(20.40)
Observations	51277	51272
R^2	0.199	0.338
Firm FE	Yes	Yes

Table 6: Price drop to gross dividend ratio

This table presents linear regression results for Equation 6. The dependent variable is the difference between the closing cum-dividend day and the opening ex-dividend day closing price, divided by the split-adjusted gross dividend amount. PDR is winsorized at a 1% level (i.e. 60 dividend events are excluded). All variables are defined in Table A1. t-statistics are given in parentheses. ***, **, * indicate significance at the 1%, 5% and 10% levels.

	PDR									
	DE	AT	BE	FR	FI	IT	LU	NL	ES	CH
$CumExPeriod$	-0.085									
	(-1.50)									
$CumCumPeriod$	-0.001									
	(-0.02)									
$Spillover2012$		0.256	0.286**	0.134***	-0.033	0.325**	0.017	-0.000	-0.410***	0.094
		(1.58)	(2.53)	(2.94)	(-0.39)	(2.23)	(0.05)	(-0.00)	(-2.93)	(0.64)
$Spillover2016$		0.285*	0.179	0.187***	0.116	0.271*	-0.239	0.066	0.005	0.175
		(1.83)	(1.52)	(4.05)	(1.38)	(1.94)	(-0.61)	(0.76)	(0.04)	(1.20)
$ForeignOS$	0.001	0.005	0.012**	0.002	-0.003	0.002	0.002	-0.000	0.005	0.004
	(0.40)	(0.86)	(2.37)	(1.23)	(-0.90)	(0.52)	(0.10)	(-0.11)	(1.06)	(1.55)
$DomesticOS$	0.006	-0.183*	-0.784	0.004	-0.099	0.024	-0.067	0.084	-0.067**	-0.000
	(1.27)	(-1.93)	(-0.79)	(1.59)	(-1.57)	(0.70)	(-0.87)	(0.91)	(-1.98)	(-0.02)
$DividendYield$	0.852	1.709	1.818	-0.608	5.663***	9.323***	4.081	2.635	-1.821	8.100***
	(0.71)	(0.44)	(1.08)	(-0.70)	(3.44)	(3.79)	(0.24)	(0.95)	(-0.72)	(3.46)
$BidAskSpread$	-0.001	-0.004*	0.004	0.000	0.002	0.002	-0.008	0.005	0.002**	0.002
	(-0.82)	(-1.72)	(1.14)	(0.41)	(0.56)	(1.02)	(-1.19)	(1.55)	(2.10)	(0.61)
β_j	-0.153*	-0.428**	-0.113	-0.057	-0.043	-0.591***	-0.956	-0.132	-0.358**	-0.229**
	(-1.91)	(-2.22)	(-0.72)	(-0.91)	(-0.26)	(-4.11)	(-0.96)	(-1.00)	(-2.04)	(-2.12)
$\frac{\sigma_{e_j}}{\sigma_{Rm}}$	0.186	1.467*	1.002	-0.042	0.303	0.778	-4.098	-0.909**	-0.354	-0.077
	(0.68)	(1.80)	(1.44)	(-0.17)	(0.80)	(1.57)	(-0.87)	(-2.05)	(-0.78)	(-0.16)
Constant	0.878***	0.564	-0.066	0.676***	0.561**	-0.024	3.100	0.925***	1.212***	0.468*
	(6.29)	(1.54)	(-0.19)	(5.92)	(2.44)	(-0.08)	(1.03)	(3.61)	(5.33)	(1.77)
Observations	628	99	110	705	135	184	30	210	199	210
R^2	0.016	0.199	0.139	0.031	0.165	0.164	0.181	0.055	0.114	0.132

Appendix

Table A1: Sources

Source	Data
Thomson Reuters	(i) Information on dividend amount, tax status, dividend withholding tax rate and ex-dividend date, (ii) information on stock price volume, market capitalization, close, open, bid and ask prices, (iii) information on SSF, open interest and trade time.
Refinitiv Tick History	Information on stock intraday price and volume.
FactSet	Information on institutional stock ownership, split into domestic and foreign shares.
Eurex exchange	Information on tick and lot size, see www.eurex.com/dynamic/action/ex-en/markets/equ/fut/1228/Single-Stock-Futures.
Manual search	Information on the tax status of dividends, see www.boersen-zeitung.de. Information on capital gains tax is obtained from OECD.

