Tax effects on the trading behavior of private investors: evidence from individual portfolio data *

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Abstract

We study the effects of capital-gains taxation on the trading behavior of individual investors. We use confidential portfolio-level panel data provided by a large commercial bank in Germany which include daily information about individual trading behavior. For causal identification, we exploit a large capital-gains tax reform in Germany. Prior to 2009, any gains from sold shares with a holding period of less than one year were subject to effectively half the personal income tax rate whereas gains from shares that were held for more than a year remained tax free. This so-called ‘speculation tax’ was abolished in 2009 and replaced by a system where the holding period was not tax relevant anymore. Using bunching techniques and hazard-rate regressions, we show that the realized holding periods and sale probabilities were considerably affected by the tax prior to 2009. In particular, we see a large spike in sales and increased selling probabilities of shares with a gain just after the 365-days threshold. Deductible losses spike just before the 365-days threshold. We do not see any spikes or irregular selling probabilities around the threshold in the post-reform years. We further show that the well-known disposition effect is attenuated by capital gains taxes. This is in line with the rationale that capital gains taxes induce investors to defer the sale of appreciated shares which counters the disposition effect that investors generally have a larger propensity to realize gains rather than losses.

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1 Introduction

Many aspects of trading behavior of individual investors are well documented in the literature.

Although capital gains of private investors are subject to taxes in most countries, much less is known about the causal effects of capital-gains taxes on investment behavior. Based on the literature (see below), we identify two potential reasons for this lack of evidence: i) data availability: some of the most commonly used data sets in the taxation literature (such as tax records, surveys, etc.) do not include information about the sells and purchases of single assets or their holding periods; ii) reforms for causal identification: capital gains taxes are often uniform or only affect individuals who pay the marginal top income tax rate. As a result, it is often difficult to find appropriate control and treatment groups to identify causal effects. In this paper, we overcome these challenges and study the causal effects of taxes on trading behavior of individual investors using unique individual-level data and a discontinuity (and its abolishment) in the German capital- gains tax system to estimate the causal tax effects on trading behavior. Our results add to the understanding of tax-induced effects for individual trading behavior and, ultimately, of the distortions caused by capital-gains taxes in trading markets.

We use confidential portfolio-level data provided by a large commercial bank in Germany.\(^1\) These data contain daily information about the entire trading behavior (including purchases and sales of stocks and other assets) in a panel of individual investors for the period 1999 to 2016. To identify tax effects, we exploit the institutional setting of capital-gains taxation in Germany before and after a large reform in 2009. This reform consisted of two major changes: i) Before the reform, half the gains arising from sales of assets with a holding period of less than one year were subject to a so-called ‘speculation’ tax. The rate for this speculation tax was equal to the marginal income tax rate of the selling investor. The gains of sales with a holding period longer than one year were not subject to taxes. As a result, the before-reform tax system created a holding-period based intertemporal discontinuity in the taxation of capital gains. This speculation tax was abolished in the context of the reform. Losses with a holding period of less than 365 days could be used to offset tax-relevant gains. ii) After the reform, all capital gains are subject to a flat tax of 25%. That is, capital-gains taxes became independent of the individual marginal tax rate and the holding period of the sold asset. Capital gains from share sales can still be offset by losses from share sales.

Our empirical approach makes use of bunching techniques and hazard-rate regressions to examine the tax effects on the probability of selling shares and on holding periods. Using the 365 days cut-off in the speculation tax before the implementation of the reform,\(^1\)

\(^1\)The type of data are comparable to the frequently used US data set which is propriety data from a discount brokerage house (e.g. Barber and Odean (2000)).
we show substantial bunching of sales with a gain during the days just to the right of this cut-off. In light of the incentive to deduct losses from the tax base, we see substantial bunching of sales with a loss just to the left of the 365-days cutoff. Accordingly, because gains with holding periods of more than 365 days are tax free, the holding period of sales that come with a gain spike just to the right of the 365-days cutoff. After this cut-off was abolished by the reform, we do not observe any bunching at the 365 days cut-off anymore, suggesting that the pre-reform bunching is not driven by any non-tax factors and can indeed be attributed to a causal taxation effect. Our bunching estimates suggest that a 1-percent increase in taxes reduces the probability of selling an asset by X-percent. All bunching results are robust to the calculation of the counterfactual distribution – either using the post-reform period as counterfactual in a difference-in-bunching approach or the usual methods from the bunching literature. We confirm our bunching results in hazard-rate models which estimate the probability to sell for each day of the holding period. We find increased selling probabilities of appreciated shares just after 365-days and of depreciated shares just before the threshold for pre-reform years. These effects vanish for periods after the reform for which the holding period is not tax relevant. Overall, our results present compelling evidence that taxes do distort trading behavior in our sample of individual investors.

