

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 across Europe, widely known as cum-ex and cum-cum trading. Both strategies are designed to profit from illicit refunds of dividend tax, using futures to share the realized gains between colluding parties. Our results document trading spillovers into more favorable tax regimes, while excessive trading disappears in markets with enacted tax reforms. All findings are robust to transaction cost, volatility, domestic and foreign institutional ownership.

Keywords: Dividend stripping, Dividend withholding tax arbitrage, Tax-motivated trading, Single stock futures, Mispricing, Ex-dividend price drop, Foreign and domestic ownership

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

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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 particular, market participants engage in collusive arrangements, using offsetting future positions to conceal their distribution of realized tax profits.¹ Recent estimates assume a tax loss in the double-digit billion range in Europe, presumably accumulated over the past 25 years. Despite the introduction of legislative frameworks, experts and legal opinions call increasingly attention to the continued practice of cum-ex and cum-cum trading² Given the prominence of this topic and the national efforts to combat these abusive tax schemes, are cum-ex and cum-cum trading still actively pursued?

This paper explores the magnitude of both cum-ex and cum-cum activity in ten European countries and analyzes trading spillovers between comparable dividend tax jurisdictions. Our rich database of Eurex single stock futures (SSF) (including pre-arranged off-book 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 the abnormal trading and pricing behavior of SSF and their respective underlying stocks around ex-dividend days. A difference-in-difference (DID) analysis helps us then to review the legislative intervention of each country and is thus of concern for tax authorities and legislators.

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

¹See 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.

²See Spengel (2021a,b, 2017); Spengel et al. (2017) and in collaboration with the research network CORRECTIV (Cum-ex Files, 2020) for tax-loss estimates on cum-ex and cum-cum trading. 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, as well. Furthermore, Spengel (2021a) assumes that cum-ex trades continue with the help of American Depositary Receipts transactions.

(Dubofsky, 1987; Grammatikos, 1989; Karpoff and Walkling, 1990; Henry and Koski, 2017). In one version, corporations additionally leverage tax differentials across borders and investor groups to profit from tax arbitrage (McDonald, 2001; Liljeblom et al., 2001; Christoffersen et al., 2003; Hodgkinson et al., 2006), 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 that contracting parties have participated in collusion with the objective to evade tax payments (Buettner et al., 2020).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 related studies, legal articles assume multiple tax reimbursements of up to five times on a single dividend payment⁵

In contrast to cum-ex transactions, cum-cum trades exploit tax differentials between domestic and foreign investors to reclaim refunds of WHT. The scheme involves 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 and in addition to the frequent stock trading, transacting parties are found to enter offsetting future positions to distribute tax profits and

³Although few respondents argued in favor of exploiting arbitrage possibilities, many courts in Germany declared cum-ex activities as illegal, see Spengel/Eisgruber DStR 2015, 785, the Federal Ministry of Finance (Bundesministerium für Finanzen) document 2021/0726914 (dated 9 July 2021), the Federal Court of Justice Germany (Bundesgerichtshof), Judgment No. 1 StR 519/20 (dated July 28, 2021), Federal Finance Court (Bundesfinanzhof), document I R 22/20 (dated on 2 February 2022).

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

⁵See Rau, DStR 2010, 1267 and Rau, FR 2011, 366-373.

hedge against market risk.⁶

Both tax reclaim schemes likely emerged in Germany around 1990, when taxation law exhibited a loophole, see Subsection 2.2, and both practices were scarcely known. It changed in 2007 when the German government revised the dividend tax provisions, but could not effectively prohibit cum-ex trades until 2012. Later, in 2016, the German government also developed rules to prevent cum-cum transactions.⁷ General estimates suggest that these transactions have affected Germany on an unprecedented scale, while investigations by state authorities and media find evidentiary documents on cum-ex and cum-cum activity in other European countries as well.⁸ Consequently, most countries reformed their tax codes to stop both reclaim schemes. However, these new measures and actions took place at different times and in different jurisdictions. Moreover, they vary in severity, and it is worth investigating the effectiveness of these implemented tax reforms.

We exploit this 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. The investigation takes a twofold approach: first, we determine for each country if and when a specific taxation change was enacted. 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 DiD 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.

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

⁶See Regional Court of Bonn, Judgment No. 62 KLS - 213 Js 41/19 - 1/19, dated March 18, 2020.

⁷See European Parliament's information document on the cum-ex files dated September 26, 2018.

⁸A 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/>.

to cum-ex trading.⁹ Our baseline results confirm the extraordinary stock trading around the ex-dividend days, albeit not for all tested 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 bias results. First, not all listed stocks were traded cum-ex or cum-cum.¹⁰ Second, insiders used future contracts and other derivatives for cum-ex and cum-cum transactions.¹¹

In this context, SSF contracts represent an ideal instrument to gain (cross-border) exposure to individual stocks (Ang and Cheng, 2005a; Pan, 2008). The future 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, SSF 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)

Our analysis relies on the Eurex SSF market. The Eurex exchange is the largest market for European-based derivatives, and we, therefore, expect to give a more detailed and complete picture of the illicit dividend tax reclaim schemes. Our key explanatory variable is open interest, the sum of open future contracts on a stock including both short and long positions. In addition, we also investigate the volume of stocks that are underlying instruments for the Eurex SSF contracts on both public and off-exchange venues.¹² 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).

⁹The 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.

¹⁰See Buettner et al. (2020) for evidence on the German (HDAX) market.

¹¹See 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.

¹²Stocks from off-exchange venues do not need to meet minimum requirements or file with the exchange supervisory authorities.

Our sample consists of 935,505 transactions, centered in 50 days over the ex-dividend events, of which 35.49% are traded off-book. Off-book future contracts are an extension of on-exchange trading, except that they allow tailored trading strategies. As such, we expect more cum-ex and cum-cum related activities in off-book than on-book trading.¹³ All trades arose from 8,221 SSF contracts and 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.

As a result of our analysis, we find that abnormal SSF trading activity around ex-dividend dates significantly decreases in Germany following the two landmark tax law changes in 2012 and 2016. This finding implies that cum-ex and cum-cum activities with SSF have ended in Germany. Simultaneously, SSF trading increases after 2012 in Austria, Belgium, and France, suggesting spillover effects to more favorable tax regimes. These trading spillovers appear again in Belgium, France, Finland, and Spain after 2016, indicating continued cum-ex or cum-cum trading in these countries. Our DiD test does not find significant changes in SSF trading for Italy, Luxembourg, and the Netherlands. We interpret this result as an indication of relatively stable ex-day trading levels over time with no effects from spillovers in between. In Austria and Switzerland, the abnormal trading activity around ex-days disappears when the governments change their taxation rules, implying effective actions to stop cum-ex and cum-cum activity with SSF.

Including controls to our analysis allow us to infer the determinants of SSF trading activity around ex-dividend days and across countries. In line with Bialkowski and Jakubowski (2012), we find that active SSF trading co-varies positively with greater equity volatility. It is, however, negatively related to stock returns, implying informed trading strategies (Roll et al., 2010; Johnson and So, 2012). Moreover, we document a concave relationship with foreign institutional ownership, suggesting high tax heterogeneity between investors and limited

¹³See Eurex Entry Services (TES), 2022.

short sale ability in the spot market (Liljeblom et al., 2001; Dhaliwal and Li, 2006).

Finally, we investigate the ex-day price decline to net 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).¹⁴ The large ex-dividend literature, however, documented mean PDR values consistently greater or less than one, see 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; McDonald, 2001; Haesner and Schanz, 2013). In this respect, cum-ex and cum-cum trading provides us an ideal setting to study whether changes in tax advantages explain ex-day price movements across countries. Our study generally supports the dynamic dividend clientele model and finds that ex-day stock prices co-vary with risk and not with changes in tax heterogeneity.