Table A2: Variable Definition

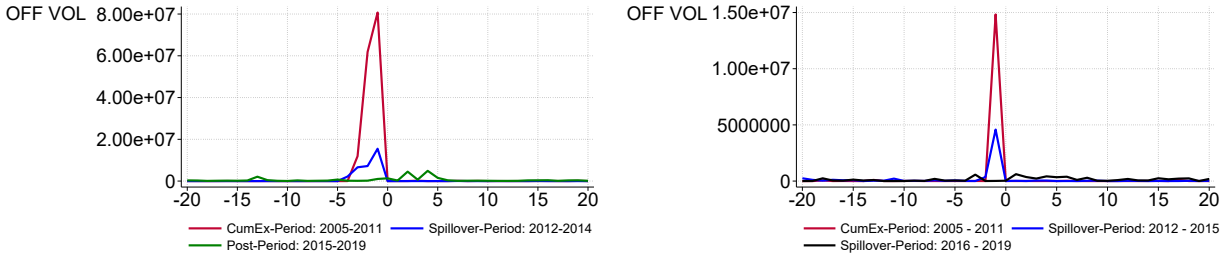
Variable	Definition
β_j	The variable measures systemic risk for stock j, estimated from the market model in Equation 5.
$\frac{\sigma_{e_j}}{\sigma_{Rm}}$	The variable measures idiosyncratic risk for stock j, estimated from the market model in Equation 5.
$BidAskSpread$	The difference between the asking price and the bid price of a stock, divided by the asking prices in bsp.
$CumExPeriod$	The cum-ex period covers the years from 2005 to 2011.
$CumCumPeriod$	The cum-cum period covers the years from 2012 to 2015.
$DividendLevel$	The implied percentage of gross dividend that has been prices in SSF, calculated by the cost-of-carry model.
$DividendYield$	The ratio between the net dividend amount and daily closing price.
$DomesticOS$	Percentage of aggregated reported holdings of domestic institutional investors divided by the shares outstanding per month.
$ForeignOS$	Percentage of aggregated reported holdings of foreign institutional investors divided by the shares outstanding per month.
$ImpliedPDR$	The implied price drop to gross dividend ratio is defined by the marginal rate of substitution between capital gains and dividend tax. The relationship is derived from the investor's choice equilibrium model, see Elton and Gruber (1970).
$Momentum$	A rolling six-month average of daily stock returns.
$OffExchangeVolume$	Daily number of traded stocks in off-exchange markets.
$OpenInterest$	The sum of open contracts on a stock including both short and long positions per day.
OTC	A dummy variable that flags one when the SSF contract is traded OTC.
$OTCShare$	Share of OTC SSF trades relative to all SSF trades per day.
PDR	The price drop to gross dividend ratio measures the share price decline on ex-day by the difference of cum-closing and ex-opening price, divided by the dividend amount.
$PostRegulation2008$	A dummy indicating the time period between July 2009 and 2011, after Switzerland changed its tax code.
$PostRegulation2013$	A dummy indicating the time period between July 2013 and 2015, after Austria suspended all dividend tax refunds.
$Size$	The logarithm of the market capitalization.

$Spillover2012$	A dummy indicating the time period between 2012 and 2015, after Germany prohibited cum-ex trading.
$Spillover2016$	A dummy indicating the time period between 2016 and 2019, after Germany prohibited cum-cum trading.
$TradeSize$	Logaritmic number of SSF contracts traded per transaction.
$TransactionTiming$	Number of days between the transaction date and the ex-dividend date.
$TimetoMaturity$	Number of days until the SSF contract expires.
$Volatility$	The standard deviation of daily stock returns within a year, multiplied by the square root of the number of days in a year.
$Volume$	Daily number of traded stocks in public markets.

Figure A1: Off-exchange stock volume: Event time

The figure shows off-exchange traded stock volume in a 20-day window surrounding the ex-dividend event (t_0). The data is aggregated for cum-ex (2005-2011), cum-cum/first spillover period (2012-2015), the post-regulated periods/second spillover period (2016-2019) for Austria, Belgium, Germany and Italy. Austria has a shorter spillover period, as the government implemented a tax reform in 2014, see Table 1. The remaining countries do not indicate any clear pattern and are therefore excluded.

