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Pasi Sorjonen

ESSAYS ON DIVIDENDS AND TAXES

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ABSTRACT: This study is a collection of three essays on the behaviour of stock prices around ex-dividend days. In Essay 1, we document that stock prices fall by 70 to 75 per cent of the dividend amount on ex-dividend days in Finland in 1989-90 and 1993-97. These results suggest that domestic individuals were marginal investors in the former period and foreign investors in the latter. There is weak evidence in favour of a tax clientele effect in 1989-90, which is a new finding in the Finnish stock market. A portfolio of stocks with high dividend yields and liquidity exhibits abnormally high trading volumes on cum and ex-days and abnormally low volumes on the following two trading days. These abnormal volumes are not matched by simultaneous abnormal returns. This evidence is consistent with long-term traders timing their trades around ex-days and inconsistent with short-term trading being of any importance.

In Essay 2, we derive a model of ex-dividend day stock price behaviour, which takes price discreteness explicitly into account. Price discreteness adds to the model a new parameter, which describes how the market rounds prices, and makes the model non-linear. Rounding is needed, because prices must change by multiples of given increments. We show that the ex-dividend ratio is a piecewise, decreasing convex function of dividend amount. For a given cum-dividend day stock price, ex-day return is a piecewise linear function of dividend yield. The effect of price discreteness on ex-day returns decreases with stock price. Therefore, the cross-sectional distribution of cum-day stock prices is important for ex-day price behaviour.

Essay 3 examines how accurately the tax rate implicit in the ex-day price drop can be estimated with commonly used methods when stock prices are discrete. The results of our simulation experiment suggest the following. First, the GLS-estimator proposed by Michaely (1991) is the best statistic among the four statistics examined. It is unbiased and has the smallest variance. The traditional ratio of price drop to dividend performs the worst. Second, tick rules are important for ex-day studies only if the ex-day price drop does not have to be adjusted for overnight return. The effect of rounding on the ex-day price drop is always less than one tick, because prices are rounded to the nearest legitimate price. Errors made in estimating the overnight return may have an effect many times larger than that on the ex-day price drop. Indeed, if ex-day price drops are contaminated by overnight returns, tick rules do not affect the results of ex-day studies. Errors made in eliminating the overnight return dominate the errors caused by tick rules. In fact, as long as ex-day prices must be adjusted for overnight return, it does not matter whether prices are continuous or discrete. Finally, standard errors of commonly used test statistics are high enough to make the identification of tax clientele effects very difficult.

KEY WORDS: asset pricing, dividends, taxation, tick size

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TIIVISTELMÄ: Tutkimuksessa on kolme erillistä esseetä, jotka käsittelevät osakekurssien käyttäytymistä osinko-oikeuden irtoamispäivän läheisyydessä. Esseessä 1 havaitaan, että osakkeen hinta putosi osingon irtoamispäivänä Suomessa vuosina 1989-90 ja 1993-97 keskimäärin 70-75 prosenttia osingon määrästä. Tulokset viittaavat siihen, että kotimaiset sijoittajat olivat marginaalisia sijoittajia ensiksi mainitulla periodilla ja ulkomaiset jälkimmäisellä. Uutena löytönä Suomen osakemarkkinoilla saadaan heikkoa tukea clientele-efektin olemassaololle vuosina 1989-90. Likvideistä korkean osinkotuoton osakkeista kootun salkun vaihdon volyymi oli osingon irtoamispäivänä ja sitä edeltävänä päivänä normaalia suurempi ja kahtena seuraavana kaupankäyntipäivänä normaalia pienempi. Salkun tuotto ei kuitenkaan näinä päivinä poikkea tavallisesta. Tulokset viittaavat siihen, että pitkän tähtäimen sijoittajat ajoittivat kauppojaan osinkolipun irtoamisen läheisyyteen, eikä lyhytaikainen kaupankäynti ollut merkittävää.

Esseessä 2 johdetaan osakekurssien käyttäytymistä osinkolipun irrotessa kuvaava malli, joka ottaa eksplisiittisesti huomioon osakekurssien epäjatkuvuuden. Hintojen epäjatkuvuuden huomioon ottaminen tuo malliin parametrin, joka kuvaa hintojen pyöristämistä markkinoilla ja tekee mallista epälineaarisen. Pyöristäminen on tarpeen, koska hintojen täytyy aina olla tietyn luvun kerrannaisia. Esseessä osoitetaan, että osingon irtoamispäivänä hinnan laskun ja osingon suhde on osingon paloittain aleneva konveksi funktio. Annetulla edellisen päivän kurssilla osingon irtoamispäivän tuotto on osinkotuoton paloittain lineaarinen funktio. Hintojen epäjatkuvuuden vaikutus osingon irtoamispäivän tuottoon riippuu käänteisesti osakkeen hinnasta. Tämän vuoksi osakekurssien jakauma on otettava huomioon selitettäessä hinnan käyttäytymistä osingon irrotessa.

Esseessä 3 tutkitaan, kuinka tarkasti osingon irtoamispäivän kurssilaskun sisältämä implisiittinen veroaste voidaan päätellä yleisimmin käytetyillä menetelmillä silloin kun osakekurssit ovat epäjatkuvia. Simulointikokeet antavat seuraavia tuloksia. Ensiksi, Michaelyn (1991) esittämä GLS-estimaattori on neljästä tarkastellusta tilastosuureesta paras. Se on harhaton ja sillä on pienin varianssi. Perinteinen hinnan pudotuksen ja osingon suhde pärjää vertailussa huonoiten. Toiseksi, osakekurssien noteeraustarkkuudella on merkitystä vain kun osingon irtoamispäivän hintaa ei tarvitse korjata yliyön tuotolla. Pyöristämisen vaikutus hintaan on aina pienempi kuin pienin mahdollinen (nollasta poikkeava) hinnan muutos, koska hinta pyöristetään lähimpään mahdolliseen sallittuun hintaan. Yliyön tuottoa estimoitaessa tehdyillä virheillä saattaa olla monta kertaa suurempi vaikutus kuin hinnan pyöristämisellä. Mikäli hinnasta on puhdistettava yliyön tuotto, hintojen noteeraustarkkuus ei vaikuta implisiittisen veroasteen estimointiin. Yliyön tuoton poistamisessa tehtävät virheet ovat suurempia kuin noteeraustarkkuuden aiheuttamat virheet. Itse asiassa, mikäli osingon irtoamispäivän kurssista on poistettava yliyön tuotto, on samantekevää, ovatko osakekurssit jatkuvia vai epäjatkuvia. Lopuksi, yleisimmin käytettyjen testisuureiden keskivirheet ovat niin suuria, että clientele-vaikutuksen tunnistaminen on hyvin vaikeaa.

AVAINSANAT: noteeraustarkkuus, osakekurssit, osingot, verotus

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Espoo, January 2000

Pasi Sorjonen

CONTENTS

1 INTRODUCTION

According to stock markets' trading rules, shares are traded with dividend coupons until the opening of the first trading day after the shareholders' meeting and without dividend coupons thereafter. The first trading day after the shareholders' meeting is called the (first) ex-dividend day and the previous trading day, usually the day of the shareholders' meeting, is called the (last) cum-dividend day. Because shares are sold on cum-dividend days with dividend coupons that entitle the owners of these shares to a previously announced dividend payment with certainty, and on ex-dividend days the same shares are sold without these coupons, one would expect that the cum-ex stock price differential is informative of the after-tax market value of the dividend.[1] Indeed, it has been argued that the ex-dividend day price drop and the dividend amount can be used to infer the tax rate of the marginal investor.

This thesis is a collection of three essays on the ex-dividend value of corporate shares. Each essay studies the behaviour of stock prices around ex-dividend days from a slightly different angle. Essay 1 is an empirical study of stock price behaviour around ex-dividend days in the Helsinki Stock Exchange in two time periods, 1989-90 and 1993-97. Essay 2 extends the standard model of stock price behaviour around ex-dividend days to take explicitly into account the accuracy with which prices can be quoted. Essay 3 is a simulation study, which examines the effect of discrete prices on the performance of methods commonly used in ex-day studies.

The organisation of the thesis is as follows. Chapter 2 gives an overview of the literature on ex-dividend day stock price behaviour. Sections 2.1 to 2.3 review the theory, empirical tests and earlier empirical findings. Finally, Chapter 3 outlines the three essays that follow, discusses how they are related to earlier studies, and summarises the results.

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[1] The amount of the dividend is decided in the shareholders' meeting on the basis of the Board's dividend proposal. Usually the Board announces its proposal up to several weeks before the meeting. In practise, the proposed dividend is typically accepted. The proposal is also published in the press, so that the magnitude of the dividend payment is public knowledge well before the shareholders' meeting.

2 AN OVERVIEW OF EX-DIVIDEND DAY STOCK PRICE BEHAVIOUR

There are two major hypotheses about stock price behaviour on ex-dividend days, the tax hypothesis and the short-term trading hypothesis. The tax hypothesis was first introduced formally by Elton and Gruber (1970). At that time, the general feeling in the financial community was that stock prices should fall on ex-dividend days by exactly the amount of the dividend. Elton and Gruber provided an economic explanation for why stock prices could actually fall by less than that [2], an observation made in practice and confirmed by early studies (see Campbell and Beranek (1955) and Durand and May (1960)). According to the tax explanation, the ex-dividend day price drop will be smaller than the dividend if dividends are taxed more heavily than long-term capital gains. More importantly, however, Elton and Gruber argue that it is possible to infer from the price drop the marginal tax rate of the marginal stockholder, which is otherwise unobservable. Stockholders' tax rates can be important, because, for example, they affect the cost of capital, enter share valuation models and have implications for corporate financial policy. What is convenient about the celebrated ex-dividend method is that one does not have to assume any particular asset pricing model in order to estimate the tax rate.

The second explanation, the short-term trading hypothesis, was first discussed by Kalay (1982). Kalay's view is based on the institutional fact that in the U.S. (as well as in many other countries) short-term capital gains are taxed at the same rate as dividends. He argues that if transaction costs are low enough and the dividend yield high enough it may be that short-term traders, who trade in order to collect dividends, rather than long-term investors, are those who determine stock prices around ex-dividend days. If this view is correct, it will not be possible to detect long-term tax rates from the ex-day price drop as was argued by Elton and Gruber. We shall discuss these two hypotheses at greater length in Section 2.1. Section 2.2 discusses test statistics used in empirical testing and Section 2.3 concludes with a review of empirical tests and findings.

[2] They also provided an explanation for why prices could fall by more than the dividend amount.

2.1 Theory

2.1.1 The tax hypothesis

Elton and Gruber (1970) (EG hereafter) argue that by observing the ex-day price change it is possible to infer the tax rate of the marginal investor. EG assume an expected after-tax wealth maximising stockholder who has decided to sell his shares and who is currently deciding on the timing of the sale. They assume an economy, where (*i*) investors are risk neutral, (*ii*) there are no transaction costs, (*iii*) all investors are subject to the same tax rates, and (*iv*) tax rates are known.

Let P_{cum} = Stock price on the cum-dividend day

P_{ex} = Stock price on the ex-dividend day

P_0 = Price at which the stock was purchased

D = The amount of dividend per share

τ_d = Marginal tax rate on dividends

τ_g = Marginal tax rate on capital gains.

Assume a current stockholder who has decided to sell his stock. He can either sell the stock on the cum-dividend day, before the stock goes ex-dividend, in which case he loses the dividend, or he can sell the stock on the ex-dividend day after receiving the dividend. If the stockholder sells on the cum-dividend day, he gets the cum-dividend stock price, P_{cum}, minus any capital gains tax liability, $\tau_g(P_{cum}-P_0)$, that may arise from the sale. His after-tax return will therefore be equal to

$$(1) \qquad P_{cum} - \tau_g(P_{cum} - P_0).$$

If the shareholder sells on the ex-dividend day, he gets the after-tax dividend, $(1-\tau_d)D$, and the ex-day stock price, P_{ex}, minus the capital gains tax liability, $\tau_g(P_{ex}-P_0)$, and the after-tax return will be

(2) $$P_{ex} - \tau_g (P_{ex} - P_0) + (1 - \tau_d) D.$$

For the shareholder to be indifferent between selling cum and ex, the after-tax returns must be equal. Therefore,

(3) $$P_{cum} - \tau_g (P_{cum} - P_0) = P_{ex} - \tau_g (P_{ex} - P_0) + (1 - \tau_d) D.$$

Equation (3) can be rearranged to get

(4) $$\frac{P_{cum} - P_{ex}}{D} = \frac{1 - \tau_d}{1 - \tau_g}.$$

Equation (4) formalises the tax hypothesis of EG.[3] The left-hand side of Equation (4) is the ex-dividend day price drop standardised by the dividend per share. The right-hand side is the marginal tax rate of the marginal investor, a variable that is generally unobservable. The tax hypothesis says that it is possible to infer this tax rate from the ex-dividend day price drop.[4]

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[3] Note that Equation (4) can be derived also by assuming that the marginal investor is a buyer, who has already decided to buy the stock but who still has to decide on the timing of the purchase. Letting P_1 denote the future selling price, buying cum-dividend yields

$$-P_{cum} + P_1 - \tau_g (P_1 - P_{cum}) + (1 - \tau_d) D$$

and buying ex

$$-P_{ex} + P_1 - \tau_g (P_1 - P_{ex}).$$

Setting the cum and ex-day returns equal to each other yields (4).

[4] Transaction costs make Equations (1) and (2) only slightly more complicated. Denote proportional transaction costs of a stock purchase by t and those of a sale by s and assume that transaction costs are fully deductible from the capital gains. If the marginal investor is a seller, who is deciding on the timing of the sale, we get

$$\frac{P_{cum} - P_{ex}}{D} = \frac{1}{1 - s} \frac{1 - \tau_d}{1 - \tau_g}.$$

Note that the cost of buying does not enter the formula above while the cost of selling does. The cost of buying does not depend on the timing of the sale and is therefore taken as given. The cost of selling depends on the selling price, which in turn depends on the timing of the sale.

If the marginal investor is a buyer, who is deciding on the timing of the purchase, we get

Equation (4) shows the connection between the ex-dividend day behaviour of stock prices and the tax rates of the marginal stockholder. It says that for the market to be in equilibrium the expected ex-dividend day stock price must be such that it makes prospective marginal buyers (sellers) indifferent between buying (selling) cum and ex. If the expected ex-dividend day stock price were too high, marginal sellers would find it profitable to defer their sales till the ex-dividend day while marginal buyers would accelerate their purchases before the ex-day. Respectively, if the expected ex-dividend day stock price were too low, marginal sellers would accelerate their sales before the ex-dividend day and marginal buyers would defer their purchases till the ex-day. Marginal investors continue to accelerate and decelerate their purchases and sales as long as their after-tax wealth depends on the timing of their transactions. Arbitrage will continue until selling (or buying) cum and ex gives the same after-tax wealth, which guarantees that ex-day stock price behaviour reveals the marginal tax rates of the marginal investor.

Next, consider the interpretation of Equation (4). First note that the size of the ex-dividend day price drop depends on the marginal tax rates on dividends and capital gains. The typical finding in ex-dividend studies prior to EG was that prices tend to fall on ex-days by less than the amount of the dividend, which implies that the left-hand side of (4) is less than one. The previous empirical findings are therefore consistent with a tax system, which taxes dividend income at a higher rate than capital gains ($\tau_d > \tau_g$). In the opposite case ($\tau_d < \tau_g$), the tax explanation predicts that stock prices fall on ex-dividend days by more than the amount of the dividend.

The right-hand side (RHS) of (4), $(1-\tau_d)/(1-\tau_g)$, can be interpreted as the marginal rate of substitution between dividends and capital gains. It gives the value of after-tax dividends in terms of before-tax capital gains. Putting it differently, it tells how many dollars of capital gains (before-tax) are needed to give the marginal investor the same after-tax

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$$\frac{P_{cum} - P_{ex}}{D} = \frac{1}{1+t}\frac{1-\tau_d}{1-\tau_g}.$$

Now the cost of selling is taken as given. Only the cost of buying depends on the timing of the purchase and therefore enters the ex-ratio formula above.

income as one dollar of dividends (before-tax). Dividends and capital gains are perfect substitutes [that is, $(1-\tau_d)/(1-\tau_g) = 1$] only if they are taxed at the same rate ($\tau_d = \tau_g$).

Elton and Gruber also suggested that there possibly exists a tax-based clientele effect.[5] They suggest that investors with high dividend tax rates want to avoid dividend income and therefore tend to invest in companies with low payout ratios. Stated differently, the higher the dividend tax rate, the smaller the proportion of stock returns the stockholder wants to get in the form of dividends and, hence, the more likely he is to hold stocks with low dividend yields. The tax clientele hypothesis therefore predicts that the dividend tax rate is negatively and the ex-dividend ratio positively correlated with the dividend yield (or the payout ratio).

To obtain more insight, it is useful to express the tax hypothesis in terms of stock returns. First, define the observed ex-dividend day return of stock i as $r_i = (P_{i,ex}-P_{i,cum}+D_i)/P_{i,cum}$. Some manipulation of Equation (4) yields

(5) $$r_i = (1-\alpha)d_i \equiv R_{LTi}$$

where $d_i=D_i/P_{i,cum}$ is the dividend yield and $\alpha = (1-\tau_d)/(1-\tau_g)$. R_{LTi} is the equilibrium rate of return if long-term investors set prices in the market. If dividends are taxed more heavily than capital gains ($\tau_d>\tau_g$), the equilibrium ex-day returns are positive, because stockholders require an extra return, a tax premium, as compensation for the extra taxes they have to pay. The size of the premium is $100(1-\alpha)$ per cent per unit of dividend yield.[6] Note that in Equation (5), the tax premium is assumed to be the same for all stocks. This is opposite to the prediction of the tax clientele hypothesis. The tax clientele hypothesis

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[5] Dividend clienteles were actually first suggested by Miller and Modigliani (1961), but their argument was based on an unspecified reason, not necessarily tax-related, to prefer one payout policy to other payout policies.

[6] Sometimes a constant is added to (5) to get

$$r_i = \mu + (1-\alpha)d_i.$$

The parameter μ has a useful interpretation. The dividend yield equals zero for all non-ex-days and the expected rate of return for these days is μ. On ex-days $D_i \neq 0$ and the expected rate of return equals μ only if $\alpha = 1$. In other words, stockholders expect to get the same return on ex-days and non-ex-days only if dividends and capital gains are taxed at the same rate ($\tau_d = \tau_g$).

predicts that the size of the tax premium 1-α is not constant across stocks, but rather varies with dividend yield being smaller for high-yield stocks and sometimes even negative. If the tax clientele hypothesis is correct, the relation between ex-day returns and dividend yield in (5) becomes weaker and difficult to identify empirically.[7]

To summarise, the predictions and implications of the tax hypothesis are the following. First, stock prices fall on ex-dividend days by less than the full amount of dividend if $\tau_g < \tau_d$. This is equivalent to saying that the ex-dividend day ratio is less than one or that the ex-dividend day abnormal return, or tax premium, is positive. Second, if there is a tax-based clientele, the ex-dividend day ratio is positively correlated with the dividend yield. This in turn is equivalent to saying that the ex-dividend day abnormal returns, or tax premiums, are negatively related to dividend yield. The tax premium may actually be negative for high-yield stocks.

[7] Previous research has taken the view that transaction costs should not enter (3) because long-term investors have already decided to trade and are only choosing the correct moment to do so. This view may be slightly incorrect. If transaction costs are proportional to the stock price, the investor will most likely incur smaller transaction costs when trading takes place on ex-days rather than cum-days, because stock prices tend to be lower on ex-days. If the cost of transacting depends on the timing of the trade, it should enter (3). Working out the details yields

$$r_i = (1-\alpha)d_i + t\frac{P_{i,cum} + P_{i,ex}}{P_{i,cum}} \equiv R_{LT}.$$

When dividends are small, stock prices on cum- and ex-days are likely to be very close. In that case the RHS term is approximately equal to $2t$, something that would be captured by a regression constant, and we get

$$r_i = (1-\alpha)d_i + 2t.$$

For large dividends cum- and ex-prices will not be equal. Assume that investors' expectations of the ex-price are rational. Under rational expectations, $P_{ex} = P_{cum} - \alpha D$. Inserting for $P_{i,ex}$ yields

$$r_i = \left[1-(1-t)\alpha\right]d_i.$$

Now transaction costs show up in the coefficient of d_i. The coefficient is reduced by $t\alpha$ compared to the case in the absence of transaction costs.

2.1.2 The short-term trading hypothesis

EG argue that stock prices may fall on ex-dividend days by less (or more) than the amount of dividend depending on the tax rates of the marginal investor. For example, if investors are taxed more heavily on dividends than on capital gains, they will choose the timing of their trading such that they are indifferent between buying or selling cum and ex. Then the equilibrium ex-dividend day price drop will be smaller than the dividend. Kalay (1982) disagrees with this view and argues that if stock prices do not fall on ex-dividend days by the full amount of dividend, then it may be possible for short-term traders to earn profits by trading around ex-days and exploit the difference between the dividend and the price drop. This argument is usually called the short-term trading hypothesis. It is originally based on the differential tax treatment of short-term and long-term capital gains in the U.S., where short-term capital gains and dividends are taxed as ordinary income, that is, at the same rate, whereas long-term capital gains are taxed at a lower rate. Profits from short-term trading will disappear when the ex-dividend day share price drop is approximately equal to the dividend and the ex-dividend ratio (4) is close to unity. At this point, the ex-dividend ratio reflects the tax rates and transaction costs of the short-term trading population rather than those of long-term investors. The implication of the short-term traders determining stock prices around ex-days is therefore that, contrary to EG's original argument, it will not be possible to infer the tax rates of the long-term investor from the ex-dividend ratio. In the presence of short-term trading, the ex-dividend ratio will be close to unity no matter what the tax rates of long-term investors are. In the absence of transaction costs, short-term trading would force the ex-dividend ratio precisely equal to one.[8]

It is important to note that the motives behind the actions of long-term and short-term investors are different. Long-term investors are concerned with the timing of their trades. They have already decided to trade for reasons not related to the dividend. The problem

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[8] The short-term trading hypothesis does not require, nor is based on, an assumption that dividends and short-term capital gains are taxed at the same rate. The crucial thing is that, whatever the tax rates are, if the tax rates of long-term and short-term traders differ sufficiently, the short-term trading population will find it profitable to trade around ex-days until the ex-ratio reflects their own tax rates and transaction costs. Kalay's original formulation of the hypothesis takes advantage of one institutional detail in the U.S. tax code. Applied to other countries and tax codes the ex-ratio predicted by the short-term trading hypothesis might look different.

they face is whether to trade before the stock goes ex-dividend or after that. Short-term traders trade because of the pricing of the dividend. Their incentive to trade would vanish if all investors had identical capital income tax rates.

Kalay notes that because of transaction costs short-term profits are eliminated if the ex-dividend ratio stays within certain bounds. Dividend capturing, that is, buying cum and selling ex, is profitable as long as the dividend payment is larger than the price drop plus transaction costs. Profits will therefore be eliminated if

$$(6) \qquad D-(P_{cum}-P_{ex})-2t\overline{P}\leq 0$$

where t is a transaction cost proportional to the stock price and $\overline{P}=(P_{cum}+P_{ex})/2$. Another way to trade around ex-days is to sell the stock short before it goes ex and buy it back afterwards. Short selling is profitable if the cum-dividend price is large enough to cover transaction costs, the repurchase price, P_{ex}, and the dividend payment, which must be returned to the initial owner of the stock. Profits from selling short will therefore be eliminated if

$$(7) \qquad P_{cum}-P_{ex}-D-2t\overline{P}\leq 0.$$

Combining (6) and (7) yields the following range within which the ex-dividend ratio must lie in order to prevent profitable short-term trading

$$(8) \qquad 1-\frac{2t}{D/\overline{P}}\leq\frac{P_{cum}-P_{ex}}{D}\leq 1+\frac{2t}{D/\overline{P}}.$$

The double inequality (8) gives the condition under which the tax rates of the long-term investor can be inferred from stock price behaviour around ex-days. It implies a number of things. First, short-term trading around ex-days is unprofitable, if the ex-ratio is within the range given by (8). On the other hand, a finding that ex-ratios fall outside the range implies that there are unexploited profit opportunities for short-term traders. This means that short-term trading is not an important determinant of stock prices around ex-days.

Otherwise, the profits would be exploited until they vanish and either one of the bounds in (8) becomes binding. But then, if either one of the bounds in (8) is binding, short-term trading must be important. Second, the profitability (and likelihood) of short-term trading decreases with transaction costs and increases with dividend yield. This is obvious, because for given transaction costs, the width of the range in (8) decreases with dividend yield, and for a given dividend yield, the width of the range increases with transaction costs. Finally, if selling short is not allowed, only the lower bound is relevant. Assume that this is indeed the case and that short-term traders are the marginal traders who set prices around the ex-day. To eliminate profits the lower bound must be binding, in which case the observed ex-ratio equals the lower bound. For given transaction costs, the lower bound, which equals the observed ex-ratio, increases with dividend yield. Hence, in the absence of short selling, the prediction of the short-term trading hypothesis is that ex-ratios increase with dividend yield. Exactly the same prediction is given by the tax clientele hypothesis. Since the two hypotheses yield similar predictions of the relation between dividend yield and ex-ratio, one must be careful in conducting empirical tests and interpreting results.