We also shed light on the interaction of tax effects and the disposition effect, which is the name for the well-established finding that investors have a larger propensity to realize gains than losses (see below for references). The effect of capital-gains taxes counter this behavior: Investors have an incentive to defer the realization of gains because it would trigger taxes decreasing the amount which can be re-invested – hence, decreasing total return. Vice versa for losses: there is an incentive to realize losses as soon as they occur, if there are gains to be shielded from taxation. As a result, the tax effect may attenuate the disposition effect, and this attenuation should increase in the size of the tax rate. Our findings confirm these priors. While we are always able to detect and confirm the disposition effect, we find that this disposition effect is less pronounced for high-tax periods relative to low-tax periods.

Our paper contributes to the understanding of the role of taxes for trading behavior of individual investors. One strand of literature (an early survey is Poterba (2002)) uses data from individual tax returns to study the link between overall capital gains and taxes. This literature usually finds a negative relation between the realization of capital gains and taxes (e.g., Ivković et al. (2005), Bogart and Gentry (1995), Jacob (2013)). However, tax-return data do not include information that are potentially important for a comprehensive understanding of tax effects on trading behavior; in particular, they lack information on the holding periods of single assets and, more importantly, they do not include information about any assets that are not sold (i.e., unrealized gains and losses).
As a result, calculating the probability of selling assets along the holding period is not possible using these data. Tax return data also do not include any information about single trades – such as the type of assets (stock, fund etc.) or the type of realization (loss or gain) – which can be used to study heterogeneous effects of taxes on different types of trades or differential tax incentives for losses and gains. We move beyond this literature by using portfolio-level data provided by a commercial bank which allow us to observe holding periods and unsold assets, as well as information about individual trades.

Studies on tax effects on trading behavior using data that overcome these challenges are very scarce. One exception is the paper by Ivković et al. (2005) who use data from a discount brokerage which allow them to track the single investments of individual investors – these US data are very comparable in spirit to the German data that we use. Ivković et al. (2005) distinguish between trades in taxable accounts and trades in tax-deferred accounts (IRAs or Keogh plans) to shed light on taxation effects. The paper finds a negative relation between accrued gains and the selling probability in taxable accounts, while it does not observe such a relation in tax deferred accounts. In light of the presumption that taxes should induce investors to defer the realization of gains (see explanation above) and because this relation is only observed in taxable accounts, the authors suggest that their finding is an indication of taxation effects on trading behavior.

However, differences in trading behavior between taxable accounts and tax-deferred accounts are not necessarily fully attributable to taxation effects. Trading behavior might be different between these two types of accounts for non-tax related reasons – even conditional on investor fixed effects and exploiting that many investors have both taxable and tax-deferred accounts. For example, investors usually use tax-deferred accounts to save for retirement, and they might therefore be inclined to invest in different types of assets in these accounts than in taxable accounts. In their tax-deferred retirement accounts, investors might seek to invest in less risky assets or purchase assets for these accounts with a much longer investment horizon and hence with the explicit goal of trading these assets less frequently. This assertion that investments in taxable and tax-deferred accounts are different for non-tax reasons is supported by the literature: e.g., theory contributions on the optimal allocation of assets come to the result that certain assets, such as taxable bonds and actively-managed mutual funds, should be held in tax-deferred accounts, whereas other asset types, such as tax-exempt bonds, passively-managed mutual funds and stocks, should be located in taxable accounts (Shoven and Sialm (2004), Huang (2001) and Dammon et al. (2001)). The empirical study by Barber and Odean (2004) further shows that investors prefer to locate bonds and mutual funds in retirement accounts and harvest stock losses in taxable accounts.

Barber and Odean (2004) consider the disposition effect and also compare taxable and tax-deferred accounts using data from a discount brokerage firm.
Exploiting a large tax reform and providing sharp bunching evidence, our paper moves beyond the papers by Ivković et al. (2005) and Barber and Odean (2004) by considering a set-up with arguably more compelling identification of a causal tax effect. One additional add-on to Ivković et al. (2005) is the usage of daily data, as opposed to monthly data, which allow us to zoom-in more and let the probability of sale vary with the daily holding period.

Our paper also relates to the finance literature on the determinants of trading behavior (see references above). We particularly relate to the literature on the disposition effect.

The paper proceeds as follows. Section 2 describes the institutional background of capital-gains taxation in Germany during our sample period. Section 3 provides information on the data and the calculation of holding periods in this data set. We describe the empirical strategy and causal identification in Section 4. The results are presented in Section 5. Section 6 concludes the paper.