(a) Austria & Belgium



(b) Germany & Italy

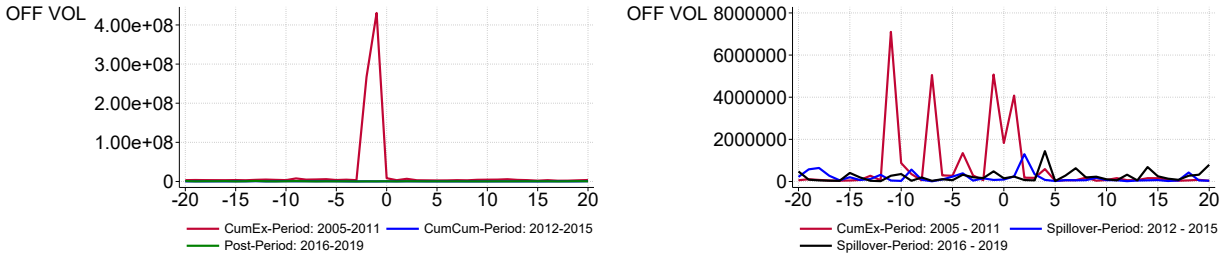


Figure A2: PDR

The figure shows the evolution of the actual PDR and implied PDR over time. The implied PDR is reflected by tax differential between capital gains and dividend tax, i.e. $PDR = \frac{(1-\tau_d)}{(1-\tau_g)}$ .The relationship is derived from the investor's choice equilibrium, see Elton and Gruber (1970). We obtained the withholding dividend tax from Thomson Reuters. Capital gains tax are retrieved from the OECD database, assuming that capital gains are subject to the standard corporate income tax rate of a country.