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. An Appendix presents a case study of SSF mispricing in Germany. The case study evidences significant overpricing in SSF by about 14%, roughly half of the withholding dividend tax. This finding arises from the profit-shifting between colluding parties in cum-ex transactions.

2 Dividend tax arbitrage strategies and regulation

2.1 Cum-ex and cum-cum transaction with SSF

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

¹⁴See Allen and Michaely (2003) for a literature review.

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 afterward 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 institutional 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 that deviate from their fair market value to let the high-tax investor participate in the tax refund.¹⁵

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

¹⁵see 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.

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 special investment vehicles or investment funds, especially for cum-ex/cum-cum trading.¹⁶

¹⁶See 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 shareowner.

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.¹⁷ 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.¹⁸

Investigations by state authorities and the media find evidence of cum-ex and cum-cum schemes in neighboring markets as well. To prevent the trading schemes of multiple taxation refunds, several countries changed 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]

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

¹⁷The 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)).

¹⁸See the European Parliament's information document on the cum-ex files dated September 26, 2018.

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.¹⁹ 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.²⁰ Ever since SSF were first introduced in October 2005, trading has multiplied substantially, yet with

¹⁹We 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.

²⁰As 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.

a significant year-to-year variability. Starting with 740,068 open interest in 2005, trading grew continuously 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 transaction data on SSF are anonymous and include open interest, the execution time (a timestamp in seconds), and the underlying stock. The period draws from October 2005 to August 2019.²¹ Moreover, the dataset discloses information on whether the future contracts were off-book trades. It leaves us with 935,505 trades from 8,221 future contracts, of which 35.49% are traded off-book. 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.²²

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.²³ 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

²¹The sizes of contracts include mostly 100 and 1,000 shares. The tick size is 0.0001 for most SSF.

²²Ince and Porter (2006) draw attention to coverage and classification issues in the Thomson Reuters database that can influence statistical inferences.

²³Thomson Reuters distinguishes between extra and special dividends to determine the source of payment. Special dividends originate from the company's extraordinary profits, while extra dividends are paid from the company's regular net profits or reserves.

events. Moreover, we remove every observation with tax-free dividends.²⁴ 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 on-exchange and over-the-counter stock markets) from Thomson Reuters.²⁵ All information is converted to €. The natural logarithm of 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%.

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.

We do not find considerable variation between specific underlying characteristics. A great

²⁴Tax-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.

²⁵Thomson Reuters defines off-exchange trading as over-the-phone negotiated trades, broker to broker trades, dark trades, and OTC Link system trades.

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. Table 2 presents descriptive statistics of all of the key variables in the final sample.

[Table 2 about here]

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 investor groups, with a 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 exhibited 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.²⁶

²⁶For 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 the 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.

4 Empirical analysis and results

Subsection 4.1 examines abnormal SSF trading activity around ex-dividend days and derives spillovers from changing market dynamics. Subsection 4.2 estimates the implied tax-revenue loss for each country, while Subsection 4.3 investigates stock behavior around ex-dividend days.

4.1 Trading activity around ex-dividend days

Methodology for analysis

This section examines trading spillover effects of cum-ex and cum-cum trading in ten European countries using a difference-in-difference regression model. 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. Finally, if the trading activity remains constant over time, no spillovers were generated. Additionally, we test for abnormal stock volume in exchange and off-exchange markets to corroborate our outcome.

$$\begin{aligned} TradingActivity_{jt} = & \beta_0 + \beta_1 \cdot \sum_{i=-10}^{10} D_i \times CumExPeriod_t + \beta_2 \cdot \sum_{i=-10}^{10} D_i \times CumCumPeriod_t \\ & + \beta_3 \cdot \sum_{i=-10}^{10} D_i + \beta_4 \cdot CumExPeriod_t + \beta_5 \cdot CumCumPeriod_t \\ & + \beta_6 \cdot X_{jt} + Firm_j + \epsilon_{jt}, \end{aligned} \quad (1)$$

Our empirical model in Equation 1 is estimated over all three tax regimes for Germany

separately. D_i represents an event day dummy variable, which captures the trading activity across ex-day dividend events for day i in the event window $[-10, +10]$. Consistency of results is established by controlling for both market and asset characteristics in X_{jt} . The vector includes *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 costs are displayed by *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). $Firm_j$ denotes stock-level fixed effects.

To consistently report positive coefficients and in order to compare results between all countries, we exchange the dummy variables for cum-ex (2005-2011) and cum-cum period (2012-2015) in Equation 1 with the first (2012-2015) and second spillover period (2016-2019). The empirical model in Equation 2 is estimated over all three tax regimes for each country k separately.

$$\begin{aligned}
TradingActivity_{jt}^k = & \beta_0 + \beta_1 \cdot \sum_{i=-10}^{10} D_i \times Spillover2012_t + \beta_2 \cdot \sum_{i=-10}^{10} D_i \times Spillover2016_t \\
& + \beta_3 \cdot \sum_{i=-10}^{10} D_i + \beta_4 \cdot Spillover2012_t + \beta_5 \cdot Spillover2016_t \\
& + \beta_6 \cdot X_{jt} + Firm_j + \epsilon_{jt}
\end{aligned} \tag{2}$$

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 mar-

kets. As result, we interpret that cum-ex and cum-cum activities with SSF have 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.²⁷

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 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 indeed. Yet, the negative correlation between dividend yield and stock volume is unexpected. High levels of open interest are driven by a large share of off-book future trades, suggesting that both schemes were traded public (and not necessarily on off-exchange venues).

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.²⁸ 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,

²⁷Although this relationship appears appealing and intuitive, it is inconsistent with Ang and Cheng (2005b); Vipul (2008); Danielsen et al. (2009); Bialkowski and Jakubowski (2012).

²⁸Dhaliwal 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.

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 support that institutional ownership adversely impacts open interest. The authors conclude that institutional ownership serves as a proxy for short saleability. Investors, therefore, trade SSF contracts less if they have the possibility to short sell a stock.

Country-by-country analysis

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. Compared 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.

[Table 4 about here]

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 Implied tax-revenue loss

In the next section, we compute the implied tax-revenue loss in € caused by cum-ex and cum-cum trading with SSF. The magnitude is estimated for each country k by summing up the abnormal SSF trading over all dividend events i :

$$ImpliedTaxLoss^k = \sum_i ExcessOpenInterest_{ji} \times LotSize_{ji} \times D_i \times WHT_i^k \quad (3)$$

$LotSize_j$ is the total number of stocks traded in one SSF contract j . D_i represents the gross dividend, while WHT_i^k is the dividend withholding tax at dividend event i for country k .

Results are reported in Table 5. The estimates point to a total revenue loss of € 1.099 billion, of which Germany, France, and Switzerland account for the largest proportion. In comparison, Italy and Luxembourg show only small reference values and therefore confirm that cum-ex and cum-cum trading have only a minor effects in these countries. The estimations for the implied tax-revenue loss are based on the sample period between October 2005 to August 2019. While the sums may overestimate results, it is a straightforward approach to compare the size of the tax losses across countries.

[Table 5 about here]

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).²⁹ 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.³⁰ 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.³¹ 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-

²⁹When 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 before 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.

³⁰Koski 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 afterward.

³¹Alternative 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.

cum trading are strongly motivated by tax considerations because both strategies create a tax differential through 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. 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.³² 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.

³²If 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: $PDR = \frac{(1 - \tau_d)}{(1 - \tau_g)}$.

Extreme outliers are winsorized at a 1% level (i.e., 60 dividend events are excluded).³³ 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).

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

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

$$E[r_j] = \hat{\beta}_{0j} + \hat{\beta}_{1j} R_m^{CI} \quad (5)$$

R_m^{CI} is the realized stock return on the ex-day of a value-weighted stock market index.³⁴

We use a similar identification strategy as in ???. $X_{j,t}$ 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, $\frac{\sigma_{e_j}}{\sigma_{Rm,j}}$, which we estimate from the market model in Equation 5. The constant shows the mean value. Regression results are presented in Table 7.