2 Institutional Background

Our analysis is based on the system of capital-gains taxation in Germany between 1999 and 2016 (i.e., the time period of our data set). We focus on the trade of shares and describe in this section how capital gains occurring from shares are treated in Germany. A major reform of capital-gains taxation was implemented in 2009 and therefore falls into our sample period.

Taxation of capital gains before 2009. Before the reform, the taxation was dependent on the holding period of the underlying asset. The gains and losses of assets sold within a holding period of 365 days or less were subject to taxation. This tax was commonly referred to as a ‘speculation tax’. The tax rate was determined by the personal income-tax rate (PIT), which depends on the sum of all income types (wage income, self-employment, etc). For example, this top income tax rate was 42% in 2008 and applied for overall taxable income greater than 52,152 EUR. Losses from sales with a holding period of $\leq 365$ days could be used to offset gains. Between 2001 and 2008 a so-called half-income method applied: one half of the gains/losses from capital gains with holding periods $\leq 365$ days were subject to the tax.

For illustration, consider a fictitious investor who is subject to the top-income tax rate of 42%. She makes gains worth 2000 EUR from assets with a holding period of $\leq 365$ days, and she sells assets within the holding period which lead to losses of 200 EUR. The resulting capital-gains tax liability for this investor then was $\frac{1}{2} \times (2000 - 200) \times 0.42 = 378$ EUR.
The gains resulting from assets with a holding period of more than 365 days were not subject to any taxes; the resulting tax liability on gains was zero if the underlying asset was held for more than 365 days. Accordingly, losses resulting from assets with a holding period of more than 365 days could not be deducted from the tax base.

This system of capital-gains taxes applied to assets such as stocks\(^2\), funds, certificates (except guarantee certificate) and capital gains from bonds (except zero bonds). Overall, the system creates large incentives to realize gains after the relevant holding period of 365 days, while losses should be realized within the 365-days holding period to reduce the tax base.

Taxation of capital gains since 2009. The tax treatment of capital gains was substantially reformed as of January 2009. In stark contrast to the old system, the holding period of assets is not tax relevant anymore. That is, the holding-period based 'speculation tax' was abolished in the context of this reform. It was replaced by a system where all capital gains and capital losses where subject to a flat tax of 25% or, if the PIT rate is smaller than 25%, the PIT rate. That is, the tax on capital gains/losses was min(25%,PIT rate). Losses can be used to offset gains. The half-income method was abolished.

Consider again a fictive investor who is subject to the top PIT rate (which is > 25\%) and who has capital gains of 2000 EUR and capital losses of 200 EUR. Her tax liability after the reform is independent of the holding periods of the underlying assets and sums up to: \( (2000 - 200) \times 0.25 = 450 \) EUR. Importantly, any tax incentives to hold assets for a certain time period were abolished. The old pre-2009 tax rules applied to all assets bought before January 2009.

3 Data Description

3.1 Data

3.2 Measuring the Holding Period

We measure the holding period as the difference in days between purchase date and sales date. For example, if a fictive investor buys 5 shares of some firm on the second of October and sells them on the 15\textsuperscript{th} of October in the same year, this would result in a holding period of 13 days. In some cases, we don’t observe the first purchase of a share in the data e.g. if some investor had bought the shares prior to the first of January 1999. Since for those cases we cannot calculate a holding period, we have to drop them from

\(^2\)As long as the investor is not a substantial shareholder
our sample. If there are multiple buys before the first sale occurs we apply the first in first out principle which is inline with the German tax law. If one purchase is sold on several days we create one observation for each sell. E.g. the same fictive investor who buys five shares on the second of October sells three shares on the 5th of October and two on the 15th of October we create two observations one with a holding period of two days and the other with a holding period of 13 days. Sometimes shares change their isin or shares are splitted. We try to account for this by using hand collected data for isin changes and data on splits and reverse splits from datastream.

Our analysis is based on 2.6 million observations of appreciated shares 2.4 million shares which had depreciated in the pre reform period. In the after reform it is based on 1.2 million observations of appreciated and 0.8 million depreciated shares. Restricting the sample to half a year before and after the intertemporal tax discontinuity results in 280 thousand realizations with gains and 380 thousand realizations of losses in the pre reform period. After the reform 200 thousand gains and 120 thousand losses were realized.

4 Empirical Strategy

Our empirical strategy aims at identifying the causal effect of capital taxes on trading behavior, in particular on holding periods and the probability to sell an asset. We focus on the trading of shares throughout our analyses. In addition, we shed light on the interaction of tax effects and the famous disposition effect.