As with the tax hypothesis, it is convenient to rewrite the short-term trading hypothesis in terms of stock returns. For simplicity, we break the double inequality (8) into two separate inequalities and examine the returns to selling short and dividend capturing separately. First, from (8) we see that short-selling around ex-dividend days is unprofitable as long as

$$(9) \qquad r_i \geq -2t\,\overline{P}_i \big/ P_{i,cum} \equiv R_{SSi}$$

where $\overline{P}_i = (P_{i,cum} + P_{i,ex})/2$ and R_{SSi} is the lowest ex-day return consistent with short-selling equilibrium. Inequality (9) is binding if short-sellers set stock prices around ex-days. Because transaction costs are strictly positive, (9) implies that short selling is profitable only if ex-day returns are sufficiently negative. In addition, ex-day returns decrease with transaction costs. Karpoff and Walkling (1990) note that most studies report positive ex-day returns and therefore short-selling around ex-days is probably not very common.

Dividend capturing is unprofitable as long as

$$(10) \qquad r_i \leq 2t\,\overline{P}_i / P_{i,cum} \equiv R_{1i}$$

where R_{1i} is the highest ex-day return consistent with buying cum and selling ex. Condition (10) is binding if short-term traders who trade in order to collect dividends set prices in the market. If this is the case, equilibrium ex-day returns are positive and increase with the cost of transacting (but will not exceed round-trip transaction costs). Both short selling and dividend capture imply that ex-day stock returns are unrelated to dividend yield if $\tau_d = \tau_g$ for the short-term trader. In terms of Equation (5), this implies that the coefficient of dividend yield, 1-α, is zero.

There is no reason why the analysis of short-term trading should be restricted to investors whose dividend income and capital gains are taxed at the same rate. In some countries, there are investors who actually favour dividends over capital gains due to tax considerations. Common examples are U.S. corporations for whom only 15 per cent of the dividends received used to be taxable. The effective dividend tax rate was therefore very low for them, only 0.15 times the corporate tax rate. Such investors may not only find it profitable to buy the stock cum and sell ex, but they may also be willing to accept a negative ex-day rate of return. Let γ denote the taxable proportion of dividend income. Buying cum and selling ex is unprofitable if

$$(11) \qquad -(1+t)P_{cum} + (1-t)P_{ex} - \tau_g\left[(1-t)P_{ex} - (1+t)P_{cum}\right] + D - \tau_d \gamma D \leq 0$$

which implies the following restriction for the return on stock i

$$(12) \qquad r_i \leq \frac{\gamma\tau_d - \tau_g}{1-\tau_g} d_i + 2t\,\overline{P}_i / P_{i,cum} \equiv R_{2i}$$

where R_{2i} denotes the highest ex-day stock return consistent with buying cum and selling ex when only a proportion γ of dividends is taxable. Assuming that $\tau_d = \tau_g = \tau$, (12) simplifies to (see Lakonishok and Vermaelen (1986))

(13) $$r_i \leq 2t\,\overline{P}_i / P_{i,cum} - \frac{(1-\gamma)\tau}{1-\tau} d_i \equiv R_{2i}.$$

Inequality (12) is binding if short-term traders who prefer dividends to capital gains are the marginal traders.[9] Since they pay lower taxes on dividends than on capital gains, the required rate of return decreases with dividend yield. The required return can be negative if the dividend yield is very high and the dividend tax benefits more than compensate for the transaction costs.

To summarise the discussion above, assuming that short selling is not allowed, the short-term trading hypothesis predicts the following. First, the profitability of short-term trading increases with dividend yield and decreases with transaction costs. If short-term trading is important so that profits from buying cum and selling ex are eliminated, ex-ratios tend to increase with dividend yield. The same prediction is given by the tax clientele hypothesis and, therefore, it may be difficult to interpret empirical results. Second, if $\tau_d = \tau_g$ for short-term traders, ex-ratios tend to vary around unity and ex-day returns are determined by transaction costs and are unrelated to dividend yield. If a short-term trading population with $\tau_d < \tau_g$ is important in determining prices around ex-days, ex-ratios tend to be greater than one and ex-day returns negatively related to dividend yield. Returns can be either positive or negative.

2.1.3 The current view

An obvious question to ask when there are two or more trading populations with different tax rates is, which population determines stock prices around ex-days. The answer is that, in an auction market, stock prices are set by those who are willing to pay the highest price,

[9] Condition (10) is a special case of (12). Note that (12) can also be written as

$$R_i \leq (1-\alpha_{st})d_i + 2t\,\overline{P}/P_{i,cum} \equiv R_{ST}$$

where $\alpha_{st} = (1 - \gamma\tau_d)/(1-\tau_g)$ reflects the tax rates of a short-term investor.

or equivalently, by those who require the lowest return. The two hypotheses discussed above can be combined by writing the equilibrium ex-dividend day rate of return as

(14) $$r_i = \min(R_{LTi}, R_{1i}, R_{2i}).$$

Long-term traders set prices if transaction costs are high enough to prevent dividend capture trading, in which case

(15) $$R_{LT} = \min(R_{LT}, R_{1i}, R_{2i}).$$

In the opposite case, when transaction costs are low enough to allow dividend capture trading, short-term traders take full advantage of the difference between the dividend amount and the ex-day price drop and press the ex-day stock return down to the level where it reflects the costs of transacting for the marginal investor.

Early ex-dividend studies treated the tax hypothesis and the short-term trading hypothesis as more or less competing, and either hypothesis is expected to describe the ex-day behaviour of all stocks. The current view is that the two hypotheses are complementary rather than competing. The tax hypothesis is likely to describe the behaviour of one class of stocks while the short-term trading hypothesis is probably more capable of describing the behaviour of another class of stocks. In addition, there may be stocks whose behaviour is well explained by neither of the two hypotheses. In empirical work, the issue is basically to find variables that partition the sample into two sub-samples, one that is expected to give support to the tax hypothesis and another to support the short-term trading hypothesis.

As discussed above, Kalay (1982) demonstrates that the profitability of short-term trading increases with dividend yield and decreases with transaction costs.[10] In addition to dividend yield and transaction costs, still another variable that is important to short-term traders, but not necessarily to long-term investors, is liquidity (see Stickel (1991)). For

[10] By transaction costs is usually meant not only the actual trading costs but also the bid-ask spread. Karpoff and Walkling (1990) hypothesise that among stocks that are likely to attract short-term traders the ex-day return is positively correlated with the bid-ask spread, which serves as a proxy for transaction costs.

short-term traders, who trade because of the dividend, it is important that they can purchase the stock just before it goes ex-dividend and get rid of it immediately after that. The most likely candidates for targets of dividend capture are therefore liquid high yield stocks with small bid-ask spreads. It is probably among that those kinds of stocks that evidence in favour of the short-term trading is to be found. The most likely source of evidence in favour of the tax hypothesis are stocks of the opposite kind, the less liquid, low-yield stocks.

While Stickel (1991) concentrates on analysing returns on liquidity and dividend yield sorted portfolios, Lakonishok and Vermaelen (1986) analyse trading volume directly without resorting to stock returns. They note that tests based on trading volume may do a better job than tests based on stock returns in distinguishing between the tax clientele and short-term trading hypotheses. They derive three intuitive hypotheses about how trading volume should behave around ex-days if short-term traders are marginal traders. First, if short-term trading is important, investors either buy or sell short before the stock goes ex and sell or buy back after that. This implies that there will be abnormally high trading volume both before and on or after ex-days. If a minimum holding period is required, abnormal trading volume will extend to a longer period. If, on the other hand, short-term trading is unimportant, there should be no abnormal trading volume at all. Second, since profits from short-term trading decrease with transaction costs, one would expect a negative relation between abnormal volume and the cost of trading. Finally, short-term trading profits are likely to be higher for high-yield stocks and, therefore, a positive relation between abnormal trading volume and dividend yield is expected.

2.2 Empirical tests

We start by discussing what kind of test statistics have been used and try to show how they are related to each other. Some econometric problems are discussed as well. We also show how option prices can be used to estimate the implicit tax rate and discuss how dividend stripping can be seen as an event and how event study methodology can be used in ex-day studies.

2.2.1 Test statistics

The before-tax return on stock i at time t is a random variable, which can be written as the sum of expected and unexpected returns as

$$(16) \qquad R_{it} = E(R_{it}) + \varepsilon_{it} \qquad \varepsilon_{it} \sim N(0, \sigma_i^2).$$

The standard assumption in finance is that the error term is homoskedastic so that each stock has a constant variance of unexpected returns. The expected return, $E(R_{it})$, in (16) is given by an appropriate asset pricing model and does not necessarily have to be constant over time[11]. Define the expected before and after tax returns of stock i over a short time interval $(t\text{-}1,t)$ as

$$(17) \qquad E(R_{it}) = \frac{E(P_{it}) - P_{it-1} + D_{it}}{P_{it-1}}$$

and

$$(18) \qquad E(R_{it}^{at}) = \frac{(1-\tau_g)[E(P_{it}) - P_{it-1}] + (1-\tau_d)D_{it}}{P_{it-1}}$$

where the dividend is assumed to be known with certainty. Manipulating (18) and using (17) yields

$$(19) \qquad E(R_{it}) = \frac{E(R_{it}^{at})}{1-\tau_g} + \frac{\tau_d - \tau_g}{1-\tau_g}\frac{D_{it}}{P_{it-1}}.$$

Equation (19) shows that the expected return of stock i can be divided into two components. The first component is the expected non-ex-day return and the second component is a tax premium, which can be non-zero only on ex-days. For simplicity, assume that the expected non-ex-day return is constant over time and denote it by μ_i. Using $\alpha = (1\text{-}\tau_d)/(1\text{-}\tau_g)$ and inserting (19) into (16) yields the ex-day tax premium

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[11] See Brown and Warner (1985).

$$R_{it} - \mu_i = (1-\alpha)\frac{D_{it}}{P_{it-1}} + \varepsilon_{it} \quad , \qquad \varepsilon_{it} \sim N(0,\sigma_i^2). \tag{20}$$

Let day t be the ex-dividend day and day t-1 the cum-dividend day. To emphasise this, we change notation by replacing t-1 and t by *cum* and *ex*. Dividends can be non-zero only on ex-days and therefore we drop the time subscript from the dividend term. We also drop the time subscript from the error term, because we are interested in stock returns only on ex-days. Equation (20) can now be rewritten as

$$\frac{P_{i,ex} - (1+\mu_i)P_{i,cum} + D_i}{P_{i,cum}} = (1-\alpha)\frac{D_i}{P_{i,cum}} + \varepsilon_i \quad , \qquad \varepsilon_i \sim N(0,\sigma_i^2). \tag{21}$$

The left-hand sides of (20) and (21) show that deducting the expected non-ex-day return from the observed ex-day return is equivalent to adjusting the observed cum-dividend day stock price by the same expected non-ex-day return.

Equations (20) and (21) show that the implicit tax rate, α, can be estimated with simple regression analysis by explaining ex-day stock returns, adjusted by expected non-ex-day return, with dividend yield. A finding that $\alpha \neq 1$ is usually interpreted as evidence in favour of the tax explanation, if the value of α is plausible under the particular tax system in question. For a given stock i, the residual variance is constant. However, return volatility usually differs across stocks and ex-dividend day studies typically use cross-sectional data. When cross-sectional data is used, the variance of ε_i is not constant and therefore the model exhibits heteroskedasticity in the residuals. The OLS estimators of the regression coefficients are unbiased but inefficient.

Lakonishok and Vermaelen (1983) use an alternative formulation of (21). Rearranging terms and letting $\Delta P_i = (1+\mu_i)P_{i,cum} - P_{i,ex}$ and $d_i = D_i / P_{i,cum}$, one can rewrite (21) as

$$\frac{\Delta P_i}{P_{i,cum}} = \alpha d_i + \varepsilon_i . \tag{22}$$

Taking averages of both sides and solving for α yields the so called equally weighted portfolio statistic

(23) $$\alpha = \overline{\left(\frac{\Delta P}{P}\right)} \Big/ \overline{d}$$

where $\overline{d}$ and $\overline{(\Delta P/P)}$ are sample averages of d_i and $\Delta P_i \,/\, P_{i,cum}$, respectively. It is obvious that this formulation does not solve the heteroskedasticity problem because the starting point is the same as in the model presented in (21).

To correct for heteroskedasticity of ε_i in (21), both sides of (21) must be divided by σ_i yielding

(24) $$\frac{1}{\sigma_i}\frac{P_{i,ex} - (1+\mu_i)P_{i,cum} + D_i}{P_{i,cum}} = (1-\alpha)\frac{d_i}{\sigma_i} + \eta_i \quad , \qquad \eta_i \sim N(0,\sigma^2).$$

Rearranging terms yields the *GLS*-estimator of the ex-dividend ratio, first proposed by Michaely (1991)

(25) $$\frac{d_i}{\sigma_i}\frac{\Delta P_i}{D_i} = \alpha\frac{d_i}{\sigma_i} + \eta_i \quad , \qquad \eta_i \sim N(0,\sigma^2).$$

Both formulations, (24) and (25), can be used to estimate α. Sometimes we may not have information about σ_i and therefore can not make the correction for heteroskedasticity. If σ_i is set equal to unity, (25) simply reduces to (21).

When both sides of (25) are divided by d_i/σ_i we get the traditional average ex-dividend day ratio model of Elton and Gruber (1970)

(26) $$\frac{\Delta P_i}{D_i} = \alpha + \xi_i \quad , \qquad \xi_i \sim N\left(0,\sigma_i^2/d_i^2\right).$$

The average ex-dividend ratio can thus be estimated by regressing the relative price drops, $\Delta P_i/D_i$, on a constant only. In (26), α is an unbiased estimator of the tax parameter. The residual is heteroskedastic though, because the estimation procedure does not take differences in return volatility and dividend yields explicitly into account. The average ex-ratio can also be computed as the average of the individual ex-day ratios, $\Delta P_i/D_i$, in the sample.

Equation (20) can be written in excess return form as

$$ER_i = R_i - \mu_i = (1-\alpha)d_i + \varepsilon_i \tag{27}$$

where R_i is observable, μ_i can be estimated and $1\text{-}\alpha$ is assumed constant. The average ex-day excess return can be written as

$$AER = R - \mu = (1-\alpha)\bar{d} \tag{28}$$

where R is the average ex-day return and $\bar{d}$ is the average dividend yield. A non-zero AER is evidence in favour of a tax premium. Eades, Hess and Kim (1984 and 1994) use standardised excess returns in estimating the tax premium. The standardised excess return, SER_i, is obtained by dividing excess returns in (27) by the standard deviation of stock returns, σ_i, which can be estimated from stock return data[12]

$$SER_i = \frac{R_i - \mu_i}{\sigma_i} = \frac{(1-\alpha)d_i}{\sigma_i}. \tag{29}$$

Under the null hypothesis of no tax effect, the test statistic follows a student-t distribution with mean zero and variance of one.

Excess returns are sometimes used in examining tax clienteles even though they are not appropriate for this purpose. The tax clientele hypothesis predicts that investors with a higher dividend tax rate tend to invest in stocks with a lower dividend yield, which implies a negative relationship between dividend yield and $1\text{-}\alpha$. To demonstrate the

[12] Eades, Hess and Kim use data from the period 30 days before and after ex-days to estimate γ_0 and σ_i. A different estimation period starting from 50 days and ending 11 days before ex-day did not affect the results obtained.

shortcomings of excess returns in discovering tax clienteles assume that $1\text{-}\alpha$ is positive. Dividend yield is always non-negative. Further assume that there is a perfect negative correlation between d_i and $1\text{-}\alpha$, which we are trying to detect. The table below shows hypothetical values for the two variables and their product assuming that the data set is first divided into quintiles according to dividend yield.

$\bar{d}$	$1\text{-}\alpha$	$(1\text{-}\alpha)\bar{d}$
0.01	0.25	0.0025
0.02	0.20	0.0040
0.03	0.15	0.0045
0.04	0.10	0.0040
0.05	0.05	0.0025

Excess returns always measure the tax premium, $(1\text{-}\alpha)\bar{d}$. The table shows that the tax premium first increases and then falls. There is 'evidence' of a tax effect because the tax premium is non-zero, but there is no indication of a clientele effect. This is because excess returns can not identify a clientele effect. To estimate the implicit tax rates and discover the clientele effect, excess returns must be divided by dividend yield. The phenomenon at hand is familiar from microeconomics. With a linear demand curve, consumption expenditure (the product of price and quantity) first rises when price falls, but after reaching the point where the price elasticity of demand equals minus unity, further price declines lead to a fall in expenditure.

2.2.2 Call option prices and ex-ante ex-ratios

Ex-dividend studies traditionally estimate ex-post ex-ratios from realised stock price data. Investors who trade around ex-days, especially short-term traders who trade in order to capture dividends, do not know the ex-ratio in advance and, therefore, they must have in mind some expected value, or ex-ante ex-ratio, on which they base their decision to trade. In general, the ex-ante and ex-post ex-ratios need not be the same. They are on average the same only when expectations are rational. Ex-ante ratios are important, because they reflect market participants' expectations of the ex-ratio. It would therefore be convenient to have a method, which could be used to derive estimates of ex-ante ex-ratios. Recently, some authors have employed a novel technique to estimate the ex-ante ex-ratio implicit in prices of dividend unprotected call options (see Kalay and Subrahmanyam (1984) for pricing call options around ex-days and Kaplanis (1986) and Dorsman and Verboeven (1992) for estimating implicit tax rates).

Call options are generally 'dividend unprotected' so that call holders will not be compensated for stock price declines caused by dividend payments. One would therefore be tempted to believe that as the price of the underlying stock falls after dividend stripping, the price of the call also falls. Kalay and Subrahmanyam (1984) show that this is not the case. The call price adjusts continuously to changes in expectations of future dividends, so that the call price today is already adjusted for all discounted expected future dividends. Hence, the expected ex-dividend stock price is already embedded in the cum-day call price and we should observe no discrete price change on the ex-dividend day. Therefore, returns on call options on ex-dividend days should not be different from returns on any other day. If the overnight return is ignored, the price of a call option should be the same on the cum- and ex-dividend days. Any change in the call price must then be caused by the fact that the ex-day stock price was different from expected.

If call prices are not expected to change around ex-days, how is it then possible to estimate tax rates from call prices? To explain this, let C_{cum} and C_{ex} denote call option prices and P_{cum} and P_{ex} stock prices on the cum- and ex-dividend days, and let $H = \partial C/\partial P$ denote the hedge ratio. Only the unexpected component of the ex-day stock price affects the cum-ex call price change and therefore the following equation must hold

(30) $$C_{ex} - C_{cum} = H\left[P_{ex} - E\left(P_{ex}\right)\right] \quad .$$

Dividends are introduced by inserting the expected ex-day stock price (ignoring the overnight return)

(31) $$E\left(P_{ex}\right) = P_{cum} - E(\alpha)D$$

into (30). This yields

(32) $$C = b_0 + b_1 P + e$$

where $$C = \frac{C_{ex} - C_{cum}}{H \times D} \quad , \quad P = \frac{P_{ex} - P_{cum}}{D}$$

and e is the error term. Equation (32) can be used to estimate the expected ex-ratio, $E(\alpha)$. The (negative of the) observed ex-ratio is used to explain the call price change divided by the product of the dividend and the hedge ratio. We would expect that $b_0 = E(\alpha)$ and $b_1 = 1$, so that the constant term gives the ex-ante ex-dividend ratio.

2.2.3 Ex-dividend days as events

Finally, we turn to discussing how event study methodology can be used in ex-dividend studies. The ex-dividend day is the event day, or day 0, and the event period is usually extended to include at least five days before and after the ex-day. One often assumes that stock returns are generated by the popular market model (see for example Brown and Warner (1985) and Copeland and Weston (1988, pp. 361-362)), so that the return on asset i is related to the market return as

(33) $$R_{it} = \beta_{0i} + \beta_{1i} R_{mt} + \varepsilon_{it}$$

where R_{it} is the observed return on asset i, R_{mt} is the observed return on the market index and ε_{it} is an error term measuring the unexpected returns.

If dividends and capital gains are perfect substitutes ($\alpha = 1$), the market model is a proper model also during the ex-dividend (or event) period. Under the assumption that the original model used to estimate betas is correctly specified, the residual (ε_{it}) and the cumulative residual, or abnormal return (AR) and cumulative abnormal return (CAR) as they are often called, are random variables with mean zero. On the other hand, if dividends are taxed more heavily than capital gains ($\alpha < 1$), the market model will predict too low returns for ex-days, because it does not take into account the fact that investors expect a tax premium equal to $100(1\text{-}\alpha)$ per cent for each unit of dividend yield they receive (see equation (5)). Therefore, in this case we would expect to find that AR_t and CAR_t are different from zero. A CAR_t different from zero supports the Elton - Gruber hypothesis, whereas CAR_t equal to zero supports the short-term trading hypothesis of Kalay (assuming that $\tau_d = \tau_g$ for the short-term trader).

Since the profitability of short-term trading increases with dividend yield, it is natural to compare abnormal returns of portfolios of low- and high-yield stocks. We would expect that if the tax hypothesis of EG is correct, the market model explains returns of high-yield stocks less accurately than those of low-yield stocks. Indeed, we would expect to find positive abnormal returns on ex-days and these abnormal returns should be larger for high-yield stocks than low-yield stocks. On the other hand, if Kalay's short-term trading argument is correct, the market model should perform well also in the event period, and there should be no abnormal returns on ex-days. Finally, there is no reason why abnormal return behaviour should be restricted to ex-days only. If short-term trading is important, it probably concentrates on a number of days around the ex-day.

Another variable that has been used to group stocks to those that are more and less likely traded by short-term traders is liquidity (see Stickel (1991)). It is not necessarily important for long-term investors that the stocks they trade are liquid whereas for short-term traders liquidity is important. For short-term traders who trade because of the dividend, it is important that they can purchase the stock just before it goes ex-dividend and get rid of it immediately after that. Therefore, if the short-term trading hypothesis is true, the market model should work better the more liquid the stock and the higher its dividend yield. Respectively, if EG are correct, liquidity should be irrelevant, and the only thing we should find is that the market model is less accurate for high yield stocks than for low yield stocks.

2.3 Review of empirical findings

Any review of the literature necessarily involves some classification and grouping of studies. Usually the classification can be done in a number of different ways and the final choice depends on what issues one wishes to focus on. Here the emphasis is on test design. In designing empirical tests it is useful to think of what kind of results would represent evidence in favour of or against the hypotheses that are to be tested and what kind of test conditions would be ideal for testing. Since the behaviour of stock prices around ex-days is somehow related to taxes and the profitability of short-term trading, it may be instructive to consider how past and contemporary institutional details can be of help in constructing meaningful tests. Because different tax laws have different implications on ex-day behaviour, the institutional setting is important. We pay special attention to the way tests are designed and how changes in institutions have been used to construct better tests.

One can roughly divide ex-dividend studies into two broad categories. The first category includes studies that examine data periods when institutions were unchanged. Basically, the main concern in the studies of this category has been whether the ex-dividend ratio is different from one. All the early ex-dividend studies, like Campbell and Beranek (1955), Durand and May (1960), Elton and Gruber (1970), Kalay (1982), McInish and Puglisi (1980), as well as many later ones, fall into this category. Practically all of them arrive at the same conclusion: stock prices tend to fall on ex-dividend days by less than the amount of the dividend. This result is consistent with the tax hypothesis and long-term trading population with a preference towards capital gains. The main problem with these studies is that they estimate the effect of taxes on the value of dividends by using data from periods when tax rates have no or little variation. Theoretically speaking, it could be that those results that appear to provide evidence in favour of the tax hypothesis are caused by a factor, which is left uncontrolled for.

Studies falling in the second category take full advantage of changes in institutions in order to construct more powerful tests of the tax hypothesis. These studies examine data periods when changes in institutions have predictable consequences on ex-day behaviour. Changes in uncontrolled factors are not likely to be perfectly correlated with changes in institutions and therefore studies in this category are more likely to eliminate their effect. An obvious way to test the tax hypothesis is to look at ex-dividend day behaviour around major tax reforms. The empirical evidence supports the tax hypothesis, if the estimated tax premium changes after the tax reform consistently with the prediction of the tax hypothesis. Of course, the tests make sense only when the implications of the reform are straightforward. Examples of studies in the second category include, for example, Barclay (1987), Booth and Johnston (1984), Grammatikos (1989), Lakonishok and Vermaelen (1983), Michaely (1991), Poterba and Summers (1984) and Robin (1991).

2.3.1 Tests with static institutions

Among the first ex-dividend day studies ever published in academic journals are Campbell and Beranek (1955) and Durand and May (1960). Campbell and Beranek examine ex-dividend day behaviour of NYSE stocks in 1949-50 and 1953. They find that the price drop is on average 90% of the dividend. This finding leads them to note that investors buying shares will do better if they buy ex while investors selling will do better if they sell cum. They do not, however, recommend a policy of buying cum and selling ex, because the price drops of individual stocks are very dispersed. Durand and May examine 43 ex-days of a single stock, AT&T, in 1948-59. The average price drop during three sub-periods varies from 90 to 102 per cent of the dividend. The authors conclude that their findings provide only weak support to the findings of Campbell and Beranek. They summarise their results by saying that if one is willing to accept a small difference between the price drop and the dividend, then compared to the dividend the price drop is smaller rather than larger.