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

Overall, results are mixed and we believe further investigation is warranted. Contrary to expectation, the 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 between 2005 and 2015, we reject that tax-induced trading

³³Graham 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 at the firm level, which makes it impossible to infer a reasonable marginal investor's tax bracket Ainsworth et al. (2020).

³⁴Amsterdam 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

impounds tax heterogeneity in stock prices.

[Table 7 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.

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 suggest no spillover effects, and we do not find specific cum-ex/cum-cum related tax reforms 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 customized off-book trades. Furthermore, we find that foreign institutional ownership is positively related to trading activity. This relationship is described by a concave function, indicating high tax heterogeneity between investors and limited short-selling opportunities.

Analyzing the price drop ratios (PDR) of the SSF underlying securities reveals that tax heterogeneity is not reflected in stock prices, but risk decreases price declines on ex-dates.

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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.

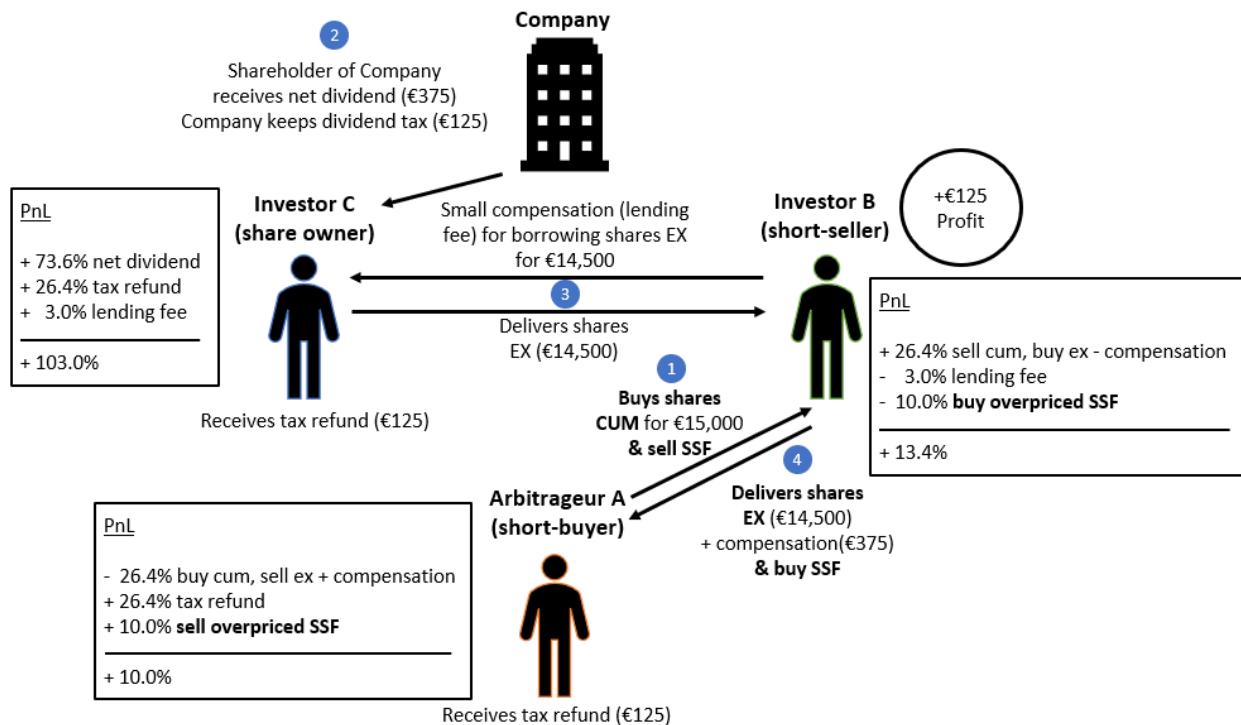


Figure 2: Total open interest on Eurex exchange

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%.

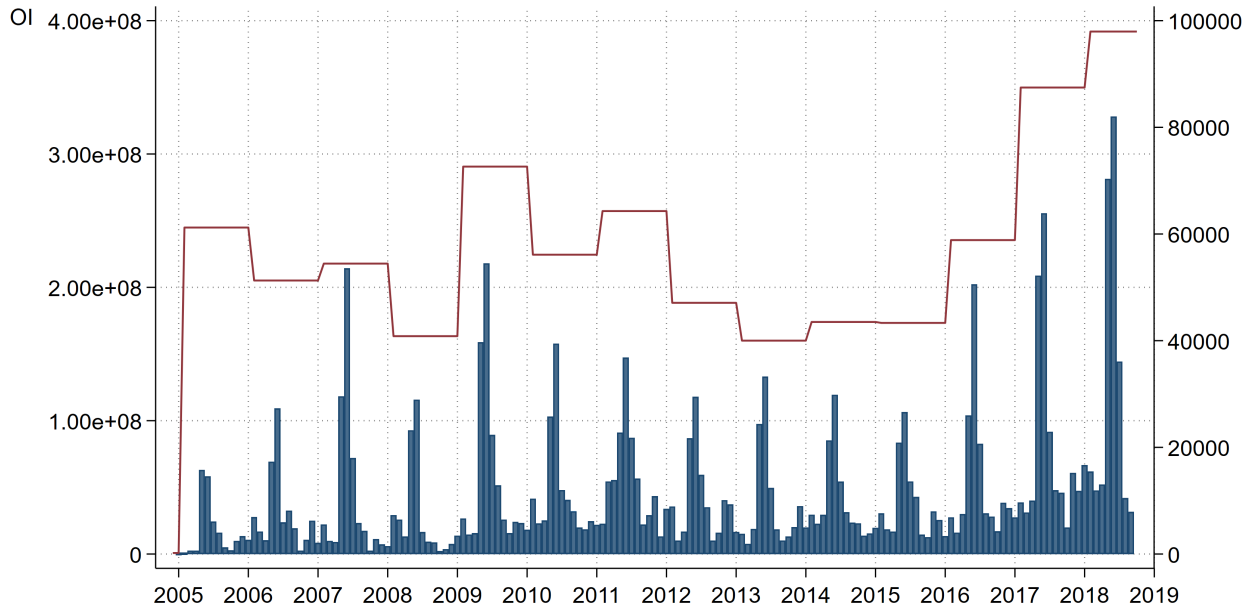
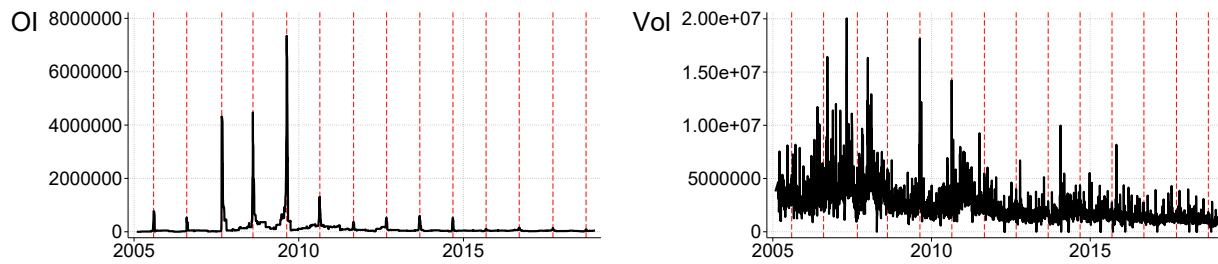


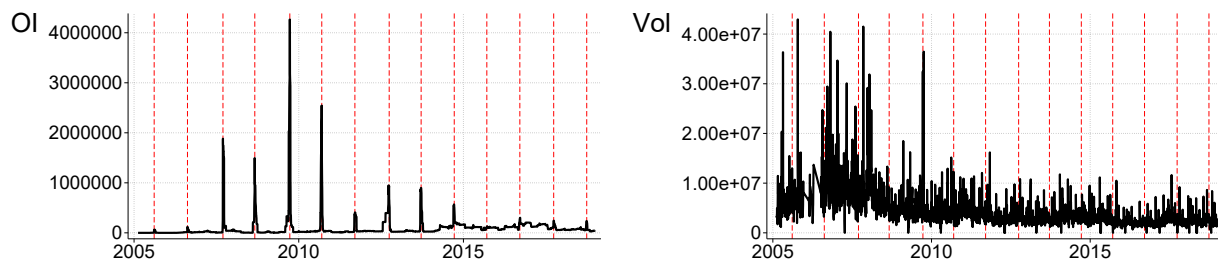
Figure 3: Open Interest and Volume: Some examples

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.