**Number of trades in weeks around the cutoff.** The starting point for our analyses are figures in which we plot the number of trades around the holding period tax cutoff of 365 days. We group the number of trades in weekly bins of seven days and primarily look at the period 26 weeks prior and 26 weeks after the pre-reform 365-days cutoff. We use bins of seven days although we have access to daily sales data because of a mechanical pattern in the daily data which causes noise and is smoothed out in weekly data. Since it is not possible to trade on weekends, some day-measured holding periods occur more often than others. For example, a seven day holding period is possible for sales made on all five weekdays, whereas a four days holding period is only possible for sales made on Mondays, Thursdays or Fridays. The resulting Figure counts the number of sales in each week around the cutoff.

We plot the number of trades around the 365-days cutoff separately for years before and after the 2009 reform and separately for gains and losses. Since the holding period is tax irrelevant since the reform, we expect a smooth distribution of trades around the 365-days cutoff for the years after the reform. A causal effect of taxes on trading behavior would imply that we see an increased number of trades of appreciated assets (gains) in
the weeks after the 365-days cutoff, and an increased number of trades of depreciated assets (losses) in the weeks before the cutoff.

**Bunching Techniques.** We go on and use bunching methods to quantify the tax effects around the 365-days cutoff. Bunching approaches go back to Saez (2010) and are now commonly used (see the recent overview by Kleven (2016)). We use two approaches to estimate the required counterfactual distribution (how would the distribution look like in the absence of the tax-relevant 365-days cutoff). First, we employ the conventional method of inferring the counterfactual from the data (as in Chetty et al. (2011)). To do so, we only rely on the pre-reform data and fit a 7th-order polynomial to the counts plotted in the figure excluding the data near the cutoff. Second, we use a difference-in-bunching approach where we use the sales distribution in the post-reform periods as a counterfactual for the pre-reform distribution (as in e.g., Brown (2013); also see Kleven (2016)). To account for level differences in the number of sales before and after the reform, we divide all weekly counts by the respective total number of sales. Since post-reform trades are observed up to 311 weeks after the 365-days cutoff, we divide both post and pre reform counts by the total number of trades within the period of 311 weeks after 365 days. We apply this procedure separately for gains and losses.

For both approaches, the size of the tax effect will be proportional to the excess mass in bunching relative to the respective counterfactual distribution. To quantify the tax effect, we estimate parameter $b$ which describes the excess mass around the cutoff relative to the counterfactual distribution. Parameter $b$ is then used to calculate an implied elasticity which describes the percentage change in holding an asset in response to a one-percent change in the tax rate. We calculate a standard error for the excess mass ($b$) using a parametric bootstrap procedure. We draw from the vector of residuals with replacement to generate a new set of counts and reestimate the excess mass $b^j$. Repeating this for a thousand times gives us an estimate for the distribution of $b^j$. We use the standard deviation of the $b^j$ as our estimate for the standard error of the excess mass.

Although the intertemporal tax discontinuity leads to a notch in the budget set, there are no dominated regions. There are at least four reasons why it might be rational to sell an appreciated share even on the day before it can be sold tax free. First, time discounting e.g. if the investor needs the money on the day before. Second, expected prices, if the investor assumes that the price will drop strongly on the day after the cutoff, selling on the day before might be advantageous for her. Third, risk aversion, even if she expects that prices remain constant it might be optimal for her to sell today if prices might fall with small positive probability. In addition, if the investors has sufficient loss carryforwards she can sell an appreciated share tax free even if still the long term rate applies.
Hazard-Rate Regressions  We complement the bunching analyses with hazard-rate regressions (as used for example in Chang et al. (2016)). These hazard-rate regressions estimate for each day of the holding period the probability that a given asset is sold on this holding-period day. For this purpose, we set up our data set such that it contains one observation per individual investor, share and day of the holding period. For example, this would give us 11 observations for a share that an individual investor has held for 10 days (0, 1, 2, ..., 10). We then create a dummy variable – Sell – that indicates for each day of the holding period if the asset was sold on this respective day. We merge the resulting dataset with daily price information for all assets, extracted from Datastream.

For each day of the holding period, we estimate separate regressions in which we regress the Sell-dummy on a constant. The resulting coefficient for the constant then describes the probability that a share is sold on this particular day of the holding period. In light of the differential tax incentives for gains and losses, these regressions are estimated separately for gains and losses. Formally, we estimate the following regressions for each day of a holding period : $t$:

\[ \text{Sell}_{ijd} = \beta_0 + \varepsilon_{ijd} \text{ if } I(Gain_{ijd}) = 1 \]  

\[ \text{Sell}_{ijd} = \beta_0 + \varepsilon_{ijd} \text{ if } I(Loss_{ijd}) = 1 \]  

where indices $i, j, d$ indicate deposits of individual investors, shares, and dates, respectively. We estimate this set of regressions for pre-reform and post-reform years to see if selling probabilities around the 365-days holding-period cutoff are different before and after the reform. For illustrative purposes, we plot the estimated coefficients for each day of the holding period (separate plots for gains and losses, and post and pre reform).