The most extensive of the early studies is Elton and Gruber (1970). They use 4148 observations of NYSE stocks from April 1 1966 to March 31 1967 finding that the average price ratio is approximately 0.78. This implies that capital gains are taxed at a lower rate than ordinary income (dividends). This finding is reasonable, because at that time capital gains were taxed in the U.S. at a rate, which was one half the tax rate on ordinary income. Using the average ratio and setting $\tau_g = 0.5\tau_d$ yields an estimate of 36.4 per cent for the dividend tax rate. Elton and Gruber find their estimate both plausible and consistent with estimates obtained previously with other methods (see for example Jolivet (1966)). Elton and Gruber also test clientele effects. They rank stocks into ten portfolios separately according to dividend yield and payout ratio and compute average ex-dividend ratios for each portfolio. They find that the mean ex-ratio increases almost monotonically with dividend yield. The Spearman rank correlation coefficient is as high as 0.92 and significant at the 1 per cent level. The correlation is somewhat less pronounced between the payout ratio and ex-dividend ratio, 0.79, but it is still significant at the 1 per cent level.

The major contribution of Kalay (1982) is the introduction of the short-term trading hypothesis, which we already discussed earlier in this chapter. In addition, Kalay provides his own estimates of the ex-dividend ratio. He uses 2,540 observations during the same data period as EG and finds that the ex-ratio ranges from 0.734 to 0.881 depending on how adjustment for overnight return is done. These estimates are not statistically different from one. Kalay admits, however, that the evidence does suggest that capital gains are taxed at a lower rate than dividends. He also tests for clientele effects. The Spearman correlation coefficients between ex-ratios and dividend yield vary from 0.032 to 0.081, again depending on the adjustment for overnight return. Two of the three reported coefficients are statistically significant. The values of the coefficients are very low compared to those of EG. This can be explained by the fact that Kalay did not group the data into portfolios. Finally, Kalay notes that actual transaction costs of professional traders may not be high enough to prevent short-term trading around ex-days. The discussion of the size of the transaction costs continued in Elton, Gruber and Rentzler (1984) and Kalay (1984).

Still another early ex-dividend study is by McInish and Puglisi (1980), who examine non-convertible preferred stocks of 13 U.S. utility companies in 1976-77. They expect that corporate investors are the major buyers of preferred stock, because of their 85 per cent dividend exclusion in taxation. The average ex-ratio is close to one, 0.979 for unadjusted data and 1.022 for data adjusted for overnight return, with a lot of variation across individual stocks. No tests are reported. The authors argue that if the major buyers were corporations, the ratio should be 1.33 for long-term investors and 1.78 for short-term investors (short-term capital gains tax rate 30 and long-term rate 48 per cent). Their interpretation is that either the marginal stockholder is not a corporation or the average holding period is fifteen days or less, in which case the corporate buyer is not entitled to the 85 per cent dividend exclusion. They also run a simple test of short-term trading and find that no short-term trading strategy can beat a simple buy-and-hold strategy if 1 per cent round trip transaction costs are assumed. This is evidence against Kalay's short-term trading hypothesis.

The majority of ex-day studies published in major journals employ U.S. data. There are, nevertheless, a number of studies that use data from other countries. Here we discuss some of them. First, there are three studies that use Finnish data. Hietala and Keloharju (1995) make use of the fact that from 1984 to 1992 many Finnish corporations had both restricted and unrestricted stocks. The difference between the two classes of shares was that Finnish investors were allowed to own both unrestricted and restricted shares while foreign investors were allowed to own only unrestricted shares. Both classes of shares entitled the owner to an equal dividend payment. Since restricted shares sold at a discount compared to unrestricted shares, they offered a higher dividend yield. The results show that the average ex-ratio of restricted shares is significantly less than one and significantly higher than that of unrestricted shares. The median market adjusted ex-ratios for the period 1984 to 1990 are found to be 0.63 and 0.39, respectively. These estimates are much smaller than those reported in two previous studies by Hietala (1990) and Sorjonen (1988). In fact, they are so small that short-term trading around ex-days is probably not important in the Finnish stock market. Hietala (1990) and Sorjonen (1988) examine only restricted stocks. Hietala finds an average ex-ratio of 0.90 in the period 1974 to 1985 and rejects the short-term trading hypothesis. There is no evidence of clientele effects. Sorjonen examines approximately the same data period as Hietala and reports an average ex-ratio of 0.85.

Bosco (1987 and 1990) computes ex-ratios for Italian corporations. The average ex-ratio during the period 1962 to 1983 is 0.66. Bosco (1990) uses the estimated firm-specific ex-ratios to construct tax variables in the tradition of King (1977). He then uses the tax variables as explanatory variables in panel models of corporate dividend policy. Bosco (1987) constructs an average tax variable using the average ex-ratio and estimates a partial adjustment model of dividend behaviour for Italy. The results in both studies give support to the view that taxes affect the value of dividends.

The Japanese stock market provides an interesting case for ex-day studies. Every year the majority of stocks go ex on the same calendar date at the end of March. Hayashi and Jagannathan (1990) examine the behaviour of Japanese stock prices on five distinct ex-dates in 1983 to 1987, so that they actually have five cross-sections of data, or a panel data set. The authors note that an average ex-ratio of 0.176 found in an earlier study by Maru, Kon-ya and Yonezava (1979) is probably too low to be justified by tax rates in Japan. Instead of computing an average ratio, Hayashi and Jagannathan estimate a variant of equation (20). They can not reject the null hypothesis that dividends and capital gains are taxed at the same rate. What explains the low average ex-ratio observed in the previous study is the constant term. The constant is significantly positive and higher for ex-days than non-ex-days, implying that corporations paying no dividends experience positive returns on ex-days. The authors explain the positive constant by positive news that affects the entire stock market on the ex-day. The observed ex-ratio can be negative for low yield stocks if the dividend yield is smaller than the constant.

Finally, we conclude the section of studies based on the examination of only one tax regime with two papers that attempt to estimate an ex-ante ex-ratio by using call option prices and the method described earlier in this chapter. Kaplanis (1986) uses call option price data on 14 U.K. stocks around 360 ex-days. He finds that the expected ex-day stock price drop is very low, on average only 56 per cent of the dividend. The expected ex-ratio is statistically less than one, but not significantly different from the realised ex-ratio, 0.63, which was estimated from stock price data. Both the expected and the realised ex-ratio are positively correlated with dividend yield, which is consistent with the existence of a clientele effect.

Dorsman and Verboven (1992) examine Dutch data on 304 stocks, which simultaneously had call options listed, over the 1987-1990 period. The authors estimate an ex-ante ex-ratio of 0.76, which is significantly less than one. This estimate is almost equal to the average ex-post ex-ratio, 0.77, estimated earlier by Dorsman and Verboven (1990). The estimate is consistent with the Dutch tax laws, with individuals having an incentive to avoid dividends because capital gains are untaxed while dividends are not, and with corporations and institutions having no tax motive to trade around ex-days. There is no evidence of an empirical relationship between dividend yield and the ex-ante ratio, and hence no evidence of a clientele effect.

2.3.2 Tax reforms

A useful starting point for studies taking advantage of changes in institutions is Barclay (1987). Barclay examines NYSE data during two distinct time periods. During the first period, 1900-1910, there was no income tax in the U.S., and therefore the data should display no evidence of a tax effect. The second time period, July 2, 1962 - December 31, 1985, is well after the introduction of the income tax and the tax effects, if any, should be revealed by the data. The results show that during the pre-tax period stock prices fell by the full amount of the dividend and that there is no evidence of a tax clientele effect. In the post-tax period the value of dividends relative to capital gains is much lower than in the pre-tax period. The estimated ex-ratios (adjusted for overnight return) are 0.998 and 0.841, respectively. These findings suggest two conclusions, which are consistent with the tax hypothesis. First, before the introduction of the income tax investors valued (before-tax) dividends and capital gains as perfect substitutes and, second, investors have started to discount the value of taxable cash dividends relative to capital gains because of differential taxation of dividends and capital gains.

Michaely (1991) and Robin (1991) examine the effect of the U.S. 1986 Tax Reform Act (TRA) on ex-dividend behaviour and reach different conclusions. The TRA had two major effects. First, it diminished the dividend preference of corporate investors but did not totally eliminate it.[13] Corporate investors should therefore prefer dividends to capital gains both before and after the reform, but the preference should be weaker after the reform. Second, the tax reform gradually eliminated the preferential tax treatment of ordinary investors' long-term capital gains. Before 1986 capital gains were taxed at a lower effective tax rate than dividends, but in 1988 dividends and realised long-term capital gains became equally treated as the TRA fully eliminated the distinction between

[13] Corporate investors were allowed to exclude a given proportion of their dividend receipts for tax purposes. This proportion was 85 % in 1986, 80 % in 1987 and 70 % in 1988. At the same time the corporate tax rate was decreased from 46 % in 1986 to 40 % in 1987 and 34 % in 1988.

capital gains and ordinary income.[14] Therefore, ordinary investors should prefer capital gains before 1986 but remain indifferent after the reform.

The tax hypothesis predicts that if long-term investors set prices around ex-days, ex-ratios are expected to be less than one in 1986 while ratios after the reform are expected to be higher than in 1986. Michaely notes that the tax treatment of dividends and capital gains was approximately the same in 1966-67 and 1986. Therefore, if the tax hypothesis is correct one would expect to find ratios of the same size in 1966-67 and 1986 and a higher ratio in 1987. The results obtained from NYSE data show the following. First, the average ratio of 1986-87 is significantly higher than the average ratio of 1966-67. Second, the 1966-67 ratio is significantly lower than one, whereas the 1986-87 is not significantly different from one. Finally, the 1987 ratio is not significantly different from the 1986 ratio. Clearly, these findings do not support the tax hypothesis. An analysis of excess returns around ex-days suggests that abnormal trading with highest yield stocks takes place already several days before the ex-day and the day after. High-yield stocks earn on average positive abnormal returns before and on the cum-days and negative abnormal returns on and after the ex-days, while the excess returns for the whole sample are on average zero. These results are consistent with short-term trading around ex-days.

Robin (1991) finds that average ex-dividend day abnormal returns fall from 0.152 per cent in 1984-86 to 0.038 per cent in 1986-87, which is consistent with the tax hypothesis.[15] The decline in abnormal returns seems to be caused by high-yield stocks. These stocks have negative abnormal returns, and more negative after the reform, which suggests that they are priced by dividend preferring investors like corporations. When the highest dividend yield quintile is excluded, the results still show a statistically significant drop in ex-dividend day abnormal returns. Hence, the results support the tax hypothesis. Finally, Robin reports evidence of short-term trading among the highest yield stocks.

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[14] Before the tax reform 60 % of capital gains were excluded from ordinary investors' tax base and the maximum capital gains tax rate was set at 25 %. In 1987, the transition year between the old and the new systems, the maximum capital gains tax rate was set at 28 %, whereas the maximum ordinary income tax rate was set at 38.5 %.

[15] Results change when individual years are examined. Estimated abnormal returns for 1986 and 1988 do not support the tax hypothesis, which is consistent with Michaely (1991). Booth and Johnston (1984) note that annual estimates may fluctuate too much and in some cases make comparisons of two consecutive years difficult. They suggest that averages should be computed over tax periods rather than individual years.

Lakonishok and Vermaelen (1983) examine the effect of the 1972 Canadian tax reform on ex-dividend ratios. The prediction of the tax hypothesis is that the ratio is larger in 1972 than in 1971. The authors compute two different test statistics, the traditional Elton-Gruber statistic and their own portfolio statistic (see equation (23)). In both cases they measure the price drop from cum close to both ex open and ex close and in each case they also try rounding dividends to the nearest 1/8. This yields eight different ratio estimates for both years. In seven cases the ratio falls after the reform which is inconsistent with the tax hypothesis. The difference is significant at the 5% level only when the Elton-Gruber statistic is measured from close to open with dividends rounded. With unrounded dividends, however, the result is reversed and the predicted ratio increase is observed, but again the difference is statistically insignificant. Lakonishok and Vermaelen also find a positive relation between dividend yield and ex-dividend ratio. This relation is strongest among the highest dividend yield deciles[16]. The general conclusion is that while taxes probably affect ex-dividend day behaviour of stock prices, this behaviour should not be used to infer the tax rate of a long-term investor.

The same 1972 Canadian tax reform, as well as two other reforms, is examined by Booth and Johnston (1984). They simply compute Elton-Gruber statistics without correcting for heteroskedasticity. The average annual ratios in 1971 and 1972 are exactly as in Lakonishok and Vermaelen (1983). The change in the average ex-ratio is consistent with the tax hypothesis when the price change is measured from close to open, but inconsistent when the price change is from close to close. However, when the average ratio is computed over the tax periods, 1970-71 and 1972-76, the results are consistent with the tax hypothesis. The average ex-ratio in Canada, 0.491 over the period 1970-80, is very low compared to the average ratio of U.S. stocks. Annual data display no evidence of a clientele effect, but over the entire data period there is weak evidence in favour of a clientele effect, especially in the highest five yield deciles. The average ratio is less than one in all deciles, which implies that investors in all tax brackets prefer capital gains to dividend income.

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[16] Low dividend yields may cause a problem here. Tables VII and VIII in Lakonishok and Vermaelen (1983) show that dividend yield is less than 1 % for approximately 65 % of the firms in 1971 and 55 % in 1972.

The U.K. has experienced a number of tax reforms and minor changes in tax rates and is therefore well suited, if not ideal, for analyses of the effects of taxes on stock returns. Poterba and Summers (1984) examine the effects of two reforms on ex-day stock returns. The 1965 tax reform introduced a capital gains tax at a rate of 30 per cent. Since dividend taxes were unaltered, the expected effect is that the relative value of dividends should increase and tax premiums fall. The second reform in 1973 introduced an imputation system. The authors claim that this reform decreased the dividend tax rate and, therefore, it should have further decreased tax premiums. Poterba and Summers employ a small data set which contains daily stock price data on 16 large U.K. firms from 1955 to 1981. They use both ex-day and non-ex-day data to estimate an extended market model, where stock returns are explained by market returns and dividend yield. The model allows for a different tax premium for the dividend yield in each of the three tax regimes. The results show that changes in the capital gains tax rate had the expected but statistically insignificant effect on ex-day returns. The estimated tax premiums are roughly the same for the first two tax regimes. When only ex-day returns are used to estimate the model the estimates are 0.440 and 0.413. These numbers imply that ex-ratios are approximately 0.56 and 0.49. A second result is that the dividend tax reform had a substantial effect on ex-day returns. The estimated tax premium for the third tax regime is negative, -0.061, implying an ex-ratio of 1.06 and an investor preference for dividends.

2.3.3 Changes in transaction costs

Another useful institutional change that has been used to test the tax hypothesis is the introduction of negotiated commissions in the U.S. on May 1, 1975, which reduced the costs of short-term trading. Eades, Hess and Kim (1984) note that nominal round-trip costs to short-term traders were 2 per cent when commissions were non-negotiable and probably much less after they became negotiable. Hence, if there is evidence to be found of short-term trading in the U.S. it is more likely to be found after commissions became negotiable. This is explicitly tested in Karpoff and Walkling (1988 and 1990). The authors provide evidence for their view that the tax and short-term trading explanations are complementary rather than competing hypotheses. The tax hypothesis that ex-dividend day stock returns reflect tax premiums required by long-term investors describes more likely the behaviour of low-yield stocks, while the statement of the short-term trading hypothesis that these abnormal returns reflect transaction costs of short-term traders is more likely to describe the behaviour of high-yield stocks. Therefore, ex-day returns of high-yield stocks are expected to be positively related to transaction costs. Karpoff and Walkling (1988) regress ex-dividend day abnormal returns on four different proxies of transaction costs. The results point to two conclusions. First, there is practically no evidence of short-term trading when commissions were non-negotiable. This result holds for all stocks, including high yield stocks. Second, there is strong evidence of short-term trading among high-yield stocks after commissions became negotiable. The results are robust with respect to the proxy of transaction costs used.

Karpoff and Walkling were not satisfied with the proxies of transaction costs in their 1988 study. In their 1990 study, they examine ex-day behaviour of NASDAQ stocks. The NASDAQ data is convenient because it contains information on bid-ask spreads, which constitute a major component of transaction costs. They define the relative spread simply as the daily spread divided by the average of the bid and ask prices, and take an average over 30 days to get a reliable estimate. The results point to the following. First, ex-day abnormal returns are on average positive and statistically significant. Second, ex-day abnormal returns increase with dividend yield. Third, when regressing the bid-ask spread on ex-day abnormal returns, the finding is that ex-day abnormal returns are positively correlated with bid-ask spreads. The correlation between ex-day abnormal returns and spreads increases with dividend yield. Within the lowest yield quintile the correlation is not statistically significant. This result is consistent with dividend capture among high yield stocks. The results are not sensitive to the market model specification and are not caused by infrequent trading of some stocks. Finally, Karpoff and Walkling divide the stocks in the highest yield quintile into four groups according to whether they have below or above average spreads and yields. They find that the highest (lowest) correlation between abnormal returns and spreads is among stocks with above (below) average yields and below (above) average spreads. This evidence supports their view that not all high-yield stocks are likely to be targets of dividend capture, but rather the proportion of likely targets increases with dividend yield.

The most convincing evidence against the tax hypothesis is reported in Eades, Hess and Kim (1984). While almost all prior studies concentrate on analysing common stocks, Eades, Hess and Kim extend their analysis to preferred stocks and distributions that should have no tax consequences at all. The common stock sample reveals strong evidence in favour of an ex-dividend tax premium. The evidence is much weaker after commissions became negotiable, but abnormal returns are still positive and statistically significant or marginally significant. The preferred stock sample exhibits significantly negative abnormal returns, which is consistent with dividend preferring investors. Evidence against the tax hypothesis comes from the analysis of non-taxable distributions of common stocks. There should be no tax consequences and therefore no tax premium for stock dividends, stock splits and non-taxable cash distributions. However, the empirical results reveal statistically significant positive abnormal returns for stock dividends and splits and negative abnormal returns for non-taxable cash distributions. Furthermore, the authors find anomalous return behaviour around ex-days. The common stock sample exhibits highly significant positive abnormal returns during the five days prior to and negative abnormal returns during the five days after the ex-day. The anomalous behaviour of other samples is weaker and extends to a shorter period around the ex-day. The authors examine several explanations to account for these findings but the data do not give support to any of them. The empirical evidence in this study therefore casts serious doubt on the tax hypothesis.

2.3.4 Risk premium

Anyone who buys the stock before it goes ex and sells afterwards is exposed to price risk during the holding period. Investors may not be able to diversify all of this risk. In the U.S., ordinary corporations are prospective short-term traders. They are allowed to exclude 85 per cent of their dividend income after a minimum holding period and therefore face lower taxes on dividend income than capital gains.[17] The minimum holding period was extended from 16 to 46 days in 1984. If corporations trade around ex-days, they are exposed to more price risk after 1984 than before and there should be less short-

[17] See footnote 13.

term trading after 1984, if the price risk can not be hedged. Empirically, the effect, if any, is to be found among high-yield stocks. Grammatikos (1989) finds that average ex-ratios are less than one both before and after the reform. However, the average ratio is larger and the average market adjusted ex-day return is smaller before the reform. The decline in the average ratio and the rise in the average ex-day return are driven by high-yield shares. The evidence is consistent with the tax hypothesis among low-yield shares and with lessened short-term trading among high yield shares. Grammatikos further divides his sample of NYSE stocks into stocks with traded options available and stocks with no options available. The extension of the holding period should affect only stocks whose price risk cannot be hedged with options. The results show that the tax reform affected the non-optionable stocks much more than the optionable stocks. This suggests that risk premiums may be important in the behaviour of stock prices around ex-days and that ex-day abnormal returns may not be explained solely by taxes.

The existence of risk premiums in ex-day returns is further investigated recently by Fedenia and Grammatikos (1993). They note that long-term investors who trade around ex-days for reasons unrelated to dividends probably hold well-diversified portfolios and therefore care only about systematic risk. If these investors dominate, only systematic risk is priced and tax premiums are positive. Short-term traders who collect dividends by buying stocks before they go ex and sell afterwards may be exposed to risk that can not be fully diversified. They may therefore care about both systematic and unsystematic risk. If they dominate in the market, unsystematic risk will be priced as well, but there should be no evidence of a tax premium. To test these hypotheses, Fedenia and Grammatikos use NYSE and AMEX data to form two portfolios, a low-yield and a high-yield portfolio, of stocks that go ex on the same calendar date. For both portfolios they estimate a three-factor model, where the factors are dividend yield, systematic risk and unsystematic risk. The coefficients give estimates of the tax premium and two risk premiums. The results show the following. First, the tax premium is significantly positive for the low-yield portfolio and only systematic risk is priced. This is consistent with the view that prices of low-yield stocks around ex-days are determined by long-term investors who hold well diversified portfolios and require a tax premium as compensation for higher taxes on dividends than capital gains. Second, unsystematic risk is priced for the high-yield portfolio and the tax premium is not significantly different from zero. This finding supports the view that ex-day prices of high-yield stocks are set by short-term traders who are unable to fully diversify their portfolios around ex-days and who require no tax premium because dividends and capital gains are taxed at the same rate.

To summarise, the empirical results of Grammatikos (1989) and Fedenia and Grammatikos (1993) show that risk may have an important role in models that attempt to explain ex-dividend day stock price behaviour, in particular when short-term traders are dominant. Heath and Jarrow (1988) reach the same conclusion in their theoretical study.

2.3.5 Trading volume around ex-dividend days

The tax clientele hypothesis and the short-term trading hypothesis are difficult to test because they give similar predictions of the relation between ex-ratios and dividend yield. To overcome this difficulty, Lakonishok and Vermaelen (1986) examine trading volumes around ex-days. They define normal trading volume as an historic average volume and abnormal volume as anything in excess of the historic average. They find abnormally high trading volume starting five days before ex-days and especially after commissions became negotiable. There is no evidence of abnormal volume within five days immediately after ex-days. One plausible explanation for this is the minimum holding period of 16 days for U.S. corporations to qualify for the 85 per cent dividend exclusion in taxation. To test this, Lakonishok and Vermaelen extend the event period to cover 16 trading days. They find that the average daily abnormal trading volume from six days to thirteen days after the ex-day is highly significant, and only during the period of negotiated commissions. It therefore appears that the abnormal trading volume observed before ex-days is matched by abnormal trading volume well after ex-days. This finding supports the view that the behaviour of corporate investors who buy stocks before ex-days to collect dividends and sell them after the required 16 day holding period is an important determinant of stock prices around ex-days in the U.S. Finally, Lakonishok and Vermaelen divide the sample into sub-samples according to dividend yield and normal trading volume, which proxies for liquidity. The results show that abnormal volume increases with both dividend yield and liquidity. This is exactly as expected and consistent with short-term traders investing primarily in stocks with high yield and high liquidity.

2.3.6 Summary of the review

The overall picture of stock price behaviour around ex-dividend days given by the studies reviewed above is somewhat unclear. In some cases conflicting results are obtained from the same data periods. The picture becomes clearer if one takes into account what was hypothesised and what was actually tested at different times, not to mention the different techniques used. The main results are summarised in Table 1.

Only the tax hypothesis was tested in the early ex-dividend studies. The issue was whether stock prices fall on ex-dividend days by the full amount of the dividend. The general finding in these studies is that prices fall by less, and therefore these studies provide evidence in favour of the tax hypothesis. The short-term trading hypothesis proposed by Kalay was not published until 1982 and therefore the actions of short-term traders were not of interest to researchers before the 1980's. Many ex-dividend studies supporting the tax hypothesis were published before that and, consequently, do not take the actions of short-term traders into account at all. Some later results even contradict earlier findings. For example, Michaely (1991) finds that average ex-ratios are much lower in the period examined by Elton and Gruber (1970), 1966-67, than twenty years later, even though the tax treatment of dividends and capital gains was roughly the same during the two periods. It is not clear whether such findings should be explained by the behaviour of short-term traders who have learned to collect dividends during the past few decades or by the failure of the tax hypothesis to explain ex-day stock price behaviour. On the other hand, more evidence in favour of the tax hypothesis is provided by Barclay (1987) who finds no evidence of a tax premium before the income tax was introduced in the U.S.

After the emergence of the short-term trading hypothesis, the tax and short-term hypotheses were treated as competitive for a long time. The issue was to test which of these two hypotheses was supported by the data. A number of studies compare stock price behaviour around ex-days during different tax regimes. The evidence is mixed. Conflicting results are obtained for example in studies that employ U.S. or Canadian data. Michaely (1991) and Lakonishok and Vermaelen (1983) attribute ex-day returns to short-term trading while Robin (1991) and Booth and Johnston (1984) find evidence in favour of the tax hypothesis. Results from the U.K. stock market support the tax hypothesis (Poterba and Summers (1984)). The importance of short-term traders becomes clear in studies that examine ex-day returns in periods with different costs of transacting, usually before and after commissions became negotiable in the U.S. The general finding in these studies is that there is evidence of short-term trading among high-yield stocks and especially after commissions became negotiable. The results reported by Eades, Hess and Kim (1984) with non-taxable distributions are puzzling. They suggest that factors other than taxes may also influence ex-day return behaviour. One such factor in common stock prices may be the risk premium as suggested by Grammatikos (1989) and Fedenia and Grammatikos (1993).

Recent studies by Karpoff and Walkling (1988 and 1990) and Lakonishok and Vermaelen (1986) take the view that the tax explanation and the short-term trading hypothesis are complementary rather than competing hypotheses. By grouping stocks into portfolios according to yield, bid-ask spreads and liquidity or volume they find evidence that supports this view. Short-term trading is important among stocks with high yield, low bid-ask spread (transaction costs) and high liquidity, whereas long-term traders seem to determine ex-day prices of stocks with opposite characteristics.