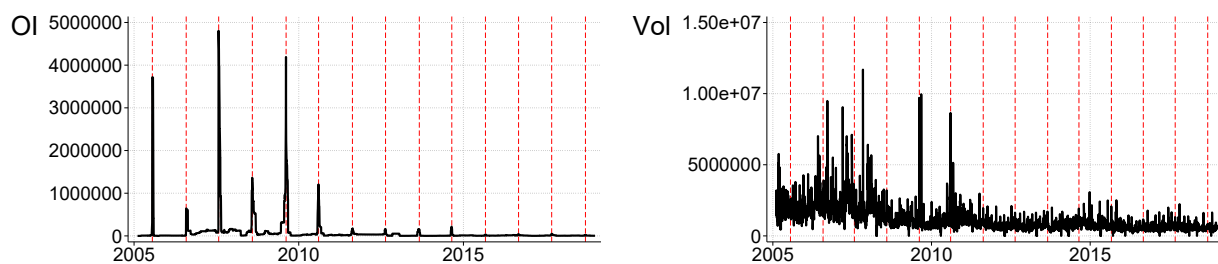
(a) Allianz



(b) SAP



(c) Munich RE



(d) Deutsche Post

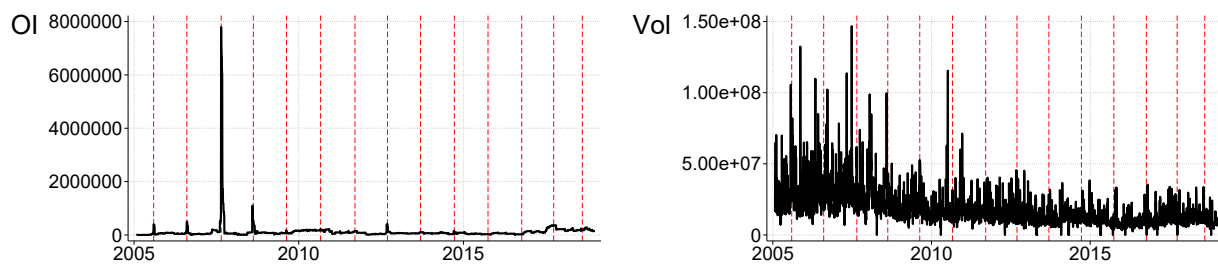
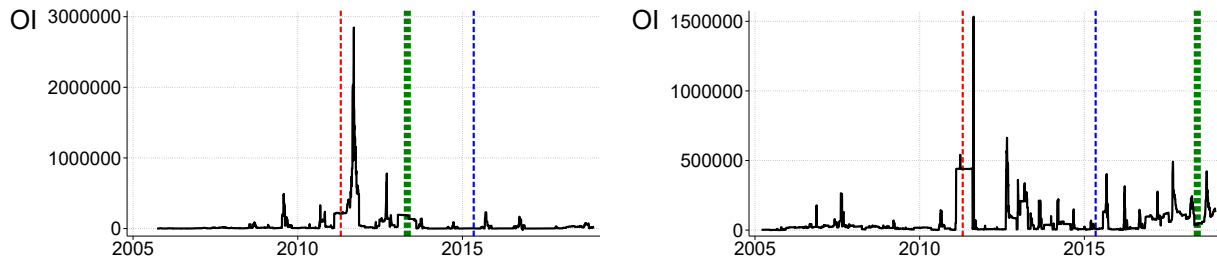


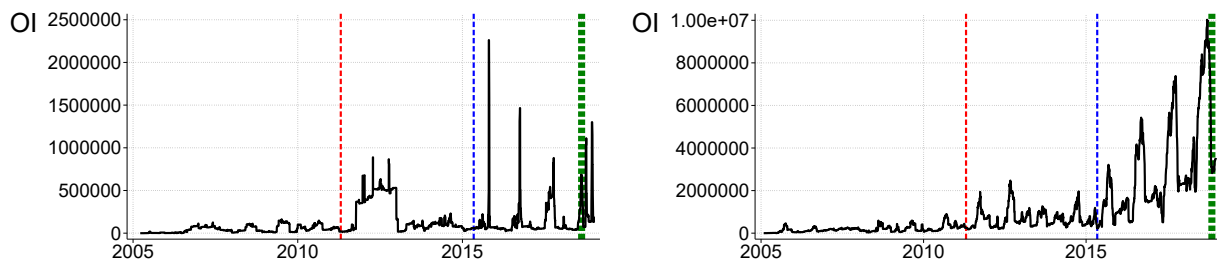
Figure 4: Open Interest

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.