This procedure provides graphical evidence whether the selling probabilities are affected by taxation. One particular advantage of the hazard-rate approach is the possibility to make use of our daily data. In addition, they exploit shares which are not sold (whereas the bunching approach is solely based on actually sold assets) and it allows to include control variables.

The hazard-rate approach also allows us to estimate if potential tax effects depend on the magnitude of the gain or loss of an investor. This is potentially relevant because an investor with a large loss faces larger incentives to sell the share before the 365-days cutoff because deducting a large loss reduces the tax base by more than a small loss. In addition, if the loss is only small the investor might want to wait and see if share prices rise. Equivalently, a large gain would trigger a larger tax liability, which increases the incentive to sell a gain after the cutoff. For this purpose, we include a control variable into the above regressions which measures the percentage change in the value of the share:
\[ Sell_{ijd} = \beta_0 + \beta_1 Change_{ijd} + \varepsilon_{ijd} \text{ if } 1(Gain_{ijd}) = 1 \] (3)

\[ Sell_{ijd} = \beta_0 + \beta_1 Change_{ijd} + \varepsilon_{ijd} \text{ if } 1(Loss_{ijd}) = 1 \] (4)

where the Change \ Variable describes the change between the share price at holding-day \( t \) and the purchasing \( \frac{p_{ijd} - p_{ij0d}}{p_{ij0d}} \). The constant in these regressions describes the selling probability for shares without a price change, and \( (\beta_0 + \beta_1) \) estimates the selling probability for changes of size 1.

**Interaction of Taxes and Disposition Effect.** We aim to test if taxes affect the extent of the disposition effect. The starting point of the analysis is to measure the existence and magnitude of a potential disposition effect in our data. Following the literature (e.g., Chang et al. (2016)), we regress a Sale dummy (see above) on a dummy indicating whether a share comes with a gain on this day of the holding period. Formally, we estimate the following regression for each day of the holding period and using all sample years and shares with both gains and losses:

\[ Sell_{ijd} = \beta_0 + \beta_1 Gain_{ijd} + \varepsilon_{ijd} \] (5)

If \( \beta_1 \) is greater than zero in this regression, this is evidence of a disposition effect; i.e., gains are sold with larger probabilities than gains. The coefficient for \( \beta_1 \) further measures the magnitude of the disposition effect.

In a next step, we estimate the above regression separately for pre-reform and post-reform years. Any difference between pre and post reform years, especially around the 365-days cutoff, sheds light on the tax effects of the disposition effect. The difference in the disposition effect between post-reform and pre-reform years can also be estimated in a DiD-type regression of the following form:

\[ Sell_{ijd} = \beta_0 + \beta_1 Pre + \beta_2 1(Gain_{ijd}) + \beta_3 Pre \times 1(Gain_{ijd}) + \varepsilon_{ijd}, \] (6)

where \( Pre \) indicates years before the reform (when the holding period mattered for the tax liability). The interaction of pre-years and the gain dummy, \( \beta_3 \), measures the difference in disposition effect before the reform relative to after the reform. We again estimate this regression separately for each day of the holding period, which allows to check if the difference between post and pre years is particularly pronounced around the 365-days cutoff.
5 Results

5.1 Tax effects on trading behavior

Figure 1 compares the pre and post reform distribution of holding periods for share packages which were sold with a gain. In the pre reform distribution there is a substantial amount of bunching just from the holding period on when gains can be realized tax free. After the reform the distribution is flat around the tax discontinuity. The absence of any bunching after the reform points out that the bunching is completely driven by the intertemporal tax discontinuity and not by any confounding event. Before and after the reform the amount of share packages sold decreases when the holding period increases.

Similarly, figure 2 compares the pre and post reform distribution of holding periods for share packages which were sold with a loss. For shares bought in the pre reform period, there is also a substantial amount of bunching. This time the bunching occurs right before the long term rate applies. The reason for this is that if the zero long term rate applies losses cannot be used anymore to offset gains which were realized in the speculation period. After the reform there is no more bunching detectable.

Level differences in between the pre and post reform distribution displayed in figures 1 and 2 cannot be interpreted, because the amount of years observed prior (10 years) and after the reform (7.5 years) differ. In addition, the amount of years with a boom and years with a bust might differ.