The recognition that the tax and short-term trading hypotheses are complementary is important for future research. Unfortunately, in small stock markets the low number of stocks limits the possibility to conduct tests similar to those of Karpoff and Walkling (1990), for example. Even so, studies that examine stock prices in other than the major stock markets can yield valuable information of return behaviour around ex-days, especially if trading rules, tax systems and other institutional details have features uncommon in other markets.

Finally, it should be borne in mind that ex-dividend studies are only a part of a larger body of literature, which examines whether taxes affect the valuation of shares in general, and not only on ex-dividend days. We will not discuss this broader issue here. It suffices to say that examples of these studies include Amoako-Adu (1983), Amoako-Adu, Rashid and Stebbins (1992), Ang, Blackwell and Megginson (1991), Bailey (1988), Blose and

Martin (1992), Brennan (1970), Hess (1982 and 1983), Lewellen, Stanley, Lease and Schlarbaum (1978), Litzenberger and Ramaswamy (1979 and 1982), Long (1978), Pettit (1977), Poterba (1986), Poterba and Summers (1985) and Vanthienen and Vermaelen (1987). Of course, this list is by no means exhaustive.

Table 1

Summary of Empirical Findings in Ex-Dividend Day Studies

Panel A: Tests with static institutions

Country Author(s) Year of Publication	Period of Analysis	Number of Observations	Major Empirical Results Conclusions
• United States Campbell and Beranek (1955)	Oct 1949 - Apr 1950 Oct 1953 - Dec 1953	199 + 200	The average drop-off is 90 per cent of the dividend. However, buying cum and selling ex would be profitable after taxes only if price drop-offs were much smaller.
Durand and May (1960)	11.3.1948 - 6.3.1959	43 ex-days of AT&T	The average drop-off is between 90 and 102 per cent of the dividend. The result weakly supports the view that share prices fall on ex-days by less than the amount of the dividend.
Elton and Gruber (1970)	1.4.1966 - 31.3.1967	4148	The average ex-ratio 0.78 is statistically less than one and supports the view that marginal tax rates can be inferred from ex-day share price behaviour. Ex-ratios increase with dividend yield and payout ratio, which is consistent with tax clienteles.
Kalay (1982)	1.4.1966 - 31.3.1967	2540	Marginal tax rates can not be inferred from ex-day price behaviour. However, average ex-ratios vary from 0.881 to 0.734, which suggests that investors face higher tax rates on dividends than on capital gains.
McInish and Puglisi (1980)	1976-1977	13 ex-dividend days of nonconvertible preferred shares of utility companies	The average ex-ratios are 1.022 with and 0.979 without adjustment to overnight return. The size of the average ex-ratio suggests that corporations are not the major buyers of preferreds around ex-days or the average holding period is 15 days or less. Short-term trading is unprofitable if 1 per cent roundtrip commission is assumed.
• Finland Sorjonen (1988)	1960-1985	766	The average ex-ratio varies from 0.78 to 0.92 depending on the sub-period examined suggesting that the marginal investor prefers capital gains to dividends. However, when corporate taxes are taken into account, investors may actually prefer dividends to capital gains.
Hietala (1990)	1974-1985	Annually 50-60 ex-days of restricted shares	The average ex-ratio 0.90 is consistent with the tax hypothesis. There are no abnormal returns around ex-days. There is no evidence of either short-term trading or clientele effects.
Hietala and Keloharju (1995)	1984-1990	238 restricted and 59 unrestricted dividends	Unrestricted shares have significantly lower ex-ratios than restricted shares. The average market adjusted ex-ratio is 0.691 for restricted shares and only 0.167 for unrestricted shares. Both ratios are so low that short-term trading is probably not important around ex-days.
• Italy Bosco (1990)	1962-1983	2310 (35 companies)	The average ex-ratio is 0.6567. Shareholders' tax rates are important in explaining corporate payout ratios and dividend policies in Italy.
• Japan Hayashi and Jagannathan (1990)	1983-1987	5882 on 5 different ex-dates	Share price falls on average by the full amount of the dividend. There is no evidence of a clientele effect. Companies that pay no dividends earn positive ex-day returns.

Panel A: Tests with static institutions (continued)

Country Author(s) Year of Publication	Period of Analysis	Number of Observations	Major Empirical Results Conclusions
• **Netherlands** Dorsman and Verboven (1990)	1981-1988	Annually 96-131	The average ex-ratio is 0.77. There is no evidence of a clientele effect.
Dorsman and Verboven (1992)	1987-1990	304 call options	The estimated average ex-ante ex-ratio is 0.76. There is no evidence of a clientele effect.
• **United Kingdom** Kaplanis (1986)	1979-1984	360 ex-days of 14 different shares	The estimated average ex-ante ex-ratio 0.56 is not statistically different from the ex-post ex-ratio. The ex-ante ex-ratio increases with dividend yield. The results are consistent with the tax clientele hypothesis and inconsistent with the short-term trading hypothesis.

Panel B: Tests with institutional changes

Country Author(s) Year of Publication	Institutional Change Period of Analysis	Number of Observations	Major Empirical Results Conclusions
• **United States** Barclay (1987)	Introduction of income tax Pre-tax period: 1.1.1900-31.12.1906, 12.12.1909-30.6.1910 Post-tax period: 2.7.1962-31.12.1985	578 + 2521 ex-dividend day portfolios	Before the income tax share prices fall on ex-dividend days by the full amount of the dividend. There is no evidence of a clientele effect. After the income tax share prices fall by less than the dividend and there is also evidence of a clientele effect.
Michaely (1991)	1986 Tax Reform Act 1986-1989	3206 (1986), 3316 (1987), 4785 (1988), 4799 (1989)	Contrary to the prediction of the tax hypothesis the average ex-ratio is unaffected by the tax reform. The relation between ex-ratio and dividend yield is U-shaped. Positive abnormal returns before ex-days and negative abnormal return after ex-days among high yield shares are evidence in favour of buying before the ex-day and selling after.
Robin (1991)	1986 Tax Reform Act 1984-1988	23219	Ex-day abnormal returns decline after the Tax Reform Act. Most of the decline is attributable to high yield shares even though the decline remains statistically significant also when the effect of these shares is removed. This is evidence in favour of the tax hypothesis. Among high yield shares there is evidence of short-term trading.
Grammatikos (1989)	1984 Tax Reform Act 1975-1985	19407 before and 2032 after the reform	The mean ex-ratio decreased from .877 before the reform to .796 after the reform. The decline was driven by high yield shares that are primary candidates for short-term trading. Furthermore, the decline was far more significant for non-optionable than optionable shares, implying that part of the ex-dividend day premium may be a risk premium.
Eades, Hess and Kim (1984)	Negotiated commissions since 1.5.1975 2.7.1962-31.12.1980	4471 ex-dividend day common stock portfolios, 493 preferred stock portfolios, 1550 stock dividend and split portfolios	The common stock sample favours the tax hypothesis especially during the period of non-negotiable commissions. The preferred stock sample shows negative tax premiums, which is consistent with tax-induced dividend clienteles. The sample of non-taxable distributions displays both positive ex-day premiums (stock dividends and splits) and negative ex-day premiums (non-taxable cash distributions) after commissions became negotiable. All samples display evidence of abnormal returns during the ex-dividend period.
Karpoff and Walkling (1988)	Negotiated commissions 1.1.1965-31.12.1984	50645 observations	Consistent with short-term trading, abnormal returns of high yield shares increase with transaction costs after commissions became negotiable.
Karpoff and Walkling (1990)	1.1.1973-31.12.1985	53205	Ex-day returns are positively correlated with bid-ask spreads. The correlation increases with dividend yield. The results are consistent with dividend capture among high yield shares.
Lakonishok and Vermaelen (1986)	Negotiated commissions 1.1.1970-31.12.1981	46245 taxable cash dividends, 2558 stock dividends and splits	Abnormal trading volume is detected before, on and 6 to 13 days after ex-days especially after commissions became negotiable. Abnormal trading volume increases with dividend yield and liquidity. Short-term trading is therefore important among liquid high yield shares especially during the period of negotiable commissions.

Panel B: Tests with institutional changes (continued)

Country Author(s) Year of Publication	Institutional Change Period of Analysis	Number of Observations	Major Empirical Results Conclusions
• United States			
Fedenia and Grammatikos (1993)	1.1.1975-31.10.1985	16544	Prices of low yield shares around ex-days are determined by long-term investors who hold well diversified portfolios and require a tax premium as compensation for higher dividend than capital gains taxes. Ex-day prices of high yield shares are set by short-term traders who require no tax premium because dividends and capital gains are taxed at the same rate, but who require a risk premium because they are unable to fully diversify their portfolios around ex-days.
• Canada			
Lakonishok and Vermaelen (1983)	Canadian 1972 tax reform 1971-1972	555 + 671	The average ex-ratio is generally lower in 1972 than 1971, which is contrary to the prediction of the tax hypothesis. The average ex-ratio is very low, only approximately 0.30 in 1972. There is some evidence of a clientele effect among the five highest dividend yield deciles.
Booth and Johnston (1984)	4 different tax regimes 1970-1980	4352	The average ex-ratio increases every tax period as predicted by the tax hypothesis. The average ex-ratio over the entire data period is 0.491. Ex-ratios are less than one at all dividend yield levels suggesting a preference for capital gains. There is no evidence of a clientele effect.
• United Kingdom			
Poterba and Summers (1984)	3 different tax regimes 1955-1981	Sample 1: 633 ex-days and 616 non-ex-days (16 companies) Sample 2: 4446	Both daily and monthly data reveal that the relative valuation of dividends and capital gains has changed over time. Especially the 1973 reform of dividend taxation had a substantial effect. The findings show that taxes are an important determinant of the relationship between dividend yields and share returns.

3. SUMMARY OF THE THREE ESSAYS

The ex-day model discussed in Chapter 2 assumes that stock price changes can be arbitrarily small. When tax rates on dividends and capital gains are taken as given the basic ex-day model predicts the following. First, the ex-dividend day price drop is a linear function of the size of the dividend. Second, the ex-dividend day price drop divided by the dividend, or the ex-dividend ratio, is constant and independent of the size of the dividend and the stock price. Third, ex-dividend day stock returns are a linear function of dividend yield. Fourth, if dividends are taxed more (less) heavily than capital gains, stock prices on ex-days fall by less (more) than the dividend amount, and ex-day stock returns are positively (negatively) related to dividend yield.

In reality, all stock exchanges have rules concerning the size of possible price changes. Usually, price changes must be multiples of the smallest possible price change, the tick. For example, in the New York Stock Exchange the tick size is 12.5 cents for the majority of stocks and all price changes must be multiples of 12.5 cents. The current tick size in the Helsinki Stock Exchange is 1 cent. It is obvious that whenever dividends are not multiples of the tick, stock prices can not fall by dividend amounts, and therefore restrictions on price increments must have an effect on ex-dividend tests. This problem was recognised already by Campbell and Beranek (1955) who examined only stocks that paid dividends in multiples of 12.5 cents. Later, Lakonishok and Vermaelen (1983) round dividends to the nearest 12.5 cents, while Booth and Johnston (1984) and Grammatikos (1989), among others, exclude stocks that pay dividends smaller than 12.5 cents.

Essays 2 and 3 in this thesis are motivated by three studies, Dubofsky (1992), Bali and Hite (1998) and Frank and Jagannathan (1998). These papers demonstrate that stock market trading rules, and especially the fact that stock prices can be quoted only at discrete intervals, may have a large impact on the behaviour of stock prices on ex-dividend days. Dubofsky (1992) shows that ex-day (abnormal) returns can be positive in a world without taxes if stock prices are quoted at discrete intervals. Frank and Jagannathan find that discrete prices cause prices in the Hong Kong stock market to fall on ex-days on average by less than the dividend amount even though neither dividends nor capital gains are taxed at all.

Essay 2 extends the basic ex-day model to take price discreteness explicitly into account. We are not aware of any earlier attempts to do this. Taking the tick size into account adds a new parameter to the model, which describes how the market rounds prices. Rounding is needed, because prices must change by multiples of given increments. At the same time, the original linear model transforms into a non-linear one.

The extended model yields a number of predictions, which are different from those of the basic model. First, when tick size is taken into account the ex-day price drop becomes a step function of the dividend amount. The price drop jumps when the direction of rounding changes. Second, the ex-dividend ratio is a piecewise decreasing convex function of dividend amount. For given tax rates, this pattern is independent of stock price as long as the same tick size applies. Third, for small dividends the ex-ratio can take a wide range of values, suggesting that the chances of obtaining misleading results must not be ignored. There is no simple definition for a small dividend, however. We demonstrate that whether a dividend is small depends not only on the dividend amount, but also on tax rates and the cum-day stock price that determines the tick size. Fourth, for a given cum-day price ex-day return is a piecewise linear function of dividend yield. The effect of the tick on ex-day returns decreases with stock price. Therefore, the distribution of cum-day prices, ignored in earlier ex-day studies, is important for ex-day price behaviour. Fifth, ex-day returns can be systematically positive or negative in the absence of taxes.

The extended model is difficult to estimate, because it is non-linear and non-differentiable. We use Finnish stock price data from 1989-95 and a grid search method to estimate the model. The results suggest that the average ex-ratio is approximately 0.7. Experiments with the entire sample and a sub-sample of stocks whose dividends are multiples of the tick yield completely different estimates of the rounding rule variable. This suggests that the rounding rule is difficult to estimate and sensitive to small changes in the estimate of the tax parameter. We are unable to perform significance tests concerning the parameters of the non-linear model and therefore the results must be treated as illustrative only.

The starting point of Essay 3 is the notion of many ex-day studies that different methods yield sometimes quite different results even when the exact same data are used. The literature gives little guidance as to what methods one should use. If, however, the choice of method is important, then empirical studies should be judged also on the basis of the method chosen.

We run a series of simulation experiments to examine how accurately the tax rate implicit in the ex-day price drop can be estimated with commonly used methods. The methods we test were introduced in Section 2.2.1. They are the average ex-dividend ratio, the GLS-estimator of the ex-ratio, the equally weighted portfolio statistic, and the regression model that explains ex-day returns by dividend yields. Several simplifying assumptions are made to generate extremely favourable conditions for an ex-day study to ensure that the abilities of these methods will not be underestimated. We assume that the ex-day price drop always reflects capital income tax rates to the extent that it is possible when cum-dividend prices, dividends and the tax rates as taken as given.

Three cases are examined. In the first case, the true ex-day price drop caused by dividend stripping can be observed. However, since prices must obey a tick rule, the price drop may not exactly reflect capital income taxes. We use two different tick rules. The first was used in the Helsinki Stock Exchange before 1996 and the second in 1996-98. In the second case, we assume that the true ex-day price can not be observed. The ex-day price drop that is actually observed reflects both taxes and overnight return and these two can be separated only by estimating the overnight return somehow. We estimate it from past returns. The error with which the overnight return is estimated depends on stock return volatility and has a direct impact on how accurately the tax rate can be estimated. Finally, in the third case there are no tick requirements so that stock prices are continuous. In addition, the overnight return must be estimated. Note that noise to the ex-day price drop comes from at most two sources (and their combination), the requirement of discrete prices and the unknown overnight return. Without this noise ex-day price drops could be explained entirely by taxes and dividends only, and that would make the exercise meaningless. We are not aware of any previous studies that simulate the influence of tick rules on estimating implicit tax rates on ex-day stock prices.

The results show that the importance of tick rules for ex-day studies depends on the nature of the ex-day price drop that we observe. First, we find that tick rules are important if we can observe an ex-day price drop that only reflects capital income taxes, dividends and tick rules, and is not contaminated by any overnight return requiring adjustment. A smaller tick size allows all methods to estimate the tax parameter more reliably than a large tick size. Also, when the larger tick is used the average ex-ratio is systematically biased. The size of the bias falls with dividend yield but is unaffected by sample size. Second, if the ex-day price drop is contaminated by overnight return, which must be removed by using an estimate of normal daily return, tick rules no longer matter. Only the amount of return uncertainty is important. The effect of errors made in estimating the overnight return is far more important than the effect of any tick rules. The reason for this is that rounding affects the ex-day price (drop) by less than one tick while the effect of errors made in estimating the overnight return can be many times larger than that. The reliability of the test statistics does not depend on the tick rules at all. Removing tick requirements altogether has hardly any effect on the reliability. Thus, from the point of view of an ex-day study, it does not seem to matter whether prices are continuous or discrete as long as ex-day prices are adjusted by an estimate of normal return. Therefore, tick rules are not important in this case.

The conclusion is that tick rules are important if we can observe the pure ex-day price drop that reflects only taxes, the dividend and tick rules, and is not contaminated by overnight return. If the price drop is contaminated by overnight return, tick rules are not important for ex-day price behaviour. The fundamental question is whether we can observe the pure ex-day price drop or not. There is no clear-cut answer to this question.

We also find that not all ex-day methods are equally reliable. Knowing this can be very useful in interpreting empirical results. We find that the GLS-estimator of the ex-ratio is always at least as good as the other estimators largely because it is the only statistic that takes both stock return volatility and dividend yield explicitly into account. If return volatility is the same for all stocks, the model that explains ex-day stock returns by dividend yields performs equally well. The average ex-dividend day ratio takes neither dividend yield nor volatility into account and therefore has the poorest performance in the simulation experiment. The standard errors of the average ex-ratios are very large.

Therefore, as Gagnon and Suret (1991) argue, it is doubtful whether a tax parameter of any reasonable magnitude can ever be found statistically different from one at conventional significance levels and sample sizes. The equally weighted portfolio statistic is almost as good as the ex-day return model, but has higher standard errors.

Finally, we examine the performance of ex-day methods in a simulation of a tax clientele test when a NYSE tick size of 12.5 cents is applied. We find that tax clientele effects can be identified reliably only if ex-day price behaviour in one dividend yield decile is substantially different from that in other deciles. This result holds even when 5,000 ex-day observations are available, the GLS-estimator is used and only a modest level of stock return volatility is assumed. Our finding suggests that results of clientele tests must be treated with caution, especially if dividend yields are low.

Essay 1 is a traditional ex-day study in that it uses actual stock price data to estimate the tax rate implicit in ex-day prices. It examines stock price behaviour around ex-days at the Helsinki Stock Exchange (HeSE) in two periods, 1989-90 and 1993-97. The tax treatment of capital income during these periods was substantially different and that allows a convenient test of ex-day price behaviour. The intermediate period, 1991-92, is a period of transition and does not provide enough data for a meaningful analysis.

In the beginning of 1991, Finland adopted an imputation system under which recipients of dividend income get full credit for the taxes paid by the dividend distributing firm. Since 1993, personal dividend tax rates have been zero while the tax rate on capital gains has been either 25% or 28%. These tax rates imply that stock prices should fall on ex-dividend days by more than 130 per cent of the dividend amount. Alternatively, if stocks are priced by tax exempted investors or investors with a zero effective tax rate on capital gains, prices should fall by the full dividend amount. Therefore, we expect that the average ex-ratio should be at least one in 1993-97. In 1989-90 the treatment of capital income in personal taxation was rich in detail and Essay 1 describes it carefully. We expect that the average ex-ratio is at most one. Thus, we predict that ex-ratios in 1993-97 are at least as large as in 1989-90.

Using price data on restricted stocks that only domestic investors were able to purchase in 1989-90 and data on all stocks in 1993-97, we estimate the implicit tax rate to be roughly 0.7 - 0.75 in both periods. These results suggest a preference for capital gains over dividends. The estimates are consistent with the tax treatment of dividends and capital gains of domestic investors in 1989-90 and inconsistent with the tax treatment of domestic investors in 1993-97. Our interpretation is that in 1989-90 the marginal investor was a domestic individual who had a lot of capital income, while in 1993-97 the marginal investor was a foreign investor. A similar finding and interpretation for 1994-97 has previously been reported by Hedvall, Liljeblom and Löflund (1998).

To test the existence of tax based clienteles in the Finnish stock market, we extend the ex-ratio model and estimate a systematically varying parameter model, which assumes that the dividend tax rate falls linearly with dividend yield. The empirical evidence gives no support for a clientele effect in 1993-97 and weak support in favour of a clientele effect in 1989-90, which is a new finding in the Finnish stock market.

Finally, to examine the importance of short-term trading around ex-days we construct a portfolio of stocks of higher than average dividend yield and normal trading volume which proxies for liquidity. The selection procedure produces a sample of 28 stocks for 1993-97. The portfolio of liquid high-yield stocks exhibits abnormally high trading volume on cum and ex-days and abnormally low trading volume on the following two trading days. There is no evidence of abnormal returns around ex-days. The average ex-ratio of this portfolio, 0.78, is in accordance with our previous results. These results imply that short-term trading around ex-dividend days is not important in the Finnish stock market. We were unable to perform the same test for 1989-90 because the size of the high-yield, high liquidity portfolio was far too small for a meaningful test. Due to a stamp duty levied on stock sales and purchases trading costs were higher in 1989-90 than in 1993-97 and therefore we expect that short-term trading was probably unimportant.

We close this summary with some comments on the general importance of the results. The empirical results of Essay 1 add to those of the already vast ex-day literature. They provide support for the idea that capital income taxes affect stock returns and thus stock prices. The results are from a small stock market, which has interesting and distinguishing features, like relatively large dividends and high transaction costs. In addition, two time periods with different tax systems offer a meaningful comparison.

Essay 2 is among the first ex-day studies ever to take tick rules into account at all. It is probably the very first study that actually derives an explicit model for the interaction of tick rules and stock price behaviour around ex-days. The outcome of this model is that the effect of tick rules on ex-day price behaviour is predictable and, at least in principle, testable. Unfortunately, it turns out that testing the model is difficult. Therefore, the extended model is a challenge for future econometric work. Essay 2 provides a starting point for further work, both theoretical and empirical. Especially interesting would be applications of the extended model to large data sets.

The results of the simulation experiments in Essay 3 are rather discomforting. They raise serious doubts about our ability to estimate the tax rate implicit in the ex-day price drop, and therefore, provide a critique of the existing empirical literature. These results are not, however, a critique of the fundamental idea that taxes affect the valuation of shares. They are not a critique of the fundamental idea of Elton and Gruber that prices around ex-days reflect capital income taxes. The results only suggest that isolating the implicit tax rate from the ex-day price drop may be very difficult indeed because of tick rules and because we can not reliably separate the overnight stock return and the price drop caused by dividend stripping. Furthermore, Essay 3 shows that the risk of obtaining a misleading estimate of the implicit tax rate is larger under some conditions than others. By identifying such conditions, Essay 3 and its results may prove useful to anyone who reads previous studies and tries to put them into perspective, or to anyone who does empirical work of her own.

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Ex-Dividend Day Behaviour of Stock Prices in Finland in 1989-90 and 1993-97

Abstract

We document that stock prices fall by 70 to 75 per cent of the dividend amount on ex-dividend days in Finland in 1989-90 and 1993-97. These results suggest that domestic individuals were marginal investors in the former period and foreign investors in the latter. There is weak evidence in favour of a tax clientele effect in 1989-90, which is a new finding in the Finnish stock market. A portfolio of stocks with high dividend yields and liquidity exhibits abnormally high trading volumes on cum and ex-days and abnormally low volumes on the following two trading days. These abnormal volumes are not matched by simultaneous abnormal returns. This evidence is consistent with long-term traders timing their trades around ex-days and inconsistent with short-term trading being of any importance.

JEL classification codes: *G12, G35*

Key words: *Dividends, Stock prices, Taxation*

1 Introduction

Elton and Gruber (1970) show that ex-dividend day behaviour of stock prices can be used to infer the tax bracket of the marginal long-term investor without having to assume any particular asset pricing model. This is a convenient result. The tax rates of long-term investors are important, because they appear in share valuation models and affect company cost of capital, the level of investment, and financial and dividend policies (see King (1977)). If long-term investors face higher tax rates on dividend income than on capital gains, the tax hypothesis predicts that stock prices fall on ex-dividend days by less than the amount of dividend, or equivalently, ex-dividend day returns are positive because investors require a tax premium as compensation for the higher dividend taxes. Elton and Gruber also suggest that investors may form dividend clienteles, based on their tax brackets. The basic idea is that stocks with high dividend yields attract investors with low dividend tax rates and vice versa.

Evidence in favour of the tax hypothesis is provided, for example, by Campbell and Beranek (1955), Durand and May (1960), Dorsman and Verboven (1990), Barclay (1987), Robin (1991), Booth and Johnston (1984), Poterba and Summers (1984), Hietala (1990) and Sorjonen (1988). The strongest evidence against the tax hypothesis is provided by Eades, Hess and Kim (1984), who find abnormal ex-dividend day return behaviour not only for taxable dividends but for non-taxable distributions as well. Hence, factors other than taxes may also influence ex-day return behaviour. One such factor in stock prices may be risk premiums (see Grammatikos (1989) and Fedenia and Grammatikos (1993)).

Another explanation for stock price behaviour around ex-dividend days is given by Kalay (1982). He argues that dividend capture or dividend avoidance activities of short-term investors, whose tax rates are sufficiently different from those of long-term investors, may determine stock prices around ex-dividend days. This would make it impossible to detect the tax rates of long-term investors. In many countries dividends and short-term capital gains are taxed at the same rate. In that case, the short-term trading hypothesis predicts that if short-term traders set prices around ex-days, stock prices fall approximately by the full amount of the dividend, or equivalently, that no tax premium can be observed in ex-day returns. Kalay shows that the profitability of short-term trading increases with dividend yield and decreases with transaction costs. Among others, Lakonishok and Vermaelen (1983) and Michaely (1991) find that short-term trading is important around ex-days. Karpoff and Walkling (1988), Karpoff and Walkling (1990) and Lakonishok and Vermaelen (1986) present evidence supporting the view that the tax explanation and the short-term trading hypothesis are complementary rather than competing hypotheses. Short-term trading is important among stocks with high yields, low bid-ask spreads (transaction costs) and high liquidity, whereas long-term traders seem to determine ex-day prices of stocks with opposite characteristics.