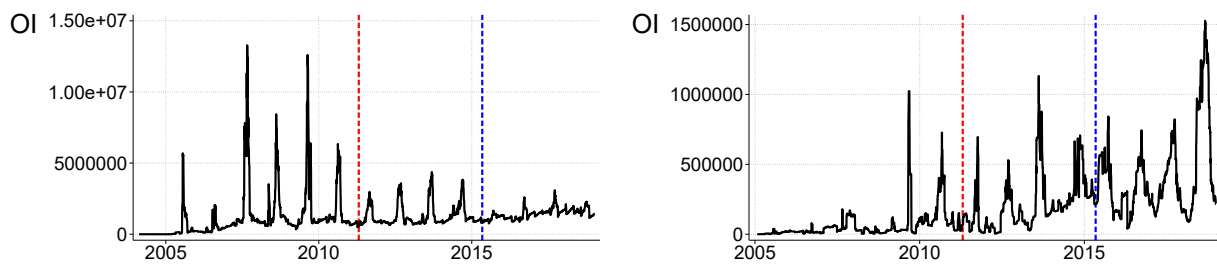
(a) Austria & Belgium



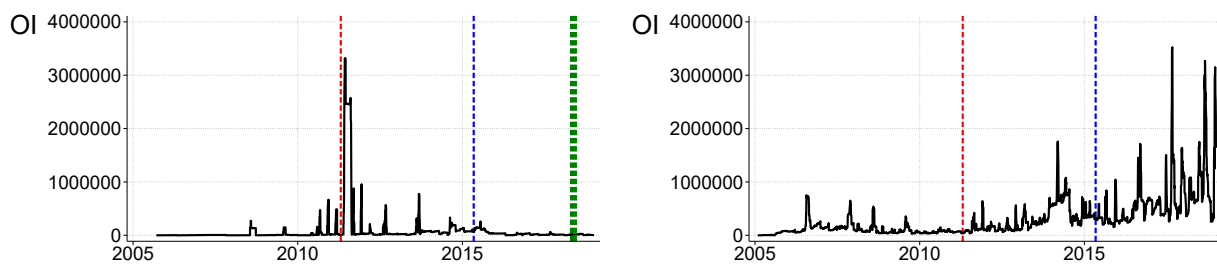
(b) Finland & France



(c) Germany & Italy



(d) Luxembourg & the Netherlands



(e) Spain & Switzerland

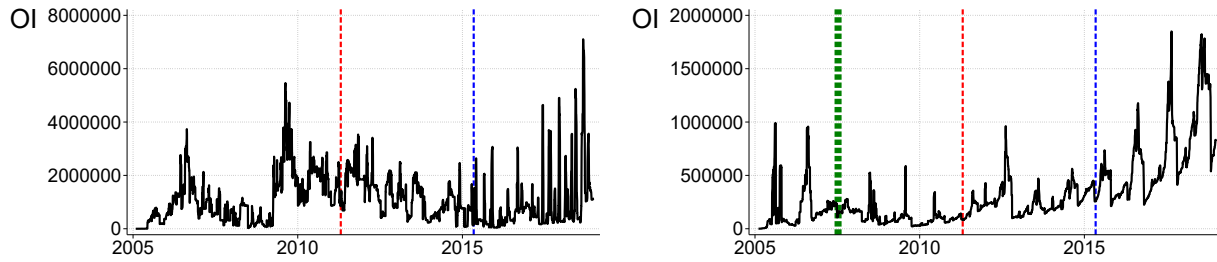
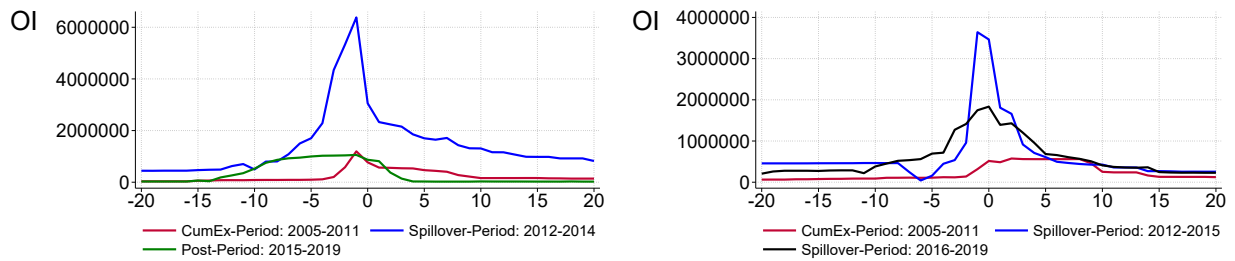


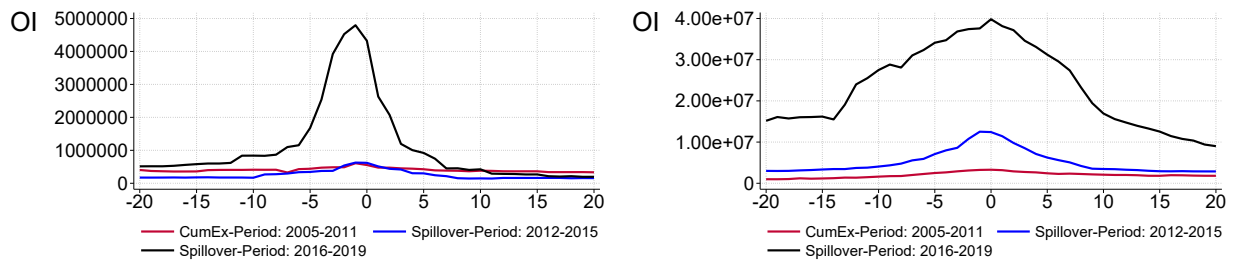
Figure 5: Open Interest: Event time

The figure shows the 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), and 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.

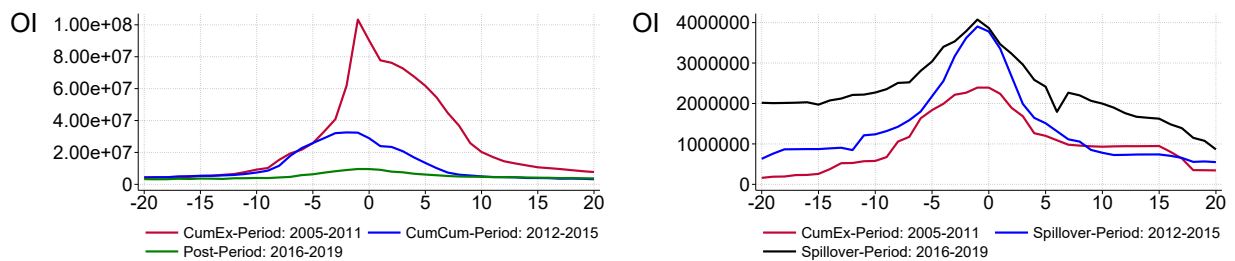
(a) Austria & Belgium



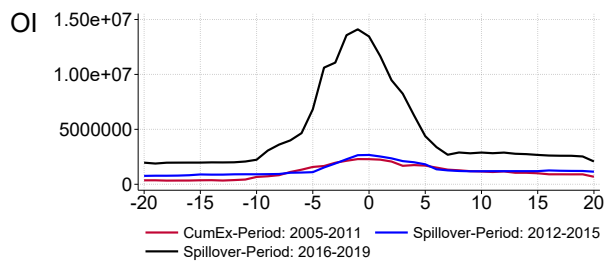
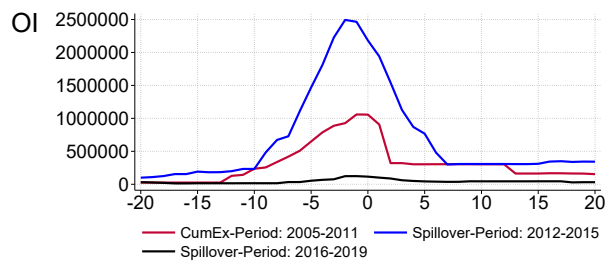
(b) Finland & France



(c) Germany & Italy



(d) Luxembourg & the Netherlands



(e) Spain & Switzerland

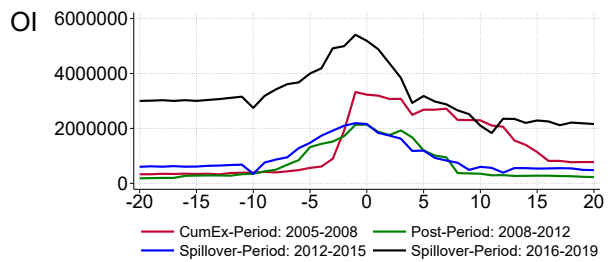
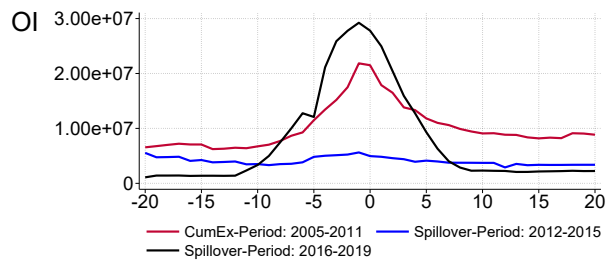


Table 1: Tax law changes and practices governing cum-ex and cum-cum trading

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 the disclosure of 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 the 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 short-seller's domestic custodian bank shall withhold the dividend tax and transmit the payment to the tax authority. However, the short-seller 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 depository institutions 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) is 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.
<i>OpenInterest</i>	206,529	0	7.9	7.8	16	2.5
<i>OFFBOOKShare</i>	45,458	0	.8	1	1	.37
<i>Volume</i>	265,464	0	14	14	21	2
<i>OffExchangeVolume</i>	62,498	-2.3	6.7	6.4	18	2.4
<i>ForeignOS</i>	259,762	0	28	26	96	15
<i>DomesticOS</i>	255,090	0	4.6	2	57	5.9
<i>Size</i>	266,116	18	23	23	26	1.2
<i>Volatility</i>	266,585	.076	.29	.26	1.8	.13
<i>Momentum</i>	266,490	-.86	.02	.018	1.5	.16
<i>DividendYield</i>	266,408	.036	2.6	2.2	32	1.8
<i>BidAskSpread</i>	263,034	-6.3	.19	.084	21	.52
<i>DividendLevel</i>	51,283	-1	.81	.81	3	.11
<i>TradeSize</i>	51,283	0	2.7	2.7	13	1.6
<i>OFFBOOK</i>	51,283	0	.017	0	1	.13
<i>TransactionTiming</i>	51,283	-20	-2.2	-2	0	1.6
<i>TimeToMaturity</i>	51,283	1	19	18	346	9.2
<i>GrossDividend</i>	2,657	.013	3.8	.9	823	35
<i>NetDividend</i>	2,657	.01	3.1	.74	644	28
<i>PDR^{gross}</i>	2,657	-1.8	.71	.77	2.9	.56
<i>PDR^{net}</i>	2,657	-2.1	.86	.91	3.5	.69
<i>ImpliedPDR</i>	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.