3 A share package could contain a thousand shares or only one both would be counted as one trade in the figures
Figure 1: Number of trades around the itd: Gains

Notes: This figure displays the number of share packages which were sold with a gain in dependency of the holding period, 26 weeks before and 26 weeks after the intertemporal tax discontinuity. The dotted blue line represents sales for which the purchase was made prior to 2009. The dotted red line represents sales for which the purchase was made after 2009. The vertical red line at x-axis value zero marks the last bin in which gains were taxable. Each point shows the number of trades in a 7 days bin of the holding period relative to the itd. A trade represents the sale of a share package independent of the size of the package. I.e. a package could contain a thousand shares or only one both would be counted as one trade.
Figure 2: Number of trades around the itd: Losses

Notes: This figure displays the number of share packages which were sold with a loss in dependency of the holding period, 26 weeks before and 26 weeks after the intertemporal tax discontinuity. The dotted blue line represents sales for which the purchase was made prior to 2009. The dotted red line represents sales for which the purchase was made after 2009. The vertical red line at x-axis value zero marks the last bin in which gains were taxable. Each point shows the number of trades in a 7 days bin of the holding period relativ to the itd. A trade represents the sale of a share package independent of the size of the package. I.e. a package could contain a thousand shares or only one both would be counted as one trade.
Figure 3 compares the pre reform distribution for gains with a counterfactual distribution estimated by fitting a 7th-order polynomial to the counts plotted in the figure excluding four bins after the cutoff. Although the number of sales decreases strongly with the holding period nearly 10 percent of the trades were made in the four bins after the cutoff. The excess mass of 1.96 in those four bins is about ten times larger than the standard errors and therefore highly significant. An excess mass of 1.96 means that the average excess mass around the cutoff is about two times as large as the average of the counterfactual distribution.

Figure 4 compares the pre reform distribution for losses with a counterfactual distribution estimated by fitting a 7th-order polynomial to the counts plotted in the figure excluding four bins before the cutoff. More than 10 percent of the trades realizing a loss were made in the four bins before the intertemporal tax discontinuity. The excess mass is with 2.73 even larger than for gains and also highly significant (29 times larger than the standard errors). The excess mass being larger for losses than for gains makes sense, because a gain can be realized tax free also on day 500 or day 1000, while a loss can only be used to offset a gain until day 365.
Figure 3: Bunching estimates: Gains

Notes: This figure displays the number of share packages which were sold with a gain in dependency of the holding period, 26 weeks before and 26 weeks after the intertemporal tax discontinuity. The dotted blue line represents sales for which the purchase was made prior to 2009. The solid red line beneath the empirical distribution is a seventh-degree polynomial fitted to the empirical distribution excluding the bins 1-4. The vertical red line at x-axis value zero marks the last bin in which gains were taxable. Each point shows the number of trades in a 7 days bin of the holding period relative to the itd. A trade represents the sale of a share package independent of the size of the package. I.e. a package could contain a thousand shares or only one both would be counted as one trade. Excess mass (b) = 1.959.
Figure 4: Bunching estimates: Losses

Notes: This figure displays the number of share packages which were sold with a loss in dependency of the holding period, 26 weeks before and 26 weeks after the intertemporal tax discontinuity. The dotted blue line represents sales for which the purchase was made prior to 2009. The solid red line beneath the empirical distribution is a seventh-degree polynomial fitted to the empirical distribution excluding the bins 0-3. The vertical red line at x-axis value zero marks the last bin in which gains were taxable. Each point shows the number of trades in a 7 days bin of the holding period relative to the itd. A trade represents the sale of a share package independent of the size of the package. I.e. a package could contain a thousand shares or only one both would be counted as one trade. Excess mass \( b \) = 2.792.
In figures 5 and 6 we use the post reform distribution of holding periods as the counterfactual distribution. Figures 5 and 6 differ in the assumption on up to which week trades are affected by the intertemporal tax discontinuity. While figure 5 assumes that even trades on day zero are affected by the intertemporal tax discontinuity, figure 6 assumes that only trades from week 26 onwards are affected. The truth being somewhere in the middle the graphs show two things: First, in any case there is excess mass detectable around the intertemporal tax discontinuity. Second, there is a substantial amount of missing mass to the left of the cutoff. In any case the excess mass around the cutoff is smaller than the missing mass left of the cutoff. While in figure 5 this still can be driven by the first weeks of the holding period, this cannot be true for figure 6. This, implies that the graph of the pre reform distribution will be larger than the post distribution not only right after the cutoff where we observe the bunching but also in the weeks after. In other words due to the intertemporal tax discontinuity selling shares with gains is postponed to larger holding periods and not only into the holding periods right after the cutoff. Not shown here we also calculated the excess mass for losses using the pre reform distribution as counterfactual. Those graphs look very similar to figure 4.
Figure 5: Bunching estimates Post 2009 Counterfactual: Gains