This paper examines the effect of capital income taxation on ex-dividend day stock price behaviour at the Helsinki Stock Exchange (HeSE) in two periods, 1989-90 and 1993-97.[1] In the beginning of 1991, Finland replaced her former two-rate tax system by an imputation system under which recipients of dividend income get full credit for the taxes paid by the dividend distributing firm. Later, in the beginning of 1993, while maintaining the imputation system, Finland introduced a uniform capital income tax rate, which was first set at 25 per cent and raised to 28 per cent in 1996. Due to full credit of the corporate tax in dividend taxation, personal dividend tax rates became zero. This implies that stock prices should fall on ex-dividend days by more than 130 per cent of the dividend amount. However, if stocks are priced by tax exempted investors or investors with a zero effective tax rate on capital gains prices should fall by the full dividend amount. In 1989-90 the treatment of capital income in personal taxation was rich in detail. We expect that prices should fall on ex-days by less than the dividend amount.

In the first sub-period, 1989-90, foreign stock ownership was restricted in Finland. Foreign investors were allowed to hold only unrestricted stocks, while domestic investors were allowed to hold both unrestricted and restricted stocks.[2] We examine

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[1] Several earlier studies, including Barclay (1987), Booth and Johnston (1984), Grammatikos (1989), Lakonishok and Vermaelen (1983), Michaely (1991), Poterba and Summers (1984) and Robin (1991), examine the effect of a major tax reform on the behaviour of stock prices around ex-dividend days.

[2] The restriction on foreign ownership was removed on January 1, 1993. For pricing of restricted and unrestricted stocks in Finland, see Hietala (1989).

the price behaviour of restricted stocks in 1989-90. The results are therefore not contaminated by the tax treatment of foreign investors' equity income. In the second sub-period, all stocks are unrestricted and therefore the tax treatment of foreign investors may affect ex-day price behaviour.

Our empirical results show that the average ex-ratio is roughly 0.7 - 0.75 in both periods, suggesting a preference for capital gains over dividends. The result is consistent with the tax treatment of dividends and capital gains of domestic investors in 1989-90 but inconsistent with that in 1993-97. Our interpretation of these findings is that the marginal investor was a domestic individual in 1989-90 but a foreign investor in 1993-97. A similar finding and interpretation for 1994-97 has previously been reported by Hedvall, Liljeblom and Löflund (1998).

To test the existence of tax based clienteles in the Finnish stock market, we extend the ex-ratio model and estimate a systematically varying parameter model which assumes that the dividend tax rate falls linearly with dividend yield. The empirical evidence gives no support for a clientele effect in 1993-97 and weak support in favour of a clientele effect in 1989-90. The previous studies of Hietala (1990) and Sorjonen (1988) find no evidence of tax clienteles in Finland while Hedvall, Liljeblom and Löflund (1998) suggest (see their footnote 18) that there might be one in 1994-97.

Finally, to examine the importance of short-term trading around ex-days, we construct a portfolio of stocks of higher than average dividend yield and liquidity. This portfolio exhibits abnormally high trading volume on cum and ex-days and abnormally low trading volume on the following two trading days. There is no evidence of abnormal returns around ex-days. The ex-day abnormal return is positive but not statistically significant. The average ex-ratio of this portfolio, 0.78, is in accordance with our previous results. These results imply that short-term trading around ex-dividend days is not important in the Finnish stock market. Unfortunately, we were unable to perform the same test for 1989-90 because the size of the high yield, high liquidity portfolio was far too small for a meaningful test. Due to a stamp duty levied on stock sales and purchases, trading costs were higher in 1989-90 than in 1993-97 and therefore short-term trading was probably unimportant.

The organisation of the paper is the following. Section 2 discusses the Finnish tax system and the ex-day model. Empirical tests are reported in Section 3. Section 4 concludes.

2 Tax treatment of dividends and capital gains in Finland

Finland has experienced two major capital income tax reforms in the 1990's. First, in the beginning of 1991, the two-rate system was replaced by an imputation system, and second, in the beginning of 1993, while still maintaining the imputation system, a uniform capital income tax rate was introduced. The major features of these tax systems are the following. First, under the two-rate system corporations were effectively taxed at a lower rate on distributed than retained profits. The treatment of capital income in personal taxation was rich in detail. Second, under the imputation system recipients of dividend income get full credit for the taxes paid by the dividend distributing firm. Thus, they deduct the corporate tax from their own dividend tax liability and pay (or obtain) the difference. Since 1993, there has been a uniform capital income tax rate. The same tax rate is applied to taxing corporate income, dividends, capital gains and interest and rental income. It was initially set at 25 per cent and raised to 28 per cent in 1996. Due to full credit of the corporate tax in dividend taxation, personal dividend tax rates are zero.

2.1 Tax discrimination between dividends and capital gains

We start by discussing the workings of the two-rate and imputation systems.[3] Let D denote the dividend announced by the firm, D_{at} the net dividend after both corporate and personal taxes, τ_d the shareholder's personal tax rate on dividends and G the gross dividend. The gross dividend is the dividend after corporate taxes but before personal taxes, so that $G = D_{at}/(1-\tau_d)$. Let τ be the tax rate on undistributed profit or the basic rate of corporation tax. τ is the tax rate the firm would face if it paid no dividends at all. Assume that there is one markka inside the company after the corporation tax but before shareholders' personal taxes, which is paid out to shareholders in the form of dividends. Define θ as the amount of money the shareholder gets after paying the personal dividend tax. Then $1-\theta$ is the personal dividend tax. The parameter θ can be viewed as the opportunity cost of retaining one markka of earnings in terms of net dividends, D_{at}, foregone, or, as a rate of tax discrimination between retaining earnings and paying out dividends.

Assume that capital gains are taxed at a rate τ_g on accrual basis and let γ denote the market value of a unit of retained earnings.[4] Then a unit of retained earnings leaves the shareholder with an after tax capital gain of $(1-\tau_g)\gamma$. Further, assume stocks are priced in such a way that investors are indifferent between capital gains and dividends at the margin. Setting the after-tax capital gain equal to the after-tax dividend, that is, $(1-\tau_g)\gamma = \theta$, and solving for γ yields

(1) $$\gamma = \frac{\theta}{1-\tau_g}.$$

Define the total tax liability, T, of the firm and its shareholders, as the sum of the corporation tax on undistributed profit and the additional taxes the company or its shareholders have to pay on distributed profit as

(2) $$T = \tau Y + \frac{1-\theta}{\theta} D_{at}$$

or

(3) $$T = \tau Y + \frac{(1-\theta)(1-\tau_d)}{\theta} G.$$

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[3] The discussion follows King (1974 and 1977), Poterba and Summers (1985) and Ylä-Liedenpohja (1993), who employ models that distinguish between various corporate tax systems by comparing their treatment of retained earnings (capital gains to the shareholder) versus distributed earnings (dividends).

Under the two-rate system, retained and distributed profits are taxed at different rates. Usually distributed profit is taxed at a lower rate than retained profit.[5] The total tax liability under the two-rate system is

(4) $$T = \tau(Y - G) + \tau_{div} G + \tau_d G$$

where τ and τ_{div} are corporate tax rates on undistributed and distributed profit. The parameter θ in the two-rate system can be solved by rearranging terms in (4) and setting the coefficient of G equal to the coefficient of G in Equation (3). We obtain for θ and γ (see also Table 1)

(5) $$\theta = \frac{1 - \tau_d}{1 - (\tau - \tau_{div})}$$

(6) $$\gamma = \frac{1 - \tau_d}{(1 - \tau_g)[1 - (\tau - \tau_{div})]}.$$

Under the imputation system, corporations are taxed at a flat corporate tax rate that is equal for retained earnings and distributions. Investors are taxed on their dividend income at the marginal tax rate, but they get at least partial credit for the tax paid by the company. Hence, shareholders are regarded as already having paid dividend taxes at rate u, the imputation rate. [6] The total tax liability under the imputation system is

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[4] The parameter γ is the appreciation of stock value resulting from retaining a unit of earnings after corporate taxes.

[5] In Finland, a lower tax rate on corporate distributions was brought by a dividend deduction in state taxation. Sixty per cent (in 1984-1988 and 40 per cent in 1989) of the distributed profit in excess of tax free dividends received was tax deductible. In practise, a corporation was entitled to the dividend deduction only if it distributed more dividends than it received, because dividends received from another domestic corporation were not taxable income. In addition, 100 per cent of dividends paid on new equity were deductible from profits in state taxation in the year of the share issue and the next five years, after which the normal 40 or 60 per cent rule was applied.

[6] Assume that the announced cash dividend is, say 6, and the imputation rate 40 per cent. The grossed-up dividend is 10. If the shareholder's marginal tax rate is greater than the imputation rate he or she must pay more taxes on the cash dividend at a rate which is the difference between the marginal and imputation rates. For example, if the marginal tax rate is 50 per cent the shareholder's dividend tax is 5 but because 4 is already paid in advance the additional tax liability is 1 If the marginal tax rate is less than the imputation rate, the shareholder gets a tax refund for excess taxes paid.

(7) $$T = \tau Y + \tau_d G - uG.$$

Again, θ can be solved by rearranging terms in (7) and setting the coefficients of G equal to the coefficient of G in Equation (3). Solving for θ and γ yields [7]

(8) $$\theta = \frac{1-\tau_d}{1-u}$$

and

(9) $$\gamma = \frac{1-\tau_d}{(1-\tau_g)(1-u)}.$$

The parameter γ takes both corporate and personal taxes into account. It is therefore a measure of total tax discrimination between distributed and retained profit. If γ is less than one, the tax system discriminates dividends in favour of capital gains, while γ greater than one implies that capital gains are taxed more heavily than dividends. Thus, γ, earlier defined as the market value of a unit of retained earnings, measures the relative value of after-tax dividends in terms of after-tax capital gains. [8]

Poterba and Summers (1985, p.245) define still another tax variable, α, which takes only personal taxes into account. This investor tax preference ratio is given by

(10) $$\alpha = \frac{1-\tau_d}{1-\tau_g}$$

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[7] An intuitive explanation is the following. Assume that the dividend after corporate taxes (and before personal taxes) is 1. The taxable dividend income for the shareholder is the grossed-up dividend $1/(1-u)$ [Note that for the imputation system $G = D_{at}/(1-\tau_d) = D/(1-u)$. Hence, the relation between D and D_{at} is given by $D_{at} = D(1-\tau_d)/(1-u)$. For the two-rate system $G = D = D_{at}/(1-\tau_d)$]. The personal dividend tax is then $\tau_d/(1-u)$ of which the dividend paying firm has already paid $u/(1-u)$. The personal dividend tax rate is given by $(\tau_d-u)/(1-u)$. The dividend after personal taxes is $\theta = 1-(\tau_d-u)/(1-u)$, or $\theta = (1-\tau_d)/(1-u)$. The value of a unit of retained earnings to the shareholder is $(1-\tau_g)\gamma$. Setting the after-tax amounts equal and solving for γ yields (9).

[8] Imagine that a dividend payment of 1 (after the corporation tax) is cancelled and the money retained within the firm. Under the two-rate system the shareholder returns $1-\tau_d$, the tax authorities return $\tau_d+\tau_{div}$ to the firm, and the firm pays a tax of τ on the undistributed profit. The firm retains an amount of $1-(\tau-\tau_{div})$ with an after-tax value of $(1-\tau_g)[1-(\tau-\tau_{div})]\gamma$ to the shareholder. Since $(1-\tau_g)[1-(\tau-\tau_{div})]\gamma$, is equal to $1-\tau_d$, γ must be the value of after tax dividends in terms after-tax capital gains.

for the two-rate system and

$$\alpha = \frac{1-\tau_d}{(1-\tau_g)(1-u)} \tag{11}$$

for the imputation system. It measures the relative value of a gross dividend of one markka and an increase of one markka in the stock price.

Table 1

Definitions of Tax Discrimination and Dividend Variables

	Two-Rate System	**Imputation System**
δ	$\frac{1-\tau_d}{1-(\tau-\tau_{div})}$	$\frac{1-\tau_d}{1-u}$
α	$\frac{1-\tau_d}{1-\tau_g}$	$\frac{1-\tau_d}{(1-\tau_g)(1-u)}$
γ	$\frac{1-\tau_d}{(1-\tau_g)[1-(\tau-\tau_{div})]}$	$\frac{1-\tau_d}{(1-\tau_g)(1-u)}$
Dividend announced	$D = G$	$D = (1-u)G$
Net dividend	$D_{at} = (1-\tau_d)G = (1-\tau_d)D$	$D_{at} = (1-\tau_d)G = \frac{1-\tau_d}{1-u}D$

In their seminal paper, Elton and Gruber (1970) show that ex-dividend day stock prices can be used to estimate α. Let P_{cum} and P_{ex} denote the cum-dividend and ex-dividend day stock prices. Define the before-tax and after-tax ex-day returns as

$$r_{ex} = \frac{P_{ex} - P_{cum} + D}{P_{cum}} \tag{12}$$

and

(13) $$r_{ex}^{at} = \frac{(1-\tau_g)(P_{ex} - P_{cum}) + (1-\tau_d)D}{P_{cum}}$$

where D is the dividend announced by the firm. The dividend is non-zero on ex-dividend days and zero otherwise. Manipulating (13) yields

(14) $$r_{ex} = \frac{r_{ex}^{at}}{1-\tau_g} + (1-\alpha)\frac{D}{P_{cum}}$$

where $\alpha = (1\text{-}\tau_d)/(1\text{-}\tau_g)$ is the tax preference ratio discussed above and D/P_{cum} is dividend yield. Equation (14) implies that the stock returns on non-ex-days are simply the after-tax returns grossed-up by the capital gains tax rate. Letting $\bar{r} = r_i^{at}/(1\text{-}\tau_g)$, Equation (14) can be rewritten as

(15) $$r_{ex} = \bar{r} + (1-\alpha)\frac{D}{P_{cum}}.$$

Further manipulation of (15) yields the familiar result of Elton and Gruber (1970)

(16) $$\frac{P_{cum}(1+\bar{r}) - P_{ex}}{D} = \alpha.$$

Equations (15) and (16) suggest that ex-day returns depend on the tax treatment of dividends and capital gains. If dividends are taxed more (less) heavily than capital gains in personal taxation, the tax preference ratio is less (greater) than one, and we expect, firstly, that prices on ex-dividend days fall by less (more) than the amount of the dividend, and secondly, that ex-day stock returns are positively (negatively) related to dividend yield.

2.2 The 1990 and 1992 tax reforms

This section examines how the 1990 and 1992 tax reforms changed the tax treatment of shareholders' dividend income and capital gains. Table 2 summarises the discussion below.

(a) Foundations and mutual funds

Private foundations and mutual funds are tax exempt institutions, and therefore pay no taxes on dividends and capital gains. Before 1991, these institutions paid no taxes on the gross dividend, G, and thus $G = D_{at}$. After 1991, the gross dividend was effectively taxed at the imputation rate, u, at the corporate level and therefore foundations and mutual funds received the announced dividend, D, on which no additional taxes were due. On the other hand, they were not entitled to a tax refund for the dividend tax withheld by the dividend paying firm, and therefore $D_{at} = D$. Hence, the dividend tax rate, on the dividend announced, remained zero for foundations and mutual funds after 1991. The capital gains tax rate also remained zero. Therefore, we expect that the tax preference ratio, α, of foundations and mutual funds is equal to one in 1989-97.

Table 2

The Tax Treatment of Dividend Income and Capital Gains in Finland°
(Periods 1989-90, 1991-92 and 1993-97)

		Effective marginal tax rate		
	Investor	1989-90	1991-92	1993-97
Dividends°	Individuals	$0, 0.5\tau_p, \tau_p$	$(\tau_p - u)/(1 - u)$	0
	Ordinary corporations	0	0	0
	Banks, insurance companies and stockbrokers	τ	0	0
	Foundations and mutual funds	0	0	0
Capital gains	Individuals	$\tau_p, 0.8\tau_p, 0.4\tau_p$	$\tau_p, 0.8\tau_p, 0.5\tau_p$	τ_g
	Ordinary corporations	τ	τ	τ
	Banks, insurance companies and stockbrokers	τ	τ	τ
	Foundations and mutual funds	0	0	0

° Dividend stands here for the dividend announced, which is equal to the dividend after corporate taxes. In 1989-90 the dividend announced is the gross dividend, G, while in 1991-97 it is the dividend without tax credit, $(1\text{-}u)G$.

(b) Corporations

Capital gains are fully taxable for all corporations at the corporate tax rate, τ.[9] The dividend tax rate of ordinary corporations was zero in 1989-90, while dividends of other corporations (banks, insurance companies and stockbrokers) were taxed at the rate τ.[10] In 1991, the personal dividend tax rate became $(\tau-u)/(1-u)$ for all corporations. The imputation rate, u, was set equal to τ. Therefore, while gross dividends were taxed at the imputation rate, the effective marginal tax rate, $(\tau-u)/(1-u)$, on cash dividends, D, was zero for all corporations. Thus, the dividend tax rate of ordinary corporations remained at zero from 1989 to 1997, while that of banks, insurance companies and stockbrokers fell from τ in 1989-90 to zero in 1991-97.

The tax preference ratio, α, of ordinary corporations is equal to $1/(1-\tau)$ in 1989-97, whereas the tax preference ratio of banks, insurance companies and stock brokers is equal to unity in 1989-90 and $1/(1-\tau)$ in 1991-1997. A casual look at Table 3 suggests that the tax preference ratios of corporations remain almost unchanged over time. This is not true, because the corporate tax rate changed several times in 1989-1997. Using statutory tax rates[11], we estimate that α of ordinary corporations was 1.85 in 1989-90, 1.33 in 1993-1995 and 1.39 in 1996-97. The estimates are identical for other corporations with the exception that $\alpha = 1$ in 1989-90.

[9] Since 1989, only 60 per cent of the capital gain was taxable after a five-year holding period if shares owned by an ordinary corporation are classified as fixed assets.

[10] Before 1991, dividends received by a domestic corporation from another domestic corporation were tax free with one important exception. Dividend income was fully taxable at the corporate tax rate, τ, for banks, insurance companies, pension funds and stockbrokers. Dividends were tax free for them only if the shares were classified as fixed assets in the balance sheet. Shares in fixed assets can be regarded as long-term or strategic investments that yield regular income. While banks are major shareholders in Finland, it is very doubtful that these potentially large blocks of shares were traded around ex-dividend days. Finally, for holding companies dividends were tax free only to the extent that they were redistributed to the company's own shareholders, which merely illustrates the chain principle that only the final recipient of the dividend should be taxed.

[11] The corporate tax rate was 46 per cent in 1989-90, 25 percent in 1993-95 and 28 percent in 1996-97.

(c) Individuals

In 1989-90, the effective marginal dividend tax rate for individuals was either 0, $0.5\tau_p$ or τ_p.[12, 13] In the following we refer to individuals in the zero dividend tax bracket as 'Group 1', those in the $0.5\tau_p$ bracket as 'Group 2' and those in the τ_p bracket as 'Group 3'. The dividend tax rates of all individuals decreased after the adoption of the imputation system in 1991. Dividends were taxed at the marginal income tax rate, τ_p, with full imputation of the corporate tax. The personal dividend tax rate $(\tau_p\text{-}u)/(1\text{-}u)$ became negative for low tax bracket individuals ($\tau_p < u$), either negative or positive for individuals in the middle tax brackets, and remained positive for high tax bracket individuals ($\tau_p > u$).[14] Later, in 1993, as the uniform capital income tax rate was adopted and set equal to the imputation rate and the corporate tax rate, the effective dividend tax rate, $(\tau_d\text{-}u)/(1\text{-}u)$, of all individuals became equal to zero. This reform raised the dividend tax rate of Group 1 and decreased that of Group 3. The effect on Group 2 is unclear.

The tax treatment of individuals' capital gains was fairly complicated in 1989-92.[15] Capital gains were taxed at the personal income tax rate. They were fully taxable for holding periods less than 4 years and 80 per cent taxable for a holding period of 4-5 years. For holding periods over 5 years only 40 (50 in 1992) per cent was taxable after a tax-free amount of FIM 200,000 (FIM 210,000 in 1990). Thus, the marginal capital

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[12] The effective marginal tax rate on dividends (capital gains) is the taxable proportion of dividend income (capital gain) times the marginal tax rate. For example, if only 50 per cent of dividend income is taxable, the effective dividend tax rate is $0.5\tau_d$.

[13] Individuals were allowed to make a capital income deduction from interest, dividend and rental income. The first FIM 2,000 was tax-free. Fifty per cent of the dividends and interest income between FIM 2,001 and FIM 18,000 (FIM 38,000 in 1990) were taxable at the marginal tax rate, τ_p. Dividends beyond FIM 18,000 (FIM 38,000) were fully taxable at τ_p. The capital income deduction was removed in 1991 when the imputation system was adopted.

[14] The term $(\tau_d - u)/(1 - u)$ is smaller than τ_d as long as $\tau_d < 1$.

[15] For an excellent survey of individuals' capital gains taxation in Finland, see Kukkonen (1992).

gains tax rate was τ_p, $0.8\tau_p$ or $0.5\tau_p$ ($0.4\tau_p$ in 1992).[16] Since 1993, all capital gains have been fully taxable at the uniform capital income tax rate.

The implications of the two tax reforms on individuals' tax preference ratios are not straightforward. To get some idea of the probable magnitude of tax preference ratios, we computed ballpark values under different assumptions of the identity of the marginal investor and the length of the holding period.[17] The formula used in computing the ratios is

$$\alpha = \frac{1-f-\left(\frac{(b\tau_d - f)-u}{1-u}\right)(1+r)^{-l}}{1-c\tau_g(1+r)^{-(h+l)}} \tag{17}$$

where f is the immediate withholding tax rate[18], b and c are the taxable proportions of dividends and capital gains, u is the imputation rate, r is the interest rate used in discounting future taxes, h is the length of the holding period (in years), and l is the time lag between the realisation of taxable capital income and the actual tax

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[16] In addition, the taxable capital gain was calculated using as the purchase price the larger of the original purchase price and a given percentage (25 or 50 per cent) of the sales price. Thus only part of the capital gain was taxable when an asset was sold at a price many times higher than the original purchase price.

[17] In computing the values for the tax preference ratio we make the following assumptions. First, the imputation rate is 25 per cent in 1993-95 and 28 per cent in 1996-97 and equal to the corporate tax rate. In 1989-90 the corporate tax rate used is 46 per cent, a simple average of the approximate corporate tax rates of 50 per cent in 1989 and 42 per cent in 1990. Second, we assume that the marginal tax rates of Group 1, Group 2 and Group 3 individuals are 30, 50 and 63 per cent, respectively. Third, the dividend income of a Group 1 individual is, by our definition, not more than FIM 2,000. It follows that if the dividend yield of the Group 1 individual's portfolio is very low, say 0.5 per cent, the value of the portfolio can not exceed FIM 400,000. For a higher dividend yield the value of the portfolio has to be even lower. It is therefore very unlikely that the capital gains of Group 1 individuals would exceed FIM 200,000, the tax-free amount of capital gains. Hence, we assume that Group 1 individuals have a zero capital gains tax rate. Finally, if the holding period is less than four years, we assume that it is exactly two years. If the holding period is from four to five years, we assume that it is exactly four years. If the holding period is more than five years, a holding period of exactly five years is assumed.

[18] In practice, after the tax-free capital income FIM 2,000, there was an immediate 25 per cent dividend tax on receipt of the next FIM 16,000 (FIM 36,000 in 1990), which was later taken into account in computing the final tax. Beyond FIM 18,000 (or FIM 38,000), the immediate dividend tax was 50 per cent.

payment[19]. The parameter values used are collected in Table 3 and the results are reported in Table 4.

2.3 Implications for ex-dividend day stock price behaviour

The range of tax preference ratios for 1989-90 in Table 4 is quite wide, suggesting that ex-ratios can vary a lot depending on the identity of the marginal investor. We argue that ex-ratios can not reflect very large or very small tax preference ratios. First, note that α is the amount of capital gain that makes the investor indifferent after taxes with a dividend of one. Each figure in Table 4 gives the size of the ex-ratio that makes a given investor indifferent between selling cum and ex (the column marked 'seller'), and buying cum and ex (the column marked 'buyer'). If an investor expects that the ex-ratio will deviate from these values, he will find it profitable to accelerate or delay his sales or purchases. For example, if the expected ex-ratio is smaller (larger) than the investor's own tax preference ratio, he will find it profitable to sell the stock ex (cum). A similar argument can be made for investors wishing to optimise the timing of their stock purchases around ex-days. If the expected ex-ratio is smaller (larger) than the investor's own tax preference ratio, he would find it profitable to buy the stock cum (ex). Second, when the expected ex-ratio is very small, only few investors are willing to sell cum and buy ex, while others are willing to do the reverse. The stock price tends to rise on the cum-day and fall on the ex-day, which increases the ex-ratio. Respectively, when the expected ex-ratio is very large, only few investors are willing to buy cum and sell ex, while others are willing to do the reverse. Thus, the ex-ratio tends to fall because the stock price falls on the cum-day and rises on the ex-day. Hence, it is unlikely that ex-ratios reflect very small or very large tax preference ratios. Therefore, investors with very small or very large tax preference ratios are not likely to be marginal investors.