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

	<i>OpenInterest</i>								
	AT	BE	FR	FI	IT	LU	NL	ES	CH
<i>Spillover</i> 2012 × D_{-2}	1.446** (2.36)	2.782*** (2.98)	1.236*** (4.68)	0.901 (1.19)	0.377 (0.83)	-1.511 (-1.26)	-0.015 (-0.03)	-1.068* (-1.87)	-0.852* (-1.84)
<i>Spillover</i> 2012 × D_{-1}	0.716 (1.36)	2.564*** (4.61)	0.867*** (3.52)	1.173* (1.93)	-0.237 (-0.28)	-2.379* (-1.81)	-0.072 (-0.15)	-0.867* (-1.81)	-1.033** (-2.13)
<i>Spillover</i> 2016 × D_{-2}		2.061** (2.22)	0.865*** (3.35)	1.504*** (3.34)	-0.448 (-1.02)	-3.224*** (-2.66)	0.182 (0.41)	1.365** (2.48)	-1.759*** (-3.93)
<i>Spillover</i> 2016 × D_{-1}	-2.814** (-2.29)	0.858 (1.45)	0.455* (1.87)	1.907*** (4.17)	-0.825 (-0.98)	-4.130*** (-2.61)	0.312 (0.73)	0.308 (0.62)	-2.078*** (-4.43)
<i>PostRegulation</i> 2008 × D_{-2}									-0.888* (-1.70)
<i>PostRegulation</i> 2008 × D_{-1}									-0.904* (-1.73)
<i>PostRegulation</i> 2014 × D_{-2}	0.954 (0.88)								
<i>PostRegulation</i> 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: Implied tax-revenue loss

This table presents estimation results for the implied tax-revenue loss of each country using Equation 3. The estimations for the implied tax-revenue loss are based on the sample period between October 2005 to August 2019. While the sums may overestimate results, it is a straightforward approach to compare the size of the tax losses across countries.

Country	Estimated tax loss
Germany	7,739m
Austria	136m
Belgium	137m
Finland	97m
France	1,671m
Italy	25m
Luxembourg	26m
Netherlands	170m
Spain	187m
Switzerland	800m
Total	10,988m

Table 7: 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.

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

Table A1: Sources

Source	Data
Bloomberg	Information on Euribor rates.
Eurex exchange	Information on tick and lot size, see www.eurex.com .
FactSet	Information on institutional stock ownership, split into domestic and foreign shares.
IBFD's Tax Research	Information on court rulings related to cum-ex/cum-cum activity in European countries.
Manual search	Information on dividends and their tax status, see www.boersenzeitung.de .
OECD	Information on capital gains tax in European countries.
Refinitiv Tick History	Information on stock intraday price and volume.
Thomson Reuters	(i) Information on dividend amount, tax status, dividend withholding tax rate and ex-dividend date, (ii) information on stock prices, volume, market capitalization, and (iii) information on SSF open interest and timestamps in seconds.

Table A2: Variable Definition

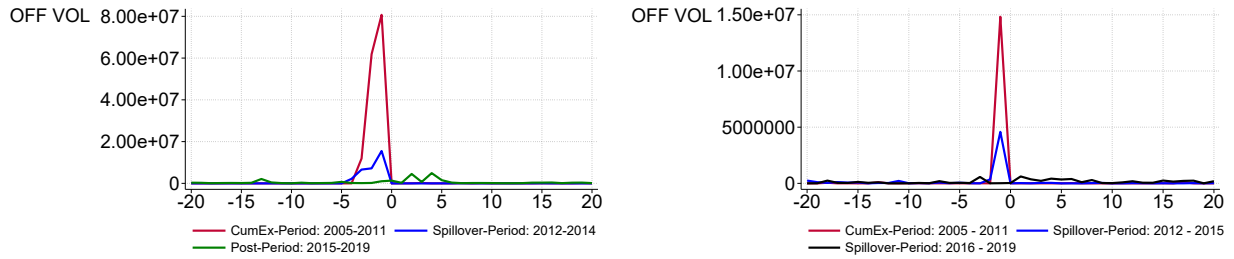
Variable	Definition
β_j	The variable measures systemic risk for stock j , estimated from the market model in Equation 5.
$\frac{\sigma_{e_j}}{\sigma_{Rm}}$	The variable measures idiosyncratic risk for stock j , estimated from the market model in Equation 5.
<i>BidAskSpread</i>	The difference between the ask price and the bid price of a stock, and divided by the ask price in BPS.
<i>CumExPeriod</i>	The cum-ex period covers the years from 2005 to 2011.
<i>CumCumPeriod</i>	The cum-cum period covers the years from 2012 to 2015.
<i>DividendLevel</i>	The implied percentage of gross dividend that has been priced in SSF and calculated by the cost-of-carry model.
<i>DividendYield</i>	The ratio between the net dividend amount and daily closing price.
<i>DomesticOS</i>	Percentage of aggregated reported holdings of domestic institutional investors divided by the shares outstanding per month.
<i>ForeignOS</i>	Percentage of aggregated reported holdings of foreign institutional investors divided by the shares outstanding per month.
<i>ImpliedPDR</i>	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).
<i>Momentum</i>	A rolling six-month average of daily stock returns.
<i>OffExchangeVolume</i>	Daily number of traded stocks in off-exchange markets.
<i>OpenInterest</i>	The sum of open contracts on a stock, including both short and long positions per day.
<i>OFFBOOK</i>	A dummy variable that flags one when the SSF contract is traded off-book.
<i>OFFBOOKShare</i>	Share of off-book SSF trades relative to all SSF trades per day.
<i>PDR</i>	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.

<i>PostRegulation2008</i>	A dummy indicating the time period between July 2009 and 2011, after Switzerland changed its tax code.
<i>PostRegulation2013</i>	A dummy indicating the time period between July 2013 and 2015, after Austria suspended all dividend tax refunds.
<i>Size</i>	The logarithm of the market capitalization.
<i>Spillover2012</i>	A dummy indicating the time period between 2012 and 2015, after Germany prohibited cum-ex trading.
<i>Spillover2016</i>	A dummy indicating the time period between 2016 and 2019, after Germany prohibited cum-cum trading.
<i>TradeSize</i>	The logarithmic number of SSF contracts traded per transaction.
<i>TransactionTiming</i>	The number of days between the transaction date and the ex-dividend date.
<i>TimetoMaturity</i>	The number of days until the SSF contract expires.
<i>Volatility</i>	The standard deviation of daily stock returns within a year, multiplied by the square root of the number of days in a year.
<i>Volume</i>	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

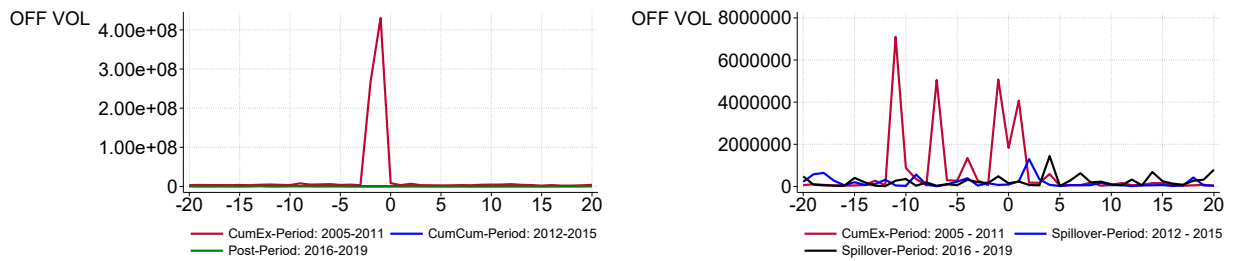


Figure A2: PDR

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 is retrieved from the OECD database, assuming that capital gains are subject to the standard corporate income tax rate of a country.