Notes: This figure displays the density of share packages which were sold with a gain in dependency of the holding period, 26 weeks before and 26 weeks after the intertemporal tax discontinuity. The dotted blue line represents the density for sales for which the purchase was made prior to 2009. The dotted red line represents the density for sales for which the purchase was made after 2009. The density is calculated by dividing the trades on a given day of the holding period by the total number of trades. The vertical red line at x-axis value zero marks the last bin in which gains were taxable. Each point shows the number of trades in a 7 days bin of the holding period relative to the itd. A trade represents the sale of a share package independent of the size of the package. I.e. a package could contain a thousand shares or only one both would be counted as one trade. Excess mass (b) = 0.5.
Notes: This figure displays the number of share sales with losses, 26 weeks before and 26 weeks after the intertemporal tax discontinuity. The dotted blue line represents sales for which the purchase was made prior to 2009. The dotted red line represents the density for sales for which the corresponding purchase was made after 2009. The density is calculated by dividing the trades on a given day of the holding period by the total number of trades, but ignoring trades which were made before week 26. The vertical red line at x-axis value zero marks the last bin in which gains were taxable. Each point shows the number of trades in a 7 days bin of the holding period relative to the itd. A trade represents the sale of a share package independent of the size of the package. I.e. a package could contain a thousand shares or only one both would be counted as one trade. Excess mass \((b) = 1.39\).
Figures 7 and 8 plot hazard rates for gains and losses respectively. The figures compare pre and post reform hazard rates. They show that our findings from the previous graphs are robust to calculating daily hazard rates. Furthermore they show that hazard rates are strongly affected by the intertemporal tax discontinuity. Additionally, figure 8 shows that the hazard rate for losses prior to the reform is higher before and after the intertemporal tax discontinuity. I.e. selling shares with losses is prepone before the cutoff day. More surprising is that the hazard rate for shares with losses is lower for holding periods before the intertemporal tax discontinuity. Seemingly, prior to the reform investors who want to sell a depreciated share with a holding period of less than one year tend to wait until close to the cutoff day. This could either mean that investors wait and see how the share performs until the cutoff day or alternatively, this could be explained by investors actively checking how their shares have performed close to the cutoff day, but not so much farther away from that day.
Figure 7: Hazard rates around the itd: Gains

Notes: This figure displays the hazard rate of share sales with gains ($\beta_0$ from equation 1), 26 weeks before and 26 weeks after the intertemporal tax discontinuity. The dotted blue line represents the hazard rate for sales for which the purchase was made prior to 2009. The dotted red line represents the hazard rate for sales for which the purchase was made after 2009. The vertical red line at x-axis value zero marks the last day of the holding period in which gains were taxable.
Notes: This figure displays the hazard rate of share sales with losses ($\beta_0$ from equation 2), 26 weeks before and 26 weeks after the intertemporal tax discontinuity. The dotted blue line represents the hazard rate for sales for which the purchase was made prior to 2009. The dotted red line represents the hazard rate for sales for which the purchase was made after 2009. The vertical red line at x-axis value zero marks the last day of the holding period in which gains were taxable.
In figure 9 we show the hazard rate for shares which have appreciated when we control for the percentage gain. We compare the resulting hazard rates before and after the reform. This graph looks very similar to figure 7, this implies that the selling probability prior to the reform is not affected by the amount of gain. The opposite is true for losses. Figure 10 shows that there is hardly any spike if we control for the percentage loss. This implies that nearly everything of the spike in hazard rates that can be seen close to the cutoff (figure 8) can be explained by the amount of the loss. In other words it is not the small losses investor sell close to the cutoff, but the big losses.
Figure 9: Hazard rates around the itd controlling for percentage change: Gains

Notes: This figure displays the hazard rate of share sales with gains ($\beta_0$ from equation 3), 26 weeks before and 26 weeks after the intertemporal tax discontinuity. The dotted blue line represents the hazard rate for sales for which the purchase was made prior to 2009. The dotted red line represents the hazard rate for sales for which the purchase was made after 2009. The vertical red line at x-axis value zero marks the last day of the holding period in which gains were taxable.
Figure 10: Hazard rates around the itd controlling for percentage change: Losses