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[19] Dividends are paid annually in Finland, usually during the first six months of the year with most dividend payments taking place in March or April. The final tax on dividends is paid in December of the following year. Therefore, if the average dividend payment takes place in April, there is on average a 20 month lag between the dividend receipt and the tax payment. The lag with capital gains tax payments is slightly different. Capital gains realised today are reported to the tax authorities by January of the following year and the tax is due in December. Therefore, the lag between the realisation of the gain and the tax payment varies between 12 and 24 months. To simplify things, we assume a lag of 18 months applies to the taxation of both dividends and capital gains. The lag is valid for individuals only, because corporations pay at least part of their tax liability in advance.

Table 3

Parameter Values

	τ_p	u	f	b	c	h	l
1989-90							
Individuals: Group 1	0.3	0	0	0	0	0, 1, 4, 5	1.5
Individuals: Group 2	0.5	0	0.25	0.5	1, 0.8, 0.4	0, 1, 4, 5	1.5
Individuals: Group 3	0.63	0	0.5	1	1, 0.8, 0.4	0, 1, 4, 5	1.5
Ordinary corporations	0.46	0	0	0	1	0, 1, 3, 5	0
Banks, insurance companies and stock brokers	0.46	0	0	1	1	0, 1, 3, 5	0
Foundations and mutual funds	0	0	0	0	0	0	0
1993-95 / 1996-97							
All individuals	0.25 / 0.28	0.25 / 0.28	0	1	1	0, 1, 4, 5	1.5
All corporations	0.25 / 0.28	0.25 / 0.28	0	1	1	0, 1, 3, 5	0
Foundations and mutual funds	0	0	0	0	0	0	0

τ_p = the capital income tax rate or the corporate tax rate, u = the imputation rate, f = the immediate withholding tax rate, b = the taxable proportion of dividends, c = the taxable proportion of capital gains, h is the length of the holding period (in years), and l is the time lag between the realisation of taxable capital income and the actual tax payment. For a seller $h = 0$. The interest rate used is 6 % for 1989-90, 5 % for 1993-95 and 3 % for 1996-97.

Table 4

Estimates of the Investor Tax Preference Ratio (α) for Some Long-Term Investors

	Holding period (years)	1989-1990 Seller	1989-1990 Buyer	1993-1995 Seller	1993-1995 Buyer	1996-1997 Seller	1996-1997 Buyer
Individuals: Group 1	1	1	1	1.30	1.28	1.37	1.35
	4	1	1	1.30	1.24	1.37	1.31
	5	1	1	1.30	1.22	1.37	1.30
Individuals: Group 2	1	1.38	1.32	1.30	1.28	1.37	1.35
	4	1.18	1.06	1.30	1.24	1.37	1.31
	5	0.92	0.87	1.30	1.22	1.37	1.30
Individuals: Group 3	1	0.90	0.84	1.30	1.28	1.37	1.35
	4	0.71	0.60	1.30	1.24	1.37	1.31
	5	0.50	0.46	1.30	1.22	1.37	1.30
Ordinary corporations	1	1.85	1.77	1.33	1.31	1.39	1.37
	3	1.85	1.63	1.33	1.28	1.39	1.34
	5	1.85	1.52	1.33	1.24	1.39	1.32
Banks, insurance companies and stock brokers	1	1	0.95	1.33	1.31	1.39	1.37
	3	1	0.88	1.33	1.28	1.39	1.34
	5	1	0.82	1.33	1.24	1.39	1.32
Foundations and mutual funds		1	1	1	1	1	1

Ignoring the extreme tax preference ratios, Table 4 suggests that ex-ratios are less than or equal to unity in 1989-90. Very small and large tax preference ratios are not a problem in 1993-97. We expect that ex-ratios are equal to unity in 1993-97 if the marginal investor is a tax-free institution and approximately 1.3 if the marginal investor is someone else. Therefore, we predict that ex-ratios in 1993-97 are at least as large as in 1989-90.

Table 4 assumes that capital gains taxes can not be avoided. In practise, however, the effective tax rate on capital gains may be close to zero if investors have enough losses to offset gains.[20] Miller and Scholes (1982) suggest that capital gains taxes can be postponed forever. One can realise losses today by selling shares, buy them back tomorrow to keep the composition of one's portfolio unaltered, and then use the losses to offset the capital gains. Table 5 shows the tax preference ratios when the effective capital gains tax rate is zero.[21] Our previous prediction that ex-ratios in 1993-97 are at least as large as in 1989-90 remains.

Table 5

Estimates of the Investor Tax Preference Ratio (α) when the Effective Tax Rate on Capital Gains is Zero

	1989-90	1993-95	1996-97
Individuals: Group 1	1	1	1
Individuals: Group 2	0.75	1	1
Individuals: Group 3	0.38	1	1
Ordinary corporations	1	1	1
Banks, insurance companies and stock brokers	0.54	1	1
Foundations and mutual funds	1	1	1

[20] The Finnish stock market boomed in the late 1980's and the market index rose more than 220 per cent from 1985 to 1989. In the autumn of 1989 the market turned from bull to bear and by autumn 1992 almost 70 per cent of the market value of stocks vanished. The sudden market decline may have gradually turned a large part of the capital gains accumulated in the late 1980's into capital losses. As short-term capital gains can be offset by short-term capital losses for tax purposes, the effective marginal capital gains tax rate may have been low in 1993.

[21] Dividend taxes are not a problem because they can not be avoided either in the old system or in the new system.

3 Empirical tests

3.1 Methodology

The starting point for empirical analysis is equation (15), which is reproduced here for convenience

$$r_i = \bar{r}_i + (1-\alpha)\frac{D_i}{P_i}. \tag{15'}$$

The subscript i in equation (15') refers to stock i. The econometric counterpart of (15') is

$$r_i = \gamma_0 + \gamma_1 d_i + \gamma_2 \bar{r}_i + \varepsilon_i \qquad \varepsilon_i \sim N(0, \sigma_i^2) \tag{18}$$

where $\gamma_1 = 1\text{-}\alpha$ is the tax parameter we are interested in, γ_0 is expected to be zero, and γ_2 is expected to be equal to 1. If γ_2 indeed equals unity, estimating (18) is equivalent to estimating

$$r_i - \bar{r}_i = \gamma_0 + \gamma_1 d_i + \varepsilon_i \tag{19}$$

where the left-hand side can be written as

$$r_i - \bar{r}_i = \left[P_{i,ex} - (1+\bar{r}_i)P_{i,cum} + D_i\right] / P_{i,cum}. \tag{20}$$

Thus, adjusting the cum-day price by the normal return amounts to the same as deducting the normal return from the ex-day return. The residual, ε_i, in (18) measures the unexpected ex-day return. Residual variance is non-constant, because stock returns have different volatility and therefore the model in (18) is heteroskedastic. To correct for heteroskedasticity, both sides of (18) must be divided by σ_i so that the model becomes

$$\text{(21)} \qquad \frac{1}{\sigma_i}\frac{P_{i,ex}-P_{i,cum}+D_i}{P_{i,cum}} = \gamma_0\frac{1}{\sigma_i}+\gamma_1\frac{d_i}{\sigma_i}+\gamma_2\frac{\bar{r}_i}{\sigma_i}+\eta_i$$

where $\eta_i = \varepsilon_i/\sigma_i$ has a constant variance. Equation (21) is very close to the one that produces the *GLS* estimator of the ex-ratio first proposed by Michaely (1991). To see the connection, let $\gamma_0 = 0$ and $\gamma_2 = 1$, and use $\gamma_1 = 1\text{-}\alpha$. Some manipulation of (21) yields

$$\text{(22)} \qquad \frac{d_i}{\sigma_i}\frac{P_{i,cum}-P_{i,ex}}{D_i} = \alpha\frac{d_i}{\sigma_i}-\frac{\bar{r}_i}{\sigma_i}+\eta_i$$

and after rearranging terms

$$\text{(23)} \qquad \frac{d_i}{\sigma_i}\frac{P_{i,cum}(1+\bar{r}_i)-P_{i,ex}}{D_i} = \alpha\frac{d_i}{\sigma_i}+\eta_i\,.$$

The *GLS* estimator of α in (23) weights the individual ex-ratios by the factor $w_i = d_i/\sigma_i$ to make the residual term homoskedastic. The model we actually estimate is (22), which we can write as

$$\text{(24)} \qquad \frac{d_i}{\sigma_i}\frac{P_{i,cum}-P_{i,ex}}{D_i} = \beta_0+\beta_1\frac{d_i}{\sigma_i}+\beta_2\frac{\bar{r}_i}{\sigma_i}+\eta_i \quad , \qquad \eta_i \sim N(0,\sigma^2).$$

We test the hypotheses that $\beta_0 = 0$, $\beta_1 = \alpha$ and $\beta_2 = -1$.[22] Capital income taxes affect the pricing of shares if $\beta_1 \neq 1$.

[22] Multiplying both sides by σ_i/d_i and ignoring the normal return yields the traditional ex-ratio of Elton and Gruber, that is, $(P_{i,cum} - P_{i,ex}) / D_i = \alpha - \varepsilon_i/d_i$.

3.2 Data

Our data set includes all companies listed on the Helsinki Stock Exchange (HeSE) that had at least one ex-dividend day during the periods 1989-90 and 1993-1997, were traded on both the last cum-day and the first ex-day, and paid strictly positive dividends.[23] Before January 1, 1993, foreign investors were allowed to purchase unrestricted stocks only, while Finnish investors were allowed to purchase both restricted and unrestricted stocks. We use data of only restricted stocks in 1989-90 for two reasons. First, the number of unrestricted stocks is small, and second, restricted shares allow us to examine the effect of capital income taxation of domestic investors on returns of shares that only domestic investors can hold. Since 1993, all shares have been unrestricted and therefore our sample for 1993-97 includes all stocks.

The data set contains closing and opening prices, and both the number of stocks traded and the trading volume. We measure the ex-day price drop from cum close to either ex open or ex close. Since not all price and volume information is available for all stocks, the number of ex-day observations available depends on the choice of prices.[24] For all stocks we use closing, opening and average prices, defined as the trading volume divided by the number of stocks traded, to compute three sets of returns days -55,...,-6 relative to the ex-dividend day (= day 0). Returns are defined as logarithmic price differences. We choose the set of returns that offers the highest number of observations and use these returns to estimate the normal return and the standard deviation of returns. If the number of observations is the same for all alternatives we use closing prices. At least 15 return observations are required, otherwise the stock is excluded. The normal return is measured both in terms of the mean and median return during the 50-day period. Stocks fulfilling these requirements form a narrow sample in our study. We also form a broad sample, which differs from the narrow one in that no return history is required.

[23] Stocks were excluded if a share issue began on the ex-dividend day. Some firms were excluded because their 1990 dividend payments were taxed according to the 1991 imputation system. Also, some Swedish firms were excluded because they announce their dividends in Swedish Crowns.

[24] Some authors form portfolios of stocks going ex-dividend on the same calendar date and treat each daily portfolio as one ex-day observation. We treat every stock going ex on the same date as a separate observation.

3.3 Results

We first estimate equation (24) using both the broad and the narrow sample. The heteroskedasticity correction requires information about σ_i. For the narrow sample, we estimate σ_i as the standard deviation of stock returns in days -55,...,-6. For the broad sample information on average returns and return volatility is not available. Therefore, we use ex-day market returns (WI-index) as proxies for normal return and set $\sigma_i = 1$ for all i. Thus, with the broad sample (24) reduces to (18).

We expect that the coefficient of the normal return be close to one. The results show something else. Correlations between ex-day returns and estimates of normal return are close to zero (with 1989-90 data the correlation coefficient is actually negative) and the regression coefficients are both small and not significantly different from zero. We obtain the same result with both samples and all measures of normal return. These findings suggest that either the return adjustment is incorrect or that there is no need for one. Therefore, we simplify the empirical model by excluding the normal return altogether. The new model is

$$\frac{d_i}{\sigma_i}\frac{P_{i,cum} - P_{i,ex}}{D_i} = \beta_0 + \beta_1 \frac{d_i}{\sigma_i} + \eta_i \tag{25}$$

where the constant term is expected to capture the normal non-ex-day return.

Graphical inspection of the data suggests that some observations are very different from the majority of observations. After a closer look, six observations are excluded in 1989-90 and one observation in 1993-97. Even after doing so we find evidence of extremely high residual non-normality and heteroskedasticity. The Bera-Jarque normality tests show values 10 times the critical value of 5.99 (5 per cent significance level).[25] This suggests the possibility of influential observations, or outliers, which indicates that our knowledge of ex-day price behaviour is restricted. Our simplistic

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[25] The Bera-Jarque normality test is a joint test of whether estimates of skewness and excess kurtosis are significantly different from zero. The test statistic has an asymptotic χ^2 distribution with 2 degrees of freedom. For details, see Judge et al. (1988) pp. 890-892.

models can explain only a relatively small part of ex-day returns with taxes and dividend yield leaving a lot of room for improvement. On the other hand, some outliers are created by the heteroskedasticity correction from observations with an unusually small or large d_i/σ_i .

Since our purpose is to study how stock prices, on average, behave on ex-days, it is important to identify the unusual observations. To detect influential observations, we compute two measures of influence for each observation, leverage and standardised residual (see Chapter 22 in Judge et al. (1988) for robust estimation). The standardised (or studentized) residual measures large errors. The residual for the *i*th observation is computed by estimating the model without this observation. It is then standardised by the estimated residual standard deviation. Standardised residuals less than two in absolute value are regarded as acceptable. Leverage measures the distance between an individual observation and the majority (average) of observations. Observations very far from the majority of observations may have a strong influence on the regression coefficients and their standard deviations. With one regressor, observations are regarded as influential if leverage exceeds $2/N$ or $3/N$ (N is the sample size). In our data set high leverage values are not common. The very few exceptions exceeding $6/N$ or $8/N$ are dropped out. Large standardised residuals, few exceeding five, several exceeding two, are more common. Again we remove observations with standardised residuals very different from other observations. In some cases, we set the limit at 2.2, but usually higher. The total number of excluded observations is small and in general the effect on parameter estimates is small.

The average ex-ratios are reported in Table 6 when ex-day price drops are measured from cum-day closing to ex-day opening and in Table 7 when only closing prices are used. These tables report the results for both the broad and narrow samples. Panel (a) of Table 6 shows that the results for the two periods bear a remarkable resemblance. The constant terms are not different from zero as we expected and restricting them to be zero has little impact on the slope coefficients. In both periods the average ex-ratio is close to 0.7. The difference between the estimated parameters in the two periods is statistically insignificant and alternates with sign depending on whether the constant is included in the regression or not. In both periods the tax parameter is (at least marginally) significantly smaller than one, although the reliability of this conclusion is undermined by evidence of residual heteroskedasticity in the latter period.

If the estimates are taken at face value they suggest the following. First, an average ex-ratio equal to 0.7 implies a roughly 30 percent dividend tax rate and a zero tax on capital gains. Alternatively, if the capital gains tax rate is positive, the dividend tax rate must exceed 30 per cent. Second, in 1989-90 the marginal investor is an individual who has a lot of capital income (see Tables 4 and 5 for the tax preference ratios). Third, since tax preference ratios of domestic investors can not be less than one in 1993-97 the marginal investor must be a foreign investor.[26] A more "frightening" explanation is that the marginal investor is a domestic investor with a zero tax rate on capital gains, believing that his or her marginal dividend tax rate is 28 per cent even though it is zero in reality. The narrow sample confirms these results for 1993-97. The results for 1989-90 are not quite the same as in the broad sample case, possibly because the sample size is much smaller, only 42 observations compared to 63 in the broad sample.

When the ex-day price drop is computed using closing prices (Table 7) the results become less clear. One explanation is that intra-ex-day returns produce noise, which the constant term alone can not remove. Two of the constants are marginally significant. When the constants are forced to zero, average ex-ratios for 1993-97 are again close to 0.7. Average ex-ratios for 1989-90 are more dispersed, potentially because of the small number of observations, and therefore difficult to interpret.

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[26] Hedvall, Liljeblom and Löflund (1998) report a similar result for 1994-97. The result is consistent with Hietala and Keloharju (1995) who find that ex-day price behaviour of restricted and unrestricted stocks is different because the capital income tax treatment of domestic and foreign investors is different.

Table 6

Ex-Dividend Day Ratios in 1989-90 and 1993-97

Cum Close - Ex Open

Panel (a) Broad sample

	N	β_0	β_1	R^2	BP	BJ
1989-90	63	-0.002 (0.486)	0.734 (1.936)	0.318	0.615 [0.433]	2.923 [0.232]
	63		0.676 (4.655)	0.315	1.074 [0.300]	3.233 [0.199]
1993-97	206	-0.001 (0.243)	0.723 (2.909)	0.221	4.885 [0.027]	5.565 [0.062]
	206		0.703 (6.559)	0.221	5.027 [0.025]	5.159 [0.076]

Panel (b) Narrow sample

	N	β_0	β_1	R^2	BP	BJ
1989-90	42	-0.148 (0.356)	0.608 (1.750)	0.155	0.000 [0.993]	3.237 [0.072]
	42		0.537 (4.514)	0.153	0.002 [0.963]	3.328 [0.189]
1993-97	148	0.029 (0.238)	0.729 (3.058)	0.317	8.533 [0.003]	3.566 [0.059]
	148		0.747 (5.219)	0.316	8.256 [0.004]	4.301 [0.116]

t-values are in parentheses below parameter estimates. The t-tests are H_0: $\beta_0 = 0$ and H_0: $\beta_1 = 1$. BP is the Breusch-Pagan test of heteroskedasticity. $BP = N*R^2$, where R^2 is from the regression of squared residuals on the explanatory variables. BJ is the Bera-Jarque test for normality of residuals. p-values are in brackets below BP and BJ.

Table 7

Ex-Dividend Day Ratios in 1989-90 and 1993-97

Cum Close - Ex Close

Panel (a) Broad sample

	N	β_0	β_1	R^2	BP	BJ
1989-90	49	-0.006 (1.151)	0.667 (2.002)	0.255	0.002 [0.961]	2.260 [0.323]
	49		0.505 (5.596)	0.234	0.000 [0.991]	2.389 [0.303]
1993-97	203	-0.005 (1.904)	0.901 (0.935)	0.264	6.039 [0.014]	0.324 [0.851]
	203		0.724 (5.384)	0.251	6.276 [0.012]	0.231 [0.891]

Panel (b) Narrow sample

	N	β_0	β_1	R^2	BP	BJ
1989-90	31	-0.698 (1.885)	0.773 (1.132)	0.340	2.498 [0.114]	3.608 [0.058]
	31		0.441 (5.667)	0.259	1.677 [0.121]	11.570 [0.121]
1993-97	147	-0.145 (0.922)	0.772 (1.985)	0.237	21.120 [0.000]	10.040 [0.002]
	147		0.683 (5.017)	0.233	22.200 [0.000]	6.099 [0.047]

t-values are in parentheses below parameter estimates. The *t*-tests are H_0: $\beta_0 = 0$ and H_0: $\beta_1 = 1$. *BP* is the Breusch-Pagan test of heteroskedasticity. $BP = N^*R^2$, where R^2 is from the regression of squared residuals on the explanatory variables. *BJ* is the Bera-Jarque test for normality of residuals. p-values are in brackets below *BP* and *BJ*.

The tax clientele hypothesis of Elton and Gruber (1970) predicts a positive relation between ex-dividend ratios and dividend yield. The argument is that investors with low dividend tax rates prefer a large proportion of their portfolio returns in the form of dividends and therefore invest in high-yield stocks, while investors with high dividend tax rates prefer a large proportion of their portfolio returns in the form of capital gains and therefore invest in low-yield stocks. Usually this hypothesis is tested by grouping stocks into deciles according to dividend yield after which the average ex-ratio is computed for each decile. Studies that employ U.S. stock price data often have several hundred observations per yield decile, but unfortunately we do not have access to such luxury. To test the existence of a tax based clientele effect in the Finnish stock market, we extend our previous model and estimate a systematically varying parameter model, which allows ex-ratios to vary continuously with dividend yield.

We start from (25), initially ignoring the constant term

(25')
$$\frac{d_i}{\sigma_i}\frac{P_{i,cum}-P_{i,ex}}{D_i}=\frac{1-\tau_d}{1-\tau_g}\frac{d_i}{\sigma_i}+\eta_i\,.$$

The tax clientele hypothesis predicts that the dividend tax rate decreases with dividend yield. We specify a linear relationship between the dividend tax rate and dividend yield

(26)
$$\tau_d=\gamma_0-\gamma_1 d_i\,.$$

This specification suggests that γ_0 is the dividend tax rate of an investor who invests in stocks that do not pay dividends. We expect that $\gamma_0 > 0$ and $\gamma_1 > 0$. There is no error term in (26), which means that the linear relationship between the dividend tax rate, τ_d, and dividend yield is assumed to hold exactly. Inserting (26) into (25') yields

(27)
$$\frac{d_i}{\sigma_i}\frac{P_{i,cum}-P_{i,ex}}{D_i}=\frac{1-\gamma_0}{1-\tau_g}\frac{d_i}{\sigma_i}+\frac{\gamma_1}{1-\tau_g}\frac{d_i^2}{\sigma_i}+\eta_i\,.$$

Table 8

Ex-Dividend Day Ratios in 1989-90 and 1993-97

Cum Close - Ex Open

	N	β_1	β_2	R^2	BP	BJ
1989-90	63	0.324 (3.307)	8.192 (1.827)	0.340	0.108 [0.947]	2.548 [0.280]
	41	0.308 (2.551)	5.616 (0.735)	0.116	6.507 [0.039]	1.328 [0.515]
1993-97	206	0.614 (3.190)	2.426 (0.793)	0.219	5.835 [0.054]	6.611 [0.037]
	148	0.772 (1.715)	-1.133 (0.308)	0.211	9.471 [0.009]	2.034 [0.362]

t-values are in parentheses below parameter estimates. The t-tests are H_0: $\beta_1 = 1$ and H_0: $\beta_2 = 0$. BP is the Breusch-Pagan test of heteroskedasticity. $BP = N*R^2$, where R^2 is from the regression of squared residuals on the explanatory variables. BJ is the Bera-Jarque test for normality of residuals. p-values are in brackets below BP and BJ.

The model we estimate is thus given by

$$\frac{d_i}{\sigma_i}\frac{P_{i,cum} - P_{i,ex}}{D_i} = \beta_1 \frac{d_i}{\sigma_i} + \beta_2 \frac{d_i^2}{\sigma_i} + \eta_i \qquad (28)$$

where $\beta_1 = (1-\gamma_0)/(1-\tau_g)$ is the tax preference ratio of an investor who does not invest in dividend paying stocks, and $\beta_2 = \gamma_1/(1-\tau_g)$.

The results are shown in Table 8. There is no evidence of a tax clientele effect in 1993-97. Estimates of β_2 are statistically insignificant and only the broad sample produces the correct sign. This is consistent with marginal investors at all dividend yield levels having the same tax preference ratio, which is estimated by β_1. Estimates of β_1 are also reasonably close to the previous estimates in Tables 6 and 7, thus corroborating our earlier findings. The results for 1989-90 are quite different. Estimates of β_1 suggest that investors investing in very low-yield stocks have a tax preference ratio of close to 0.3. Assuming that the tax rate on capital gains is zero, this implies a dividend tax rate of almost 70 %. The broad sample produces a marginally significant estimate of β_2 of size 8.2, which suggests that an increase of 0.01 in dividend yield is matched by a decrease of 0.08 in the dividend tax rate. The dividend tax rate of an investor investing in stocks yielding 5 % would then be approximately 27 %. The narrow sample does not, however, confirm this result. This evidence thus gives only weak support for the presence of a tax clientele effect in the Finnish Stock market in 1989-90. This result contradicts the previous findings of Hietala (1990) and Sorjonen (1988).

Kalay (1982) argues that ex-ratios can not be used to derive the tax rate of a long-term investor if short-term trading, that is, dividend motivated trading, around ex-days is important. Buying shares before they go ex and selling afterwards is profitable if the dividends more than cover transaction costs and the price drop, taking taxes into account. Selling shares short before they go ex and buying them back afterwards is profitable if the gain from price depreciation more than covers transaction costs and the dividend amount that must be returned to the owner of the shares, taking taxes into account. The profitability of dividend trading falls with transaction costs and increases with dividend yield. If dividend trading is important, it continues as long as marginal profits become zero. At that point, ex-day price drops exactly reflect the tax preference ratio and transaction costs of dividend traders and not the tax rates of long-term traders.

To examine the importance of short-term trading we form a portfolio of stocks with high dividend yield and high liquidity. Liquidity is measured by normal trading volume which we define as the average number of shares traded during trading days -55,...,-6 relative to the ex-day. Stocks accepted in this portfolio are required to have higher than average (median) dividend yield, higher than average (median) normal trading volume, and recorded trades in at least 48 days during days -55,...,-6. In 1993-97 a total of 28 stocks fulfilled these requirements. The average dividend yield in this sample is 2.8 % and the average normal daily trading volume is 114,895 shares. The respective numbers for the entire narrow sample are 2.2 % and 49,072 shares. An identical selection procedure produces a sample of only three stocks for 1989-90, which makes any meaningful analysis impossible.[27] Therefore, in what follows, we examine short-term trading only in 1993-97.

We use daily closing prices and trading volumes to compute the abnormal returns and volumes for days -5,...,-1,0,+1,...,+5. The normal daily return is computed as the average daily return during days -50,...,-6. The abnormal trading volume is defined as the relative deviation from the normal volume. The abnormal daily portfolio returns and volumes are computed as arithmetic averages of abnormal daily returns and volumes of the 28 stocks in the portfolio.