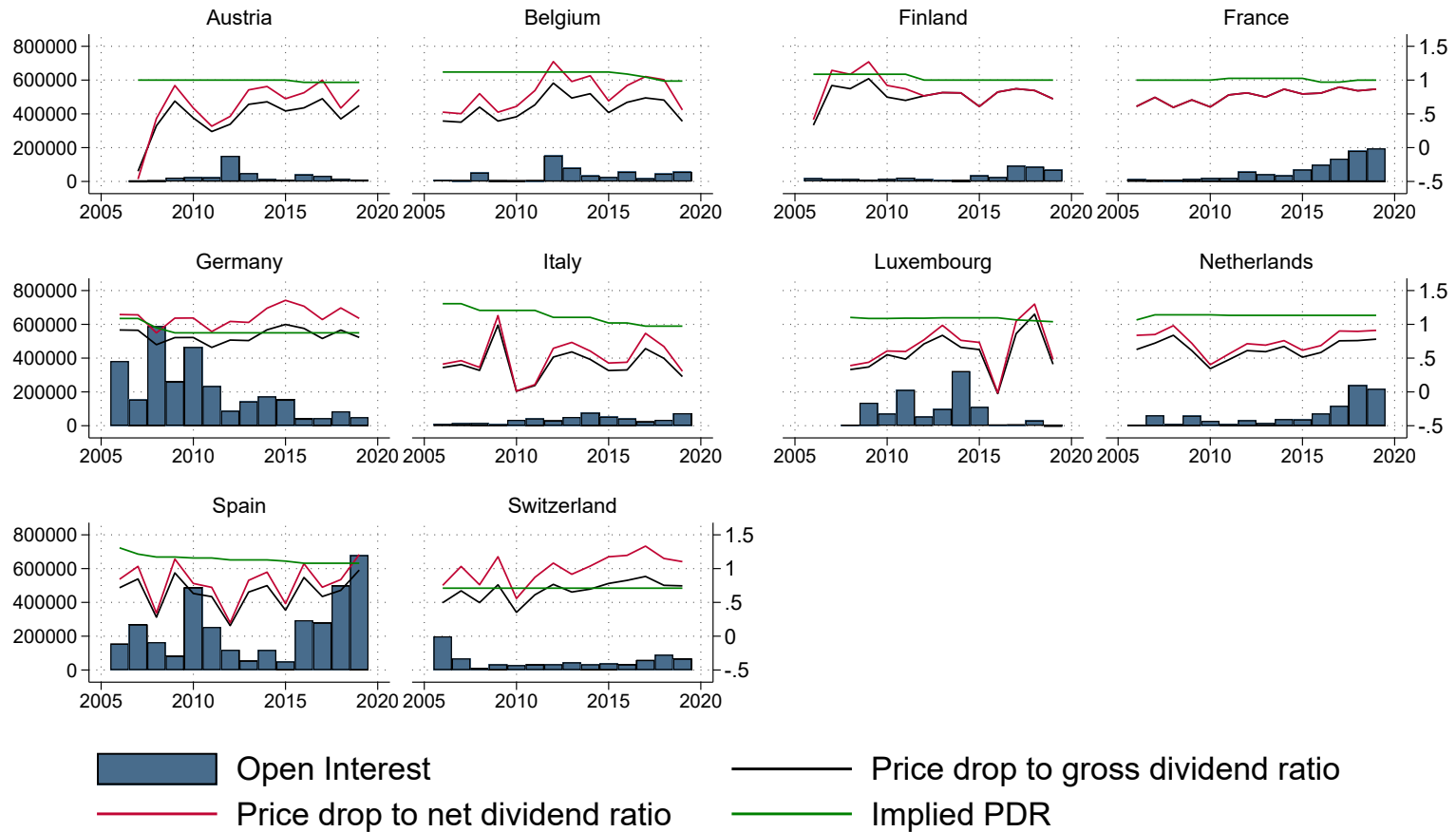


Table A3: Trading spillovers in public stock markets

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.

	<i>Volume</i>								
	AT	BE	FR	FI	IT	LU	NL	ES	CH
<i>Spillover</i> 2012 $\times D_{-2}$	-0.074 (-0.50)	0.249** (2.24)	0.062 (1.37)	0.062 (0.54)	-0.360*** (-3.67)	0.080 (0.27)	0.108 (1.42)	-0.031 (-0.37)	-1.103*** (-8.20)
<i>Spillover</i> 2012 $\times D_{-1}$	0.096 (0.64)	0.139 (1.26)	0.007 (0.16)	0.136 (1.18)	-0.065 (-0.67)	-0.063 (-0.21)	0.081 (1.07)	0.011 (0.13)	-0.524*** (-3.77)
<i>Spillover</i> 2016 $\times D_{-2}$	-0.099 (-0.64)	-0.015 (-0.14)	0.089** (2.03)	-0.112 (-1.03)	-0.543*** (-5.89)	-0.094 (-0.31)	0.149** (2.03)	0.025 (0.31)	-1.227*** (-9.43)
<i>Spillover</i> 2016 $\times D_{-1}$	0.106 (0.68)	0.089 (0.81)	0.041 (0.94)	-0.098 (-0.90)	-0.146 (-1.59)	-0.522* (-1.70)	0.081 (1.09)	0.071 (0.88)	-0.585*** (-4.36)
<i>PostRegulation</i> 2008 $\times D_{-2}$									-1.188*** (-8.88)
<i>PostRegulation</i> 2008 $\times D_{-1}$									-0.729*** (-5.27)
<i>PostRegulation</i> 2014 $\times D_{-2}$	0.056 (0.33)								
<i>PostRegulation</i> 2014 $\times D_{-1}$	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.