Notes: This figure displays the hazard rate of share sales with losses ($\beta_0$ from equation 4), 26 weeks before and 26 weeks after the intertemporal tax discontinuity. The dotted blue line represents the hazard rate for sales for which the purchase was made prior to 2009. The dotted red line represents the hazard rate for sales for which the purchase was made after 2009. The vertical red line at x-axis value zero marks the last day of the holding period in which gains were taxable.
Figure 11 plots coefficient estimates for $\beta_1$ stemming from equation 3. While prior to the reform the selling probability is hardly influenced by the percentage gain, this changes after the reform. With exception of few outliers the percentage gain reduces the selling probability after the reform. Figure 12 plots coefficient estimates for $\beta_1$ stemming from equation 4. A negative coefficient in this graph means that the selling probability increases if the percentage loss increases. For holding periods of less than one year the selling probability increases with the percentage loss. There is a pronounced spike directly at the cutoff. For holding periods of more than one year the coefficient estimates are slightly larger than zero before the reform. This implies that the higher the percentage loss the lower the selling probability becomes.
Figure 11: Hazard rates around the itd controlling for percentage change: Gains

Notes: This figure displays the effect of a percentage point change in gain on the hazard rate of share sales with losses ($\beta_1$ from equation 3), 26 weeks before and 26 weeks after the intertemporal tax discontinuity. The dotted blue line represents the effect on the hazard rate for sales for which the purchase was made prior to 2009. The dotted red line represents the effect on the hazard rate for sales for which the purchase was made after 2009. The vertical red line at x-axis value zero marks the last day of the holding period in which gains were taxable.
Figure 12: Hazard rates around the itd controlling for percentage change: Losses

Notes: This figure displays the effect of a percentage point change in loss on the hazard rate of share sales with losses ($\beta_1$ from equation 4), 26 weeks before and 26 weeks after the intertemporal tax discontinuity. The dotted blue line represents the effect on the hazard rate for sales for which the purchase was made prior to 2009. The dotted red line represents the effect on the hazard rate for sales for which the purchase was made after 2009. The vertical red line at x-axis value zero marks the last day of the holding period in which gains were taxable. A negative coefficient means that the selling probability increases.
5.2 Interaction between taxes and the disposition effect

Figure 13 shows estimates of the disposition effect in dependency of the holding period without distinguishing between pre and post reform period ($\beta_1$ from equation 5). A positive value means that the hazard rate for gains is larger than the hazard rate for losses. This is the case for most of the holding periods. However, close to the reform the hazard rate for losses is larger than the hazard rate for gains. This is driven by the pre reform period as can be seen in figure 14. Figure 14 shows estimates of the disposition effect separately for the pre and post reform period. While after the reform the disposition effect is always positive, it becomes negative just before the intertemporal tax discontinuity prior to the reform.
Figure 13: Disposition effect around the itd: All years

Notes: This figure displays the disposition effect measured as the difference in hazard rates between appreciated and depreciated shares ($\beta_1$ from equation 5), 26 weeks before and 26 weeks after the intertemporal tax discontinuity. The vertical red line at x-axis value zero marks the last day of the holding period in which gains were taxable. A positive value means that the hazard rate for gains is larger than the hazard rate for losses.
Figure 14: Disposition effect around the itd: Pre and post reform

Notes: This figure displays the disposition effect measured as the difference in hazard rates between appreciated and depreciated shares ($\beta_1$ from equation 5), 26 weeks before and 26 weeks after the intertemporal tax discontinuity. The dotted blue line represents the disposition effect prior to 2009. The dotted red line represents the disposition effect after 2009. The vertical red line at x-axis value zero marks the last day of the holding period in which gains were taxable. A positive value means that the hazard rate for gains is larger than the hazard rate for losses.
Figure 15 shows the difference in disposition effect ($\beta_3$ from equation 6) A negative (positive) value means that the disposition effect was smaller (larger) prior to the reform. While the disposition effect during the first year of the holding period was smaller in the years before the reform it was larger for holding periods of more than one year. This makes sense because after a holding period of one year gains could be realized tax free before the reform. So this represents the “pure” disposition effect without taxes reducing it. After the reform capital gains taxation counteracts the disposition effect.
Figure 15: Hazard rates Difference in disposition effect around the itd

Notes: This figure displays how the disposition effect was affected by the reform ($\beta_3$ from equation 6), 26 weeks before and 26 weeks after the intertemporal tax discontinuity. The vertical red line at x-axis value zero marks the last day of the holding period in which gains were taxable. A negative (positive) value means that the disposition effect was smaller (larger) prior to the reform.
6 Concluding remarks

TO BE DONE
References


Tables and Figures

Appendix

Additional Figures