We expect that short-selling is unimportant during our data period, because it became possible in Finland as late as in May 1995 with the beginning of securities lending.[28] [29] Since ex-dividend days are mostly scattered in March and April, short-selling around ex-days did not take place before spring 1996. Unfortunately, our sample size is too small for examining the years 1996 and 1997 separately. Also, our finding that (see Table 6) the average ex-ratio is less than one suggests that ex-day returns are generally positive and increase with dividend yield, which is inconsistent with short-selling. However, dividend capture-related trading around ex-days can be important. If it is, we expect that the portfolio of liquid high-yield stocks exhibits positive abnormal

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[27] We have reason to believe that short-term trading was not important in 1989-90. The only way to trade the dividend was to buy shares cum and sell ex. The profitability of dividend trading was further limited by a one per cent stamp duty (0.5 per cent of the trading price for both the seller and the buyer) levied on stock trades. On May 1, 1992 the stamp duty was removed, which lowered the cost of buying cum and selling ex.

[28] Daily data on securities lending volume are not available. Hedvall, Liljeblom and Löflund (1998) find that monthly securities lending volumes are generally low with much higher volumes on dividend paying months. This evidence indirectly supports the view that there is dividend trading activity around ex-days, even though we do not know to what extent securities lending is used for short-selling purposes.

[29] Securities lending also allowed a route to tax arbitrage, which did not involve trading the shares at all. For a couple of years, tax-exempt institutions and taxable investors were able to engage in mutually beneficial securities lending and borrowing during ex-day periods. Tax-exempt investors, who were not entitled to the dividend tax credit, lent shares to taxable investors who then claimed both the dividend and the tax credit. The shares and a commission (a sum of money corresponding to the dividend amount and a premium) were returned to the tax-exempt investor. Both parties gained because securities lending provided a means for transferring tax credits to investors who were entitled to them from those who were not. There is reason to believe that a considerable part of this activity was based on bilateral agreements outside the stock exchange. Since shares are not traded, stock price and volume data are not useful in assessing the importance of this activity. These deals are no longer profitable because payers of the commissions, or dividends-in-kind, are liable to pay a tax equal to the tax credit.

returns before ex-days, negative abnormal returns after ex-days, and abnormally high trading volume both before and after ex-days.

Table 9 reports the average abnormal returns and trading volumes for the high-yield high-liquidity portfolio during the ex-dividend day period. It shows that for the majority of stocks trading volumes are higher than normal on cum-days and ex-days (days -1 and 0) and lower than normal on other days. At the portfolio level, we find statistically significant positive abnormal trading volume on both days -1 and 0 followed by at least marginally significant negative abnormal volumes on days +1 and +2. These abnormal trading volumes are not matched by simultaneous abnormal returns. We find evidence of negative abnormal returns on day -5, but otherwise the return behaviour reveals no abnormalities. The lack of abnormal return behaviour around ex-days suggests that short-term trading is not important on the HeSE. The positive abnormal volumes on days -1 and 0 are consistent with long-term investors timing their trades.

The ex-day abnormal return, measured from cum close to ex close, is not different from zero. However, measured from cum close to ex open the average abnormal return is larger, 0.004, but statistically insignificant (t-value 1.670). Dividing this average abnormal return by the average dividend yield, 0.028, we obtain the tax premium per unit of dividend yield, 0.143, which implies an average ex-ratio of 0.86. This ratio differs somewhat from the estimates in Table 6, suggesting that the ex-day price behaviour of this sub-sample may be different from that of other stocks in the data set. To check this, we estimated the average ex-ratio for this sub-sample using (28). The average ex-ratio is 0.784, which is very well in line with our previous results.

Table 9

Abnormal Ex-Dividend Day Period Returns and Trading Volumes of High Yield High liquidity Stocks in 1993-97 [1]

		Abnormal return			Abnormal volume		
Day	N	> 0 (%)	Median	Mean	> 0 (%)	Median	Mean
-5	28	35.7	-0.004	-0.005 (-2.216)	28.6	-0.472	-0.073 (-0.367)
-4	28	60.7	0.009	0.006 (1.704)	35.7	-0.378	0.092 (0.387)
-3	28	60.7	0.002	0.002 (0.633)	17.9	-0.424	-0.273 (-1.908)
-2	28	46.4	-0.002	0.002 (0.527)	25.0	-0.366	0.306 (0.866)
-1	28	53.6	0.003	0.003 (1.087)	82.1	1.087	2.352 (2.484)
0	28	50.0	0.001	0.002 (0.622)	71.4	0.733	0.982 (3.722)
+1	28	60.7	0.002	0.003 (1.569)	17.9	-0.483	-0.295 (-1.988)
+2	28	50.0	0.000	0.003 (0.850)	21.4	-0.519	-0.315 (-2.263)
+3	28	35.7	-0.003	-0.006 (-1.139)	28.6	-0.338	0.087 (0.261)
+4	27	48.1	-0.001	0.002 (0.633)	32.1	-0.588	0.095 (0.294)
+5	27	51.9	0.004	0.003 (1.414)	32.1	-0.408	0.020 (0.081)

[1] The expected daily stock returns and normal trading volumes are estimated as the average stock return and average number of shares traded on days -55,...,-6 relative to the ex-days.

4 Conclusions

We examine the behaviour of stock prices around ex-dividend days in Finland during two periods, 1989-90 and 1993-97. These periods provide a convenient test of ex-day price behaviour. In 1989-90, the tax treatment of dividends and capital gains was rather complicated. We expect that the average ex-ratio should be at most one. In 1993-97, the effective tax rate on dividends was zero, while the statutory capital gains tax rate was zero for tax exempt institutions and 25-28 % for other investors. We expect the average ex-ratio to equal at least one in 1993-97. The intermediate period 1991-92 does not provide enough data for a meaningful analysis.

For the 1989-90 period we use data of unrestricted stocks that only domestic investors can hold and data of unrestricted stocks that anyone can buy in 1993-97. The average ex-ratio is in the range of 0.7 to 0.75 in both periods. The result suggests that in 1989-90 the marginal investor is an individual and in 1993-97 a foreign investor. To test the existence of tax-based clienteles, we use a systematically varying parameter model assuming that the dividend tax rate of the marginal investor falls with dividend yield. The empirical results provide weak support for a clientele effect in 1989-90 and contradict the results obtained in previous studies of Hietala (1990) and Sorjonen (1988) that use Finnish data. There is no evidence of tax clienteles in 1993-97.

Finally, to examine the importance of short-term trading around ex-days we examine the return and volume behaviour of a portfolio of stocks with higher than average dividend yield and normal trading volume. The results show that in 1993-97 trading volume is abnormally high on cum and ex days and abnormally low on the two following trading days. We do not find evidence of abnormal returns except on ex-days. This evidence is consistent with long-term investors timing their trades around ex-days and inconsistent with short-term trading of any importance. We are unable to perform this analysis for the period 1989-90 because of the small sample size. Short-term trading is, however, unlikely because of high transaction costs, including a stamp duty, and the absence of short-selling possibilities.

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Ex-Dividend Day Stock Returns and Tick Rules

Abstract

We derive a model of ex-dividend day stock price behaviour, which takes price discreteness explicitly into account. Price discreteness adds to the model a new parameter, which describes how the market rounds prices, and makes the model non-linear. Rounding is needed, because prices must change by multiples of given increments. We show that the ex-dividend ratio is a piecewise, decreasing convex function of dividend amount. For a given cum-dividend day stock price, ex-day return is a piecewise linear function of dividend yield. The effect of price discreteness on ex-day returns decreases with stock price. Therefore, the cross-sectional distribution of cum-day stock prices is important for ex-day price behaviour.

JEL classification codes: G12, G35

Key words: Asset pricing, Dividends, Taxation, Tick size

1 Introduction

In their seminal paper, Elton and Gruber (1970) show that ex-dividend day price drops can be used to estimate the tax rate of the marginal investor. If capital gains are taxed at a lower (higher) rate than dividend income, the ex-day price drop is smaller (larger) than the dividend.[1] Tax rates on dividend income and capital gains are important in corporate finance (for example in dividend policy and capital structure issues) but information about them is difficult to obtain. In this respect the ex-day method, which does not assume any particular asset pricing model, can be useful. Kalay (1982) notes that estimating the implicit tax rate may be difficult if two or more groups of investors differ substantially in their tax treatment of capital income and one group of investors finds it profitable for tax reasons to either collect or avoid dividends. If trading is important because of the dividend, ex-day price drops reflect the tax rates of the investors engaged in dividend trading and not the more interesting tax rates of long-term investors. Dividend trading is expected to be more important among stocks with high yields, low bid-ask spreads (transaction costs), and high liquidity.

Many studies have applied the ex-day methodology to data from different countries and time periods. The empirical results are mixed. Barclay (1987) examines NYSE data from a period with no income tax in the U.S., 1900-1910, and another period after the introduction of the income tax, 1962-1985. Consistent with the tax explanation in 1900-1910, investors valued (before-tax) dividends and capital gains as perfect substitutes, but in 1962-1985 the value of dividends relative to capital gains was much lower due to a tax penalty on dividend income. Poterba and Summers (1984) report similar results for two dividend tax reforms in the U.K. Michaely (1991) and Robin (1991) examine the effect of the U.S. 1986 Tax Reform Act on ex-dividend behaviour and find conflicting results. Michaely finds abnormal return behaviour consistent with short-term trading around ex-days. Also Lakonishok and Vermaelen (1983) and Booth and Johnston (1984) obtain conflicting results with Canadian data around the 1972 tax reform. Eades, Hess and Kim (1984) report statistically

[1] This is equivalent to saying that ex-day returns increase (decrease) with dividend yield. Early empirical studies (see Campbell and Beranek (1955) and Durand and May (1960)) report that stock prices tend to fall on ex-dividend days by less than the amount of the dividend.

significant negative abnormal ex-day returns for non-taxable cash distributions that should have no tax consequences at all. This suggests that factors other than taxes may also influence ex-day return behaviour. One such factor may be a risk premium as suggested by Grammatikos (1989) and Fedenia and Grammatikos (1993). Karpoff and Walkling (1988) find strong evidence of short-term trading among high-yield stocks in the U.S. after a reduction in the costs of short-term trading following the introduction of negotiable commissions in 1975, and practically no evidence of short-term trading before.

In two recent papers, Bali and Hite (1998) and Frank and Jagannathan (1998) demonstrate that discrete prices may have a considerable effect on ex-day price behaviour. Frank and Jagannathan find that discrete prices cause prices in the Hong Kong stock market to fall on ex-days on average by less than the dividend amount even though neither dividends nor capital gains are taxed at all.

This paper extends the basic ex-day model to take price discreteness into account. We show that taking the tick size into account transforms the original linear model into a non-linear one and adds to the model a new rounding rule parameter, which can be estimated. The rounding rule ensures that price changes are multiples of given minimum increments. Discrete prices make the ex-day price drop a step function of the dividend amount, and the ex-dividend ratio of Elton and Gruber a piecewise, decreasing convex function of dividends. The pattern of the ex-dividend ratio is independent of stock price as long as tick size remains unchanged.

The extended model implies that ex-day returns can be systematically positive or negative even in the absence of taxes. For a given cum-dividend day price, ex-day return is a piecewise linear function of dividend yield. In general, the effect of price discreteness on ex-day returns decreases with stock price. Therefore, the cross-sectional distribution of the cum-day stock price is important for ex-day price behaviour.

The non-linearity and non-differentiability of the extended model make empirical work difficult. We use Finnish stock price data from 1989-95 to estimate the model by using a grid search method. The results suggest that the average ex-ratio is approximately 0.7, which is consistent with earlier ex-day studies that use Finnish data, and that the market rounding rule is difficult to estimate. Since we are unable to perform significance tests, these results must be treated as illustrative only.

We start by briefly discussing the theoretical relationship between ex-dividend day stock returns and dividend yield in a world of continuous prices in Section 2. Section 3 introduces the tick rules of the Helsinki Stock Exchange to illustrate the effect of discrete prices on ex-day stock prices both graphically and via a numerical example. The Finnish tick rules are useful due to a relatively wide tick. We derive and discuss the implications of the extended model in Section 4. Section 5 reports the results of elementary empirical analysis. Conclusions are presented in Section 6.

2 The framework

Define the expected before and after-tax returns, $E(r_t)$ and $E(r_{at})$, as

(1) $$E(r_t) = \frac{E(P_t) - P_{t-1} + D_t}{P_{t-1}}$$

and

(2) $$E(r_{at}) = \frac{(1-\tau_g)E(P_t - P_{t-1}) + (1-\tau_d)D_t}{P_{t-1}}$$

where

$E(.)$ = the expectations operator

P_t = day t stock price

D_t = dividend per share

τ_d = marginal tax rate on dividends of the marginal investor

τ_g = marginal tax rate on capital gains of the marginal investor.

The dividend is non-zero on ex-dividend days and zero otherwise. Manipulating (2) yields

(3) $$E(r_t) = \frac{E(r_{at})}{1-\tau_g} + (1-\alpha)\frac{D_t}{P_{t-1}}$$

where $\alpha = (1-\tau_d)/(1-\tau_g)$ measures the relative value of dividends and capital gains and D_t/P_{t-1} is dividend yield. Equation (3) implies that the expected stock return on non-ex-days is simply the grossed-up expected after-tax return. On ex-days, the expected return depends on the tax treatment of dividends and capital gains. Further manipulation of (3) yields the familiar result first derived by Elton and Gruber (1970)

(4) $$\frac{P_{t-1} - E(P_t)}{D_t} = \alpha .$$

Equation (3) predicts that the expected ex-day return is a linear function of dividend yield. In particular, ex-day returns are positively (negatively) related to dividend yield if dividends are taxed more (less) heavily than capital gains, that is, if $\alpha < 1$ ($\alpha > 1$).[2] In terms of Equation (4), this implies that stock prices fall on ex-days by less (more) than the amount of dividend. Only when dividends and capital gains are effectively taxed at the same rate expected ex-day returns are unrelated to dividend yield. This is equivalent to saying that the ex-day price drop equals the dividend.

If trading rules restrict the precision at which stock prices can be quoted, the results derived above may not hold any more. For example, Dubofsky (1992) shows that due to NYSE and AMEX tick rules, ex-day returns may be positively related to dividend yield even in the absence of taxes. In the following, we demonstrate that the tick rules in the Helsinki Stock Exchange have similar effects.

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[2] Ex-dividend studies generally examine whether prices around ex-days are determined by long-term or short-term investors. In the context of this paper, this distinction is irrelevant.

3 Tick size in the Helsinki Stock Exchange

In real life, trading rules of stock exchanges restrict the precision at which stock prices are quoted.[3] Table 1 shows the tick sizes applied in the Helsinki Stock Exchange (HeSE) before 1.1.1999. The tick size is a step function of stock price with four price (and tick) categories before 1.1.1996 and two price categories in 1.1.1996 - 31.12.1998. The table shows these price categories and the respective tick sizes in Finnish markkas and in approximate U.S. dollars, assuming that $1 = FIM 5. In the NYSE, the most common tick size is $0.125, which is equivalent to FIM 0.625. Thus, before 1996 the tick size in the HeSE was larger than in the NYSE for stocks selling for at least FIM 100 (or $20) and smaller for less expensive stocks. In 1996-98, the HeSE tick size was always less than one sixth of the NYSE tick size. From the beginning of 1999, the HeSE quotes stock prices in euros and the tick size is always 1 cent, which is approximately one seventeenth of a dollar.

This section illustrates, first via a numerical example and then graphically, how tick size affects ex-dividend day price behaviour. We show that the effect of tick rules on ex-day returns can be fairly large. For this illustration we need to choose a tick rule with a relatively large tick size. Therefore, we choose the tick rule applied in the Helsinki Stock Exchange (HeSE) before 1.1.1996 to stocks in the third price category. The same reasoning can be applied to tick rules in other stock exchanges even though the effect of these rules on ex-day returns may be more modest.

Table 1: Tick Size in the Helsinki Stock Exchange

Stock price		Tick size			
		- 31.12.1995		1.1.1996 - 31.12.1998	
FIM	*(USD)*	*FIM*	*(USD)*	*FIM*	*(USD)*
0.01- 10	(- 2)	0.01	(0.002)	0.01	(0.002)
10 - 100	(2 - 20)	0.10	(0.02)	0.10	(0.02)
100 - 1000	(20 - 200)	1	(0.2)	0.10	(0.02)
> 1000	(> 200)	10	(2)	0.10	(0.02)

[3] See Angel (1997) for tick sizes in different countries, and Anshuman and Kalay (1998) for a discussion of the optimal tick size.

There are three assumptions implicit in Equations (3) and (4). First, all investors have identical tax rates τ_d and τ_g, second, stock price drops on ex-dividend days exactly reflect the tax rates of the marginal investor so that the ex-day price drop is equal to αD_t, and finally, price changes of any size are possible. To illustrate the effect of tick rules, we pick three cum-dividend prices from the third price category, 110, 200 and 1000 FIM, respectively, and let the dividend per share take different values. In this price category, all price changes must be multiples of 1 markka. Sometimes αD_t is not an integer, in which case the market has to round prices somehow. We assume that the market rounds 0.50 down to 0 and 0.51 up to 1. Thus, for example, ex-day prices of 101.51 and 101.50 are rounded to 102 and 101, respectively. This is equivalent to assuming that the ex-day price drop that actually takes place is an integer $\leq \alpha D_t + \frac{1}{2} \times$ *tick*, so that, for example, the price drop corresponding to αD_t of 3.49 is 3 while the price drop corresponding to αD_t of 3.50 is 4. This rounding rule is chosen for its simplicity. Later in the paper, we introduce a more general rounding rule.

We let the dividend change with increments of 0.01 and for each dividend we compute the ex-day price assuming that only taxes, the tick rule, and the rounding rule affect price behaviour on ex-days. Let us first examine the ex-dividend day price drop. With continuous prices, the ex-day price drop would be a linear function of the dividend amount with a slope coefficient equal to α. Now that we have a discrete tick rule, the price drop becomes a step function of the dividend amount, where the points of discontinuity occur when the direction of rounding changes. Figure 1 graphs the ex-day price drop as a function of dividend amount when α is equal to 0.8, 1 or 1.2. Table 2 shows the calculations for $\alpha = 1$. As long as the price stays within the same price category and the same tick rule is applied, the ex-day price drop is independent of price. Therefore, the same pattern of price drops holds for all prices in the third price category. The width of the steps in Figure 1 depends on α. As α falls the steps become wider. If $\alpha = 1$ and $D_t = 0.51$, the price drop is 1, but if $\alpha = 0.8$ the price does not change at all. On the other hand, if $\alpha = 1.2$, a dividend of 0.425 is enough to make the price fall by 1. The deviation of the actual price drop from αD_t measures the noise caused by the tick size.

Figure 2 shows the ex-day ratios as functions of dividend amount. With given α and continuous prices, ex-ratios would be constant for all dividends. With discrete prices, the ex-ratio is a piecewise convex function of the dividend. Again, for a given α, this pattern is independent of stock price as long as prices stay in the same price category and the same tick size applies. A comparison of Figures 2b and 2c shows that a larger α implies a wider range for the values that ex-ratios can take. Ex-day studies have traditionally recognised that small dividends are a problem and Figure 2 shows why. The range of values that the ex-ratio can take is wide for small dividends. Therefore, the risk of small dividend samples yielding misleading results is considerable. Figure 2 also shows that there is no single definition for a small dividend. From an ex-day point of view, a small dividend is not the same as a small D_t. Whether a dividend is small depends on αD_t and the stock price which determines the tick size. The vertical difference between the ex-ratio and the constant α is the noise caused by the tick rule.

Table 2

An Illustration of the Effect of Tick Rules on Ex-Dividend Day Ratios and Returns in the Absence of Taxes

		Cum-dividend day stock price							
		$P_{cum} = 110$				$P_{cum} = 1000$			
Dividend	Ex-day price drop	Dividend yield, %	P_{ex}	Ex-Ratio	Ex-day return, %	Dividend yield, %	P_{ex}	Ex-Ratio	Ex-day return, %
0.50	1	0.45	109	2.00	-0.45	0.05	999	2.00	-0.05
0.75	1	0.68	109	1.33	-0.23	0.08	999	1.33	-0.03
1.00	1	0.91	109	1.00	0.00	0.10	999	1.00	0.00
1.25	1	1.14	109	0.80	0.23	0.13	999	0.80	0.03
1.49	1	1.35	109	0.67	0.45	0.15	999	0.67	0.05
1.50	2	1.36	108	1.33	-0.45	0.15	998	1.33	-0.05
1.75	2	1.59	108	1.14	-0.23	0.18	998	1.14	-0.03
2.00	2	1.82	108	1.00	0.00	0.20	998	1.00	0.00
2.25	2	2.05	108	0.89	0.23	0.23	998	0.89	0.03
2.49	2	2.26	108	0.80	0.45	0.25	998	0.80	0.05
2.50	3	2.27	107	1.20	-0.45	0.25	997	1.20	-0.05
2.75	3	2.50	107	1.09	-0.23	0.28	997	1.09	-0.03
3.00	3	2.73	107	1.00	0.00	0.30	997	1.00	0.00
3.25	3	2.95	107	0.92	0.23	0.33	997	0.92	0.03
3.49	3	3.17	107	0.86	0.45	0.35	997	0.86	0.05
3.50	4	3.18	106	1.14	-0.45	0.35	996	1.14	-0.05
3.75	4	3.41	106	1.07	-0.23	0.38	996	1.07	-0.03
4.00	4	3.64	106	1.00	0.00	0.40	996	1.00	0.00
4.25	4	3.86	106	0.94	0.23	0.43	996	0.94	0.03
4.49	4	4.08	106	0.89	0.45	0.45	996	0.89	0.05

We now turn to an examination of ex-day returns. Figure 3 shows ex-day returns as a function of dividend amount. The usage of dividend amount in the horizontal axis is somewhat unorthodox, but it illustrates the effect of tick rules on ex-day returns very nicely. With continuous prices and $\alpha = 1$, we would expect that ex-day returns are zero. Figure 3 shows that with discrete prices and for a given cum-day stock price, the ex-day return is a piecewise linear function of the dividend amount. The slope of the linear segments falls with the stock price. The segments are steep for $P_{cum} = 110$ and flat for $P_{cum} = 1000$. This suggests that the noise caused by the tick rule on ex-day returns is smallest for stocks with a small relative tick size. Table 2 shows that the noise can be only 0.05 % for $P_{cum} = 1000$ but almost 0.5 % for P_{cum} close to 100. The (cross-sectional) cum-day price distribution is therefore important even though it is usually ignored in ex-day studies.

To transform Figure 3 from a plot of returns and dividends to one of returns and dividend yields, we only have to rescale the horizontal axis by dividing dividend amounts by the relevant (cum-day) stock prices. This means that the relatively flat linear segments in Figure 3 of expensive shares will be packed more tightly than the steeper segments of less expensive shares. The result is shown in Figure 4. For a given cum-price, the ex-day return is a piecewise linear function of the dividend yield and the linear segments are different for stocks with different prices. Figure 4 shows that the tick rule adds a regular saw-tooth pattern around the linear relationship predicted by Equation (3).

Every point in Figure 4 shows one possible combination of ex-day return and dividend yield for a given cum-day stock price. There is a different pattern of ex-day returns for every price. A sample of real data is simply a collection of these points with some additional noise. For example, assume that $\alpha = 1$ as in Figure 4a. One can imagine several different samples of points taken from the plot in 4a. Because of the tick rule, some of the samples may give the impression that ex-day returns increase or decrease with dividend yield even though ex-day returns are not related to dividend yield for tax reasons. Furthermore, because of the tick rule, the data could suggest that $\alpha <(>) 1$ even though quite the opposite is true.

Figure 1: Dividend and Ex-Day price Drop

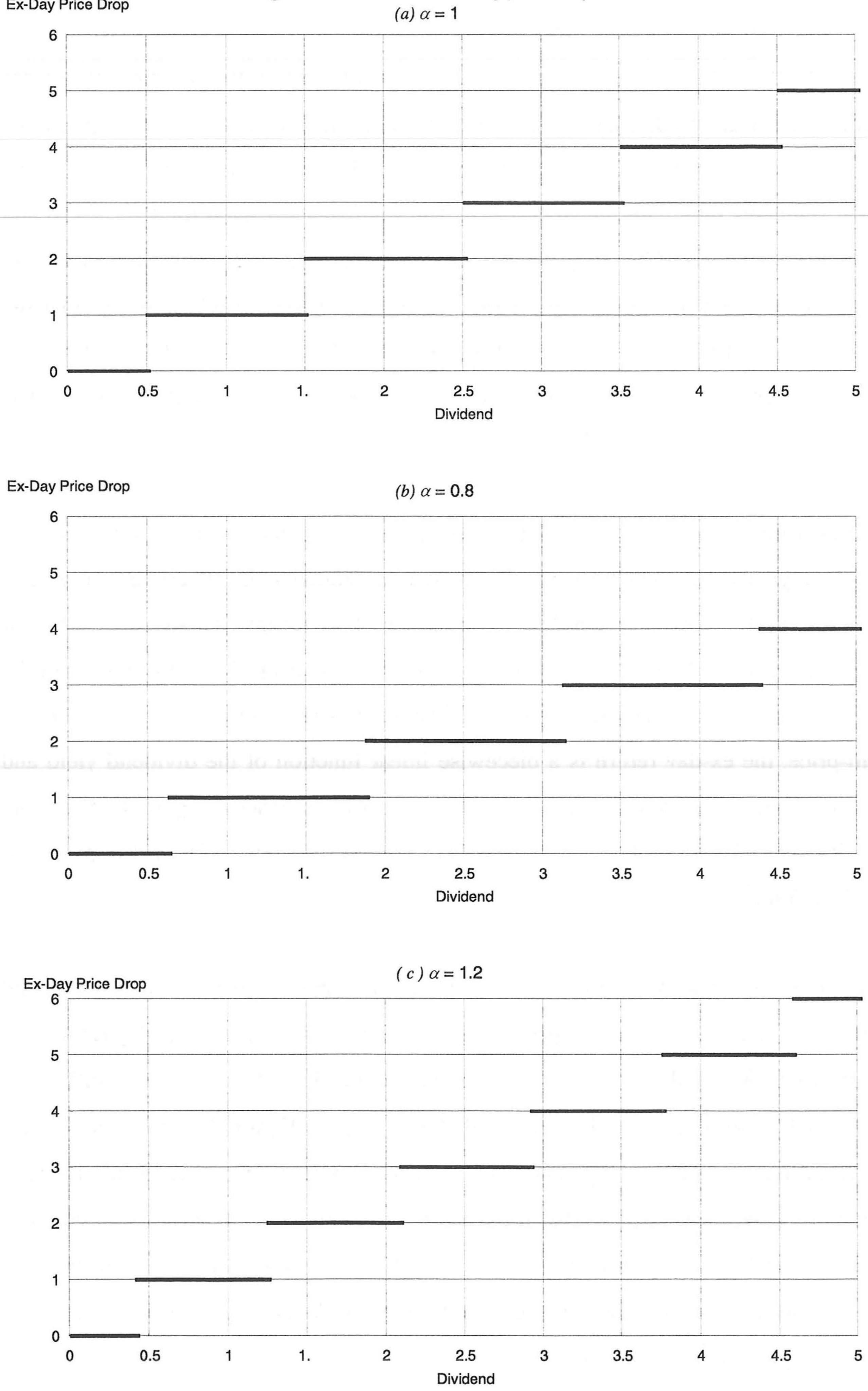


Figure 2: Dividend and Ex-Day Ratio

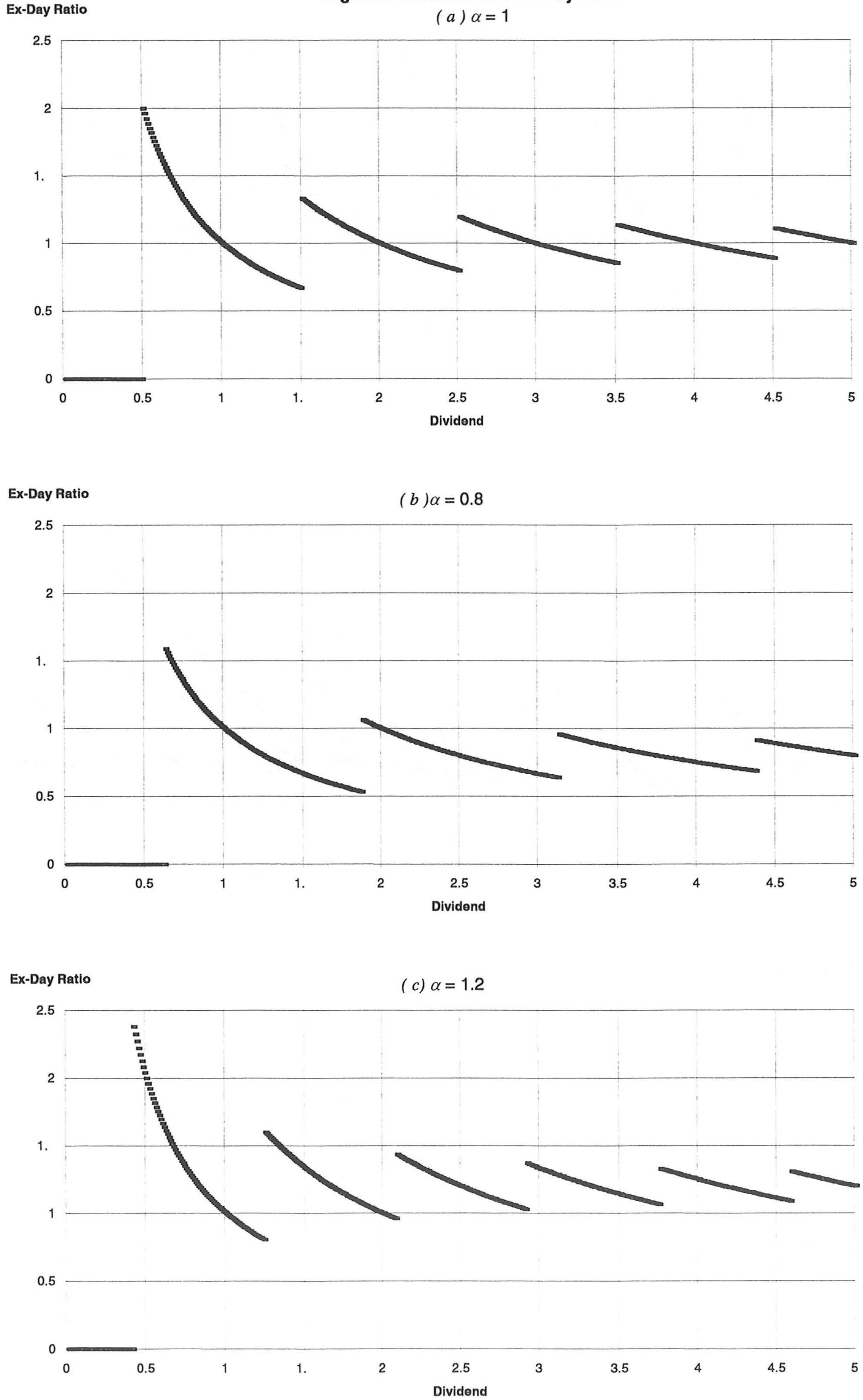


Figure 3: Dividend and Ex-Day Return

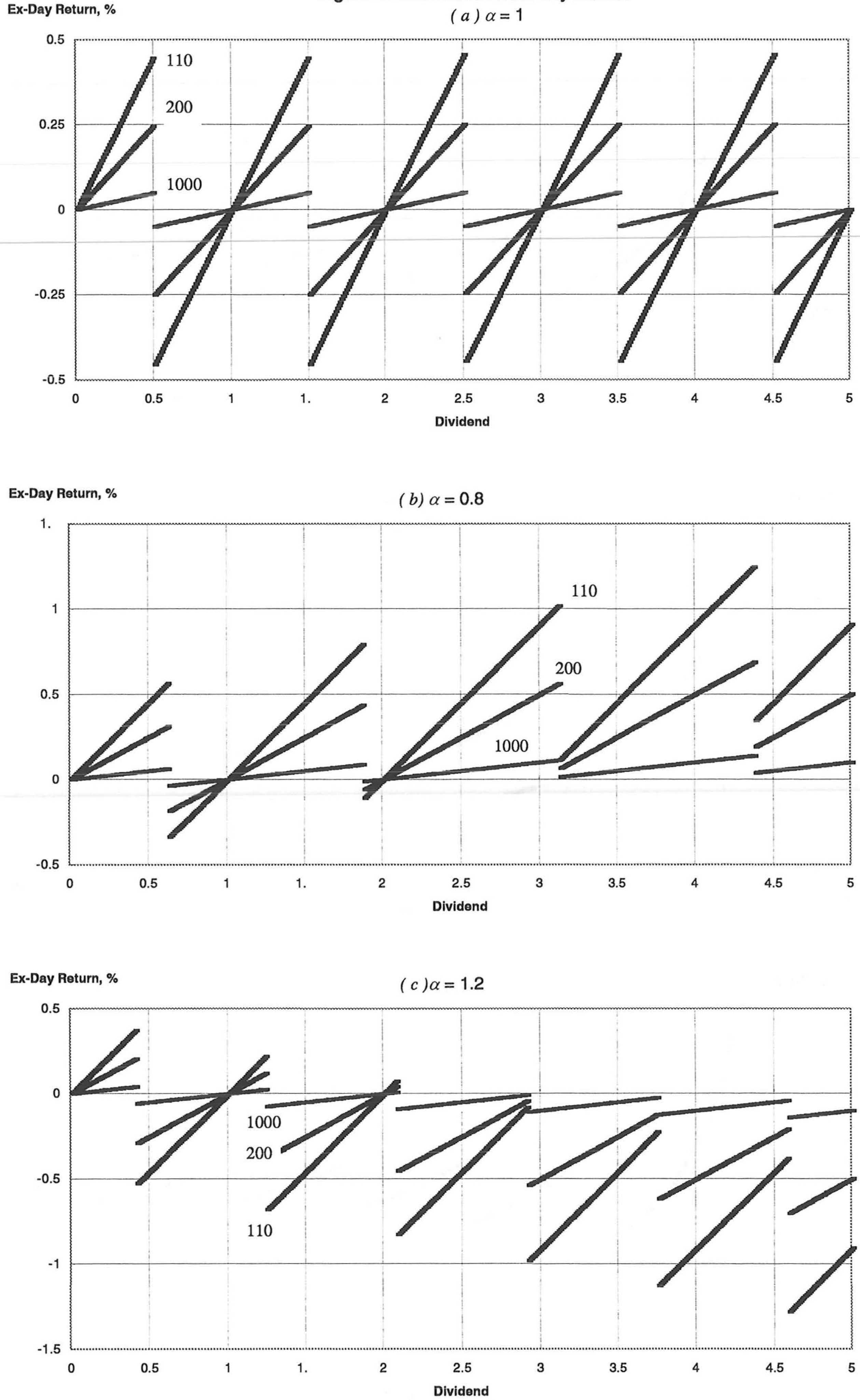
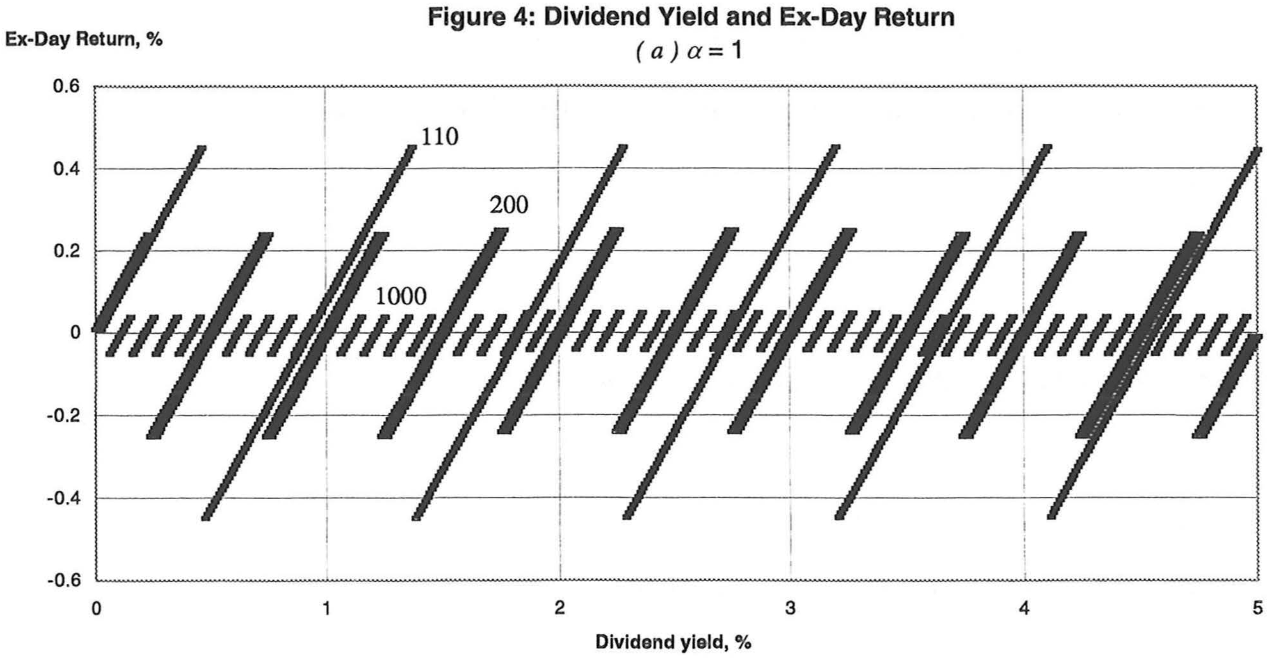
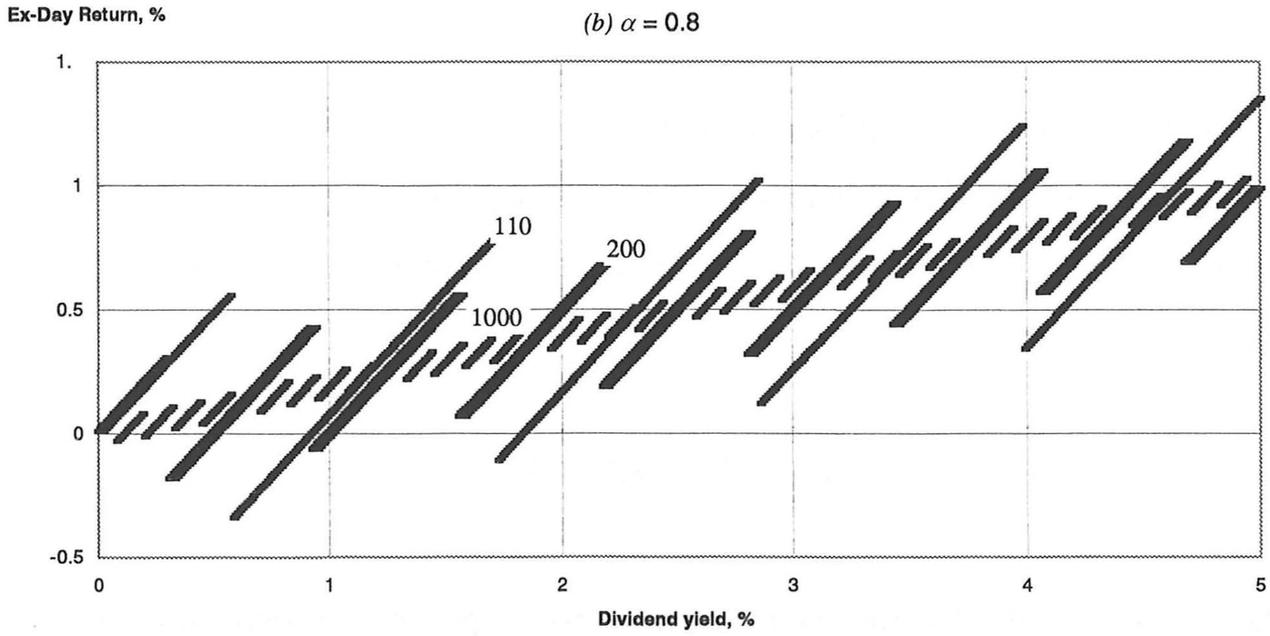
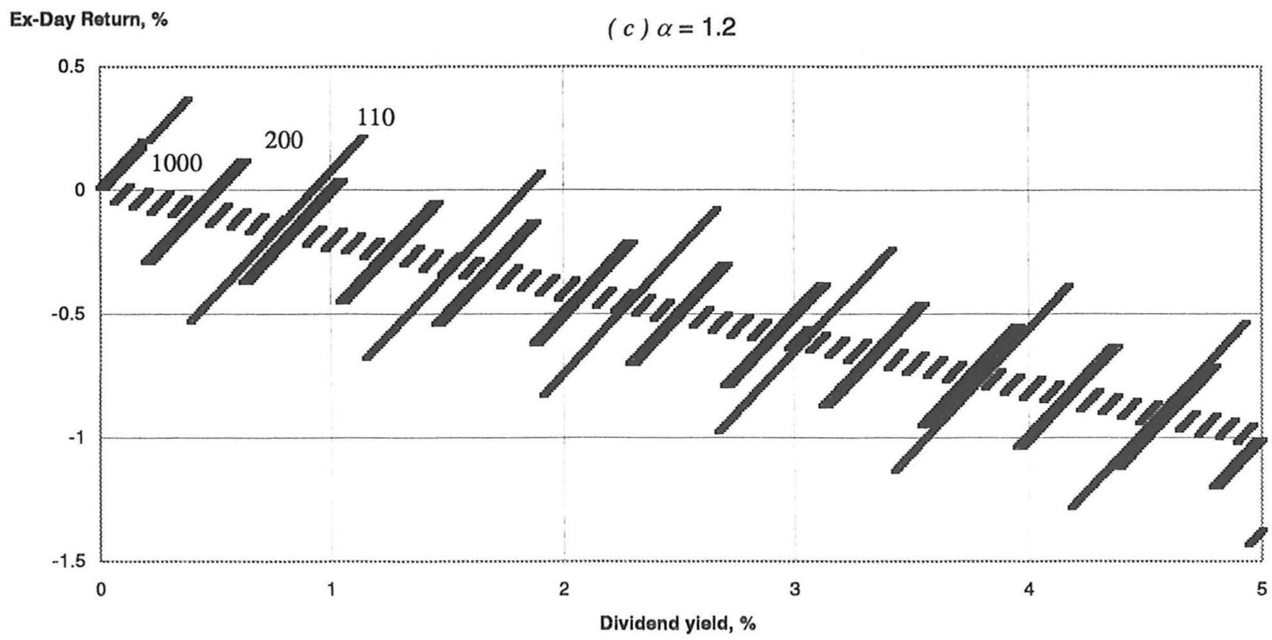


Figure 4: Dividend Yield and Ex-Day Return







The ex-day return patterns in Figures 3 and 4 show that the effect of tick rules over and above the effect of taxes on ex-day returns is regular and therefore predictable. To estimate α properly we must explicitly model the tick size. Section 4 shows how it can be done.

4 Ex-day return model in the presence of tick rules

In the absence of tick rules the ex-day price drop is exactly αD_t and the expected ex-day price (dropping the expectation operator) is

(5) $$P_t = P_{t-1} - \alpha D_t .$$

With a discrete price rule, prices can not always fall exactly by αD_t. For simplicity, assume that prices have to be integers so that the smallest price change is ± 1.[4] Denote the integer part of P_t by $P_t^* = \langle P_t \rangle$.[5] The ex-day price with discrete prices is then given by

(6) $$P_t^* = \langle P_{t-1} - \alpha D_t + \delta \rangle$$

where δ is the rule that the market uses to round prices to satisfy tick rules. For example, let $P_{t-1} = 105$ and αD_t either 2.99 or 3.01. With continuous prices P_t would be either 102.01 or 101.99. If ex-day price is always rounded down (and the price drop up), $\delta = 0$ and P_t^* is either 102 or 101. If prices are rounded up (and the price drop down) δ is slightly smaller than the tick size. With a tick size of 1, we can set $\delta =$ 0.99, in which case P_t^* is either 103 or 102. Finally, if 0.5×*tick* is rounded down and 0.51×*tick* up, as in our examples in Section 3, δ is slightly smaller than ½×*tick*. If, for example $\delta = 0.49$, we obtain $P_t^* = 102$ for both dividends.

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[4] This assumption is not restrictive. For example, if the smallest price change is ± 0.1, we can always multiply the prices and dividends by 10 after which prices must be integers with the smallest price change equal to ± 1.

[5] The integer part of P_t is the largest integer $\leq P_t$. Respectively, $P_t - \langle P_t \rangle$ is called the fractional part of P_t (see Kolmogorov and Fomin (1975)).

Note that we can not take $P_{t\text{-}1}$ in (6) out of the brackets, because generally

$$P_{t-1} + \langle \alpha D_t + \delta \rangle \neq \langle P_{t-1} - \alpha D_t + \delta \rangle .$$

On the left-hand side, the integer is taken of the price drop, and not of the price, as on the right-hand side, and these two are generally not equivalent. The ex-dividend day price drop is simply

$$P_t^* - P_{t-1} = \langle P_{t-1} - \alpha D_t + \delta \rangle - P_{t-1} . \tag{7}$$

We can now write the ex-dividend day stock return in the presence of tick rules, which we denote by r_t^*, as a sum of two components, the ex-day return with continuous prices, and a correction term, that is

$$\frac{P_t^* - P_{t-1} + D_t}{P_{t-1}} = \frac{P_t - P_{t-1} + D_t}{P_{t-1}} + \frac{P_t^* - P_t}{P_{t-1}} . \tag{8}$$

Letting γ denote the normal return on non-ex-days, Equation (3) can be rewritten as

$$r_t = \gamma + (1-\alpha)\frac{D_t}{P_{t-1}} . \tag{9}$$

Inserting Equations (5), (6) and (9) into (8) we can write the ex-day return in the presence of the tick rule and the rounding rule, δ, as

$$r_t^* = \gamma + (1-\alpha)\frac{D_t}{P_{t-1}} - \frac{(P_{t-1} - \alpha D_t) - \langle P_{t-1} - \alpha D_t + \delta \rangle}{P_{t-1}} . \tag{10}$$

Further manipulation of (10) yields the formula for the ex-ratio

$$\frac{P_{t-1}(1+\gamma) - P_t^*}{D_t} = \alpha + \frac{(P_{t-1} - \alpha D_t) - \langle P_{t-1} - \alpha D_t + \delta \rangle}{D_t} . \tag{11}$$

A number of implications arise. First, the tick rule adds to the ex-day return and ratio models (3) and (4) an additional term, P_t - P_t^*, which has two components. The first term, P_{t-1} - αD_t, is the ex-day stock price with continuous prices assuming that ex-day price drops reflect the value of dividends. The second term, $\langle P_{t-1} - \alpha D_t + \delta \rangle$, is the same ex-day stock price with discrete prices. The difference between the two terms is the effect of tick rules on the ex-day price when the cum-day price, tax rates, the dividend and the rounding rule, δ, are taken as given. It is this difference that generates the zigzag pattern of ex-day returns in Figure 4. If the discrete price rule has no effect on the ex-day price, the additional term vanishes and (10) and (11) reduce to Equations (3) and (4) again. Secondly, P_t - P_t^* is always smaller than the tick. Assume that the tick is 1 as in the Finnish case. If $\delta = 0.499$, the maximum value $|P_t - P_t^*|$ can take is 0.5. The maximum effect of tick size on ex-day returns is 0.05 % when P_{t-1} = 1000 and almost 0.5 % when P_{t-1} is close to 100. If $\delta = 0$ (the market rounds prices down) or $\delta = 0.999$ (the market rounds prices up) $|P_t - P_t^*|$ can not exceed 1. The maximum contribution of tick size on ex-day returns is therefore 0.1 % when P_{t-1} = 1000 and almost 1 % when P_{t-1} is close to 100. Since the dividend amount is always smaller than the cum-day price, the effect of tick size is larger on ex-ratios than on ex-day returns. Third, as Figure 4 demonstrates, if $\alpha = 1$, ex-day returns can be systematically positive or negative. If $\alpha > 1$, Equation (3) predicts negative ex-day returns, but (10) can explain also positive returns. Respectively, Equation (3) predicts positive ex-day returns if $\alpha < 1$, while Equation (10) implies that negative returns are not excluded when prices are discrete. Finally, accounting for the tick transforms the original linear model into a non-linear one, which due to the integer term is not differentiable everywhere. The non-linearity and non-differentiability make empirical testing of (10) and (11) difficult.

5 Empirical analysis

To get some idea of the effect of tick rules on ex-day returns we perform a simple empirical exercise. We collect stock price and dividend data from the HeSE in 1989-95.[6] The data consist of restricted stocks before 1993 and unrestricted thereafter. We require that stocks in the sample have closing quotes on cum-days and opening quotes on ex-days. No previous price history is required.

Table 1 shows the tick rule applied during the data period. It also shows that after excluding stocks priced less than 1, we obtain the price limits and tick size of one category by multiplying the price limits and tick size of the previous category by ten.[7] We can therefore scale all prices and dividends so that all stocks belong to the same price category and have the same absolute tick size. The scaling of prices and dividends does not change anything in terms of Equations (3) and (4), neither does it change the relative tick size. We transform stocks in the two lowest price categories into third price category stocks by multiplying the prices and dividends of the lowest price category stocks by 100 and those of the second price category stocks by 10. After that, the prices of all stocks are between 100 and 1000. Finally, we remove one stock with an ex-day price less than 100. There are no highest price category stocks in our sample.

The starting points for the empirical analysis are Equations (10) and (11). For simplicity, we assume that $\gamma = 0$. We also simplify notation by dropping the time subscripts so that P_i denotes the cum-day price of stock i. The empirical models can now be written as

$$r_i^* = (1-\hat{\alpha})\frac{D_i}{P_i} + \varepsilon_i \tag{12}$$

and

[6] The results of Sorjonen (1995) and Sorjonen (2000) suggest that in spite of changes in capital income taxation, ex-day behaviour during this time period is sufficiently homogeneous to warrant this combined time period.

[7] This is not a very restrictive assumption. In the HeSE, there are very few stocks in the lowest and highest price category.

(13) $$r_i^* = (1-\hat{\alpha})\frac{D_i}{P_i} - \frac{(P_i - \hat{\alpha}D_i) - \langle P_i - \hat{\alpha}D_i + \hat{\delta}\rangle}{P_i} + \varepsilon_i .$$

We first estimate (12), without a constant term, by ordinary least squares. The residuals are both heteroskedastic and non-normal. Heteroskedasticity