	<i>OffExchange Volume</i>								
	AT	BE	FR	FI	IT	LU	NL	ES	CH
$Spillover_{2012} \times D_{-2}$	-5.266*** (-5.46)	1.099 (1.35)	0.089 (0.33)	-2.669* (-1.95)	-0.125 (-0.21)	0.923 (0.30)	0.383 (0.57)	-0.277 (-0.36)	-0.876 (-0.65)
$Spillover_{2012} \times D_{-1}$	-3.327*** (-3.36)	-0.352 (-0.45)	-0.373 (-1.33)	3.164*** (2.64)	-0.838 (-1.33)		-0.042 (-0.07)	-0.400 (-0.53)	0.360 (0.31)
$Spillover_{2016} \times D_{-2}$	-9.338*** (-9.24)	0.858 (0.87)	0.304 (1.12)	-0.882 (-0.66)	-0.411 (-0.64)	3.098 (1.10)	0.238 (0.37)	0.902 (1.32)	-1.548 (-1.16)
$Spillover_{2016} \times D_{-1}$	-8.592*** (-9.44)	-4.137*** (-5.28)	0.013 (0.04)	3.699*** (3.09)	-0.770 (-1.40)	1.675 (0.81)	0.021 (0.04)	0.440 (0.68)	0.682 (0.62)
$PostRegulation_{2008} \times D_{-2}$									-1.283 (-0.94)
$PostRegulation_{2008} \times D_{-1}$									-0.158 (-0.14)
$PostRegulation_{2014} \times D_{-1}$	-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

Appendix B: A case study

Mispricing of single stock futures: Evidence from Germany

In this case study, we examine the mispricing of SSF around ex-dividend dates to evidence cum-ex trading. The Regional Court of Bonn, Germany, states that SSF have been primarily used in the construction of cum-ex schemes and that these trades exhibit significant price deviations from their fair market value. This mispricing is a result of profit shifting between colluding parties.³⁵ To confirm such mispricing across the German market, we derive fair futures values using intraday stock prices from the cost of carry model,

$$F_{t,T}^* = (S_t - D_t\nu)e^{r(T-t)}, \quad (7)$$

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 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 $F_{t,T}^*$, and divided by the gross dividend. We call this ratio the *dividend level*, which shows the percentage of a dividend that has been priced in SSF. In particular, a dividend level below (above) one increases (decreases) future prices and creates a positive (negative) deviation from the theoretical fair value ($\nu = 1$). We thereby assume that the actual future price corresponds to its fair value, i.e. $F_{t,T} = F_{t,T}^*$, and that the dividend is fully priced in the cost of carry model, $\nu = 1$.

Data restrictions do not allow us to examine SSF mispricing in neighboring countries while 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. 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

³⁵see Regional Court of Bonn, Judgment No. 62 KLS - 213 Js 41/19 - 1/19, dated March 18, 2020.

and may distort results. 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 A3 and Figure A4 show implied dividend 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 A3 and Figure A4 about here]

Our regression analysis includes controls to rule out unobserved heterogeneity issues. We control 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 days 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, the academic literature suggests including stock market characteristics, such as annualized *Volatility*, *Size*, *DividendYield*, *BidAskSpread*, and institutional ownership, i.e. *ForeignOS* and *DomesticOS*.

$$\nu_{j,t} = \beta_0 + \beta_1 \cdot CumExPeriod_t + \beta_2 \cdot X_{j,t} + Firm_j + \epsilon_{j,t} \quad (8)$$

Our empirical model in Equation 8 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 A5*.

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 the tax refund (26.4% of the dividend) was transferred to the counterpart with SSF.

[Table A5 about here]

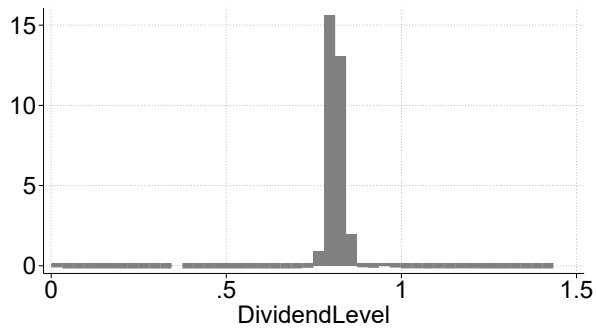
Further, the level of mispricing becomes larger for block trades and especially for OTC trades that have been performed shortly before the dividend ex-date. The remaining time until the future contracts expire has only little effect on the mispricing. Moreover, the mispricing becomes more prominent for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

Interestingly, the 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 various 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.

Figure A3: 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 the ex-dividend event.

(a) CumExPeriod: 2005-2011



(b) Post-Period: 2012-2019

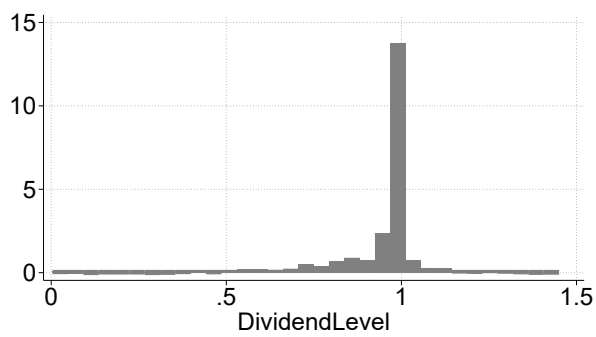
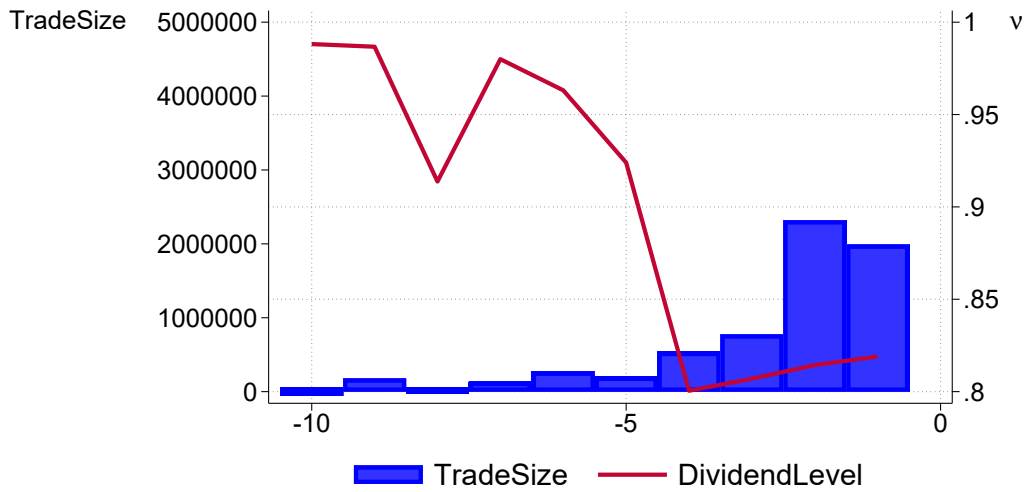


Figure A4: Implied dividend level: Event time

The figure presents mean implied dividend levels 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

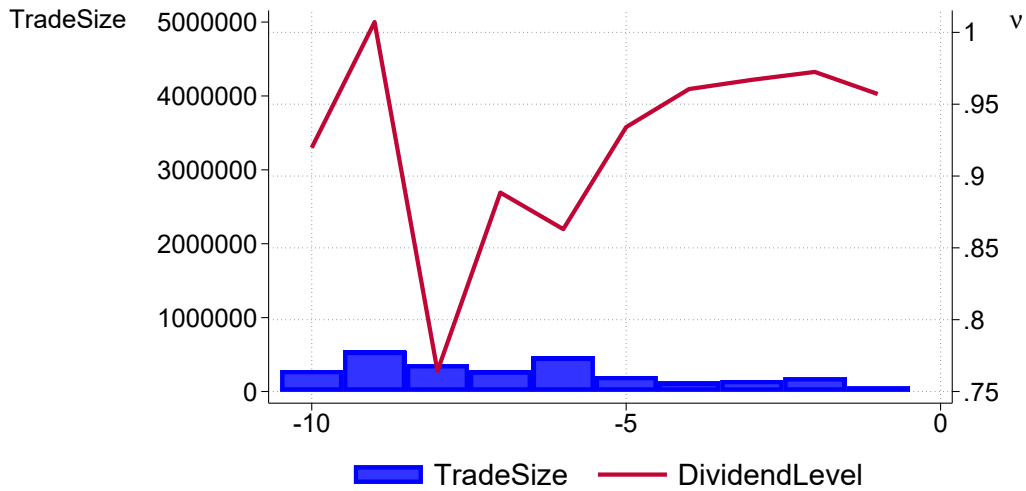


Table A5: SSF mispricing

This table presents linear regression results for Equation 8. 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.

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