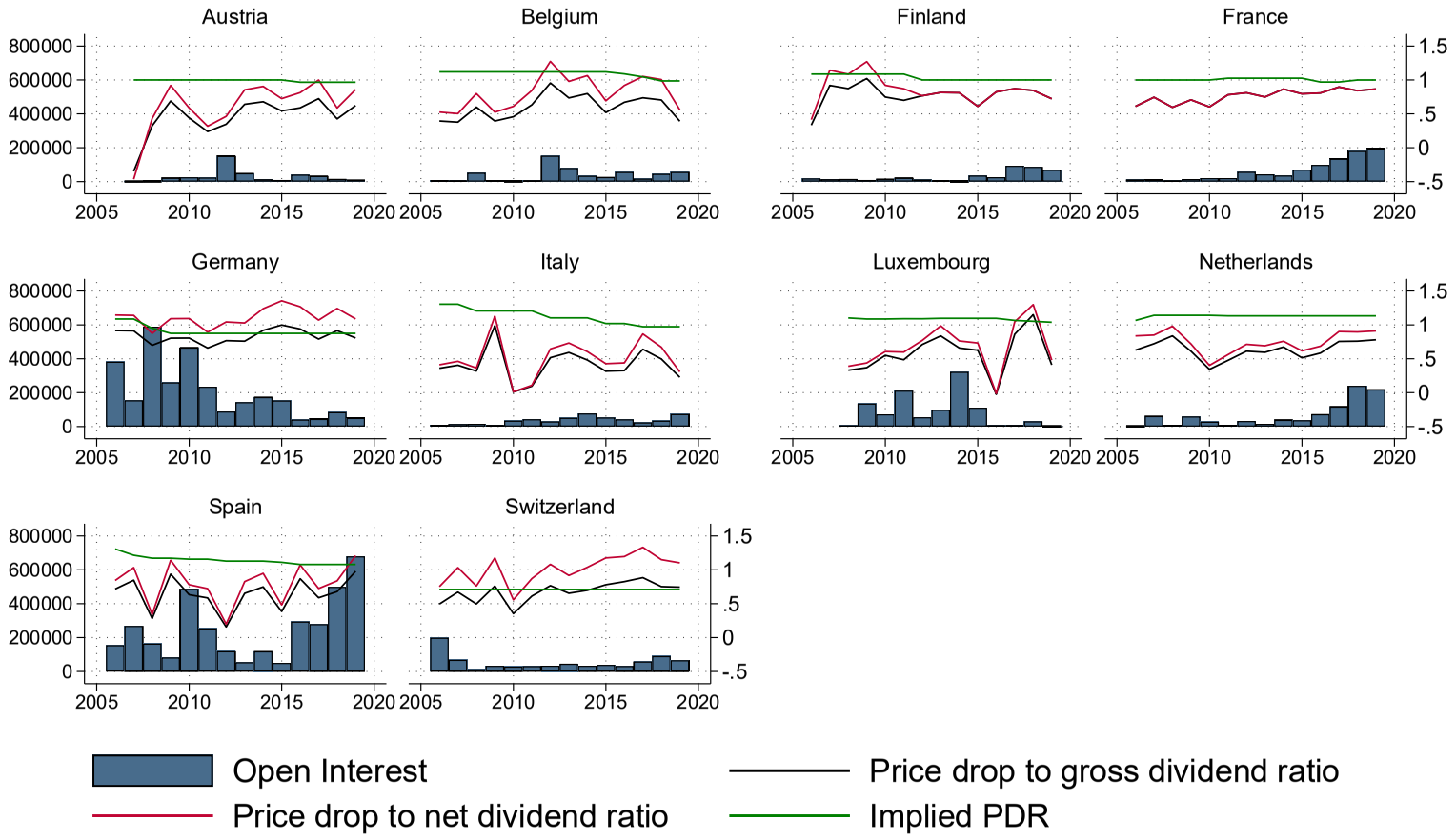


Table A3: Trading spillovers in public stock markets

This table presents OLS regression results for Equation 1. The dependent variable is the logarithmic open interest one day before the ex-dividend event. All variables are defined in Table A1. t-statistics are given in parentheses. ***, **, * indicate significance at the 1%, 5% and 10% levels.

	Volume								
	AT	BE	FR	FI	IT	LU	NL	ES	CH
*Spillover*2012 × D_{-2}	-0.074	0.249**	0.062	0.062	-0.360***	0.080	0.108	-0.031	-1.103***
	(-0.50)	(2.24)	(1.37)	(0.54)	(-3.67)	(0.27)	(1.42)	(-0.37)	(-8.20)
*Spillover*2012 × D_{-1}	0.096	0.139	0.007	0.136	-0.065	-0.063	0.081	0.011	-0.524***
	(0.64)	(1.26)	(0.16)	(1.18)	(-0.67)	(-0.21)	(1.07)	(0.13)	(-3.77)
*Spillover*2016 × D_{-2}	-0.099	-0.015	0.089**	-0.112	-0.543***	-0.094	0.149**	0.025	-1.227***
	(-0.64)	(-0.14)	(2.03)	(-1.03)	(-5.89)	(-0.31)	(2.03)	(0.31)	(-9.43)
*Spillover*2016 × D_{-1}	0.106	0.089	0.041	-0.098	-0.146	-0.522*	0.081	0.071	-0.585***
	(0.68)	(0.81)	(0.94)	(-0.90)	(-1.59)	(-1.70)	(1.09)	(0.88)	(-4.36)
*PostRegulation*2008 × D_{-2}									-1.188***
									(-8.88)
*PostRegulation*2008 × D_{-1}									-0.729***
									(-5.27)
*PostRegulation*2014 × D_{-2}	0.056								
	(0.33)								
*PostRegulation*2014 × D_{-1}	0.015								
	(0.09)								
Observations	9781	10859	69834	12980	19191	3198	20630	19954	20755
R^2	0.823	0.853	0.898	0.846	0.922	0.944	0.898	0.918	0.949
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table A4: Trading spillovers in off-exchange stock markets

This table presents OLS regression results for Equation 1. The dependent variable is the logarithmic open interest one day before the ex-dividend event. All variables are defined in Table A1. t-statistics are given in parentheses. ***, **, * indicate significance at the 1%, 5% and 10% levels.

	$OffExchangeVolume$								
	AT	BE	FR	FI	IT	LU	NL	ES	CH
$Spillover2012 \times D_{-2}$	-5.266***	1.099	0.089	-2.669*	-0.125	0.923	0.383	-0.277	-0.876
	(-5.46)	(1.35)	(0.33)	(-1.95)	(-0.21)	(0.30)	(0.57)	(-0.36)	(-0.65)
$Spillover2012 \times D_{-1}$	-3.327***	-0.352	-0.373	3.164***	-0.838		-0.042	-0.400	0.360
	(-3.36)	(-0.45)	(-1.33)	(2.64)	(-1.33)		(-0.07)	(-0.53)	(0.31)
$Spillover2016 \times D_{-2}$	-9.338***	0.858	0.304	-0.882	-0.411	3.098	0.238	0.902	-1.548
	(-9.24)	(0.87)	(1.12)	(-0.66)	(-0.64)	(1.10)	(0.37)	(1.32)	(-1.16)
$Spillover2016 \times D_{-1}$	-8.592***	-4.137***	0.013	3.699***	-0.770	1.675	0.021	0.440	0.682
	(-9.44)	(-5.28)	(0.04)	(3.09)	(-1.40)	(0.81)	(0.04)	(0.68)	(0.62)
$PostRegulation2008 \times D_{-2}$									-1.283
									(-0.94)
$PostRegulation2008 \times D_{-1}$									-0.158
									(-0.14)
$PostRegulation2014 \times D_{-1}$	-9.972***								
	(-9.43)								
Observations	933	1680	18217	2156	4122	680	5533	3980	6060
R^2	0.750	0.478	0.298	0.487	0.191	0.387	0.210	0.295	0.610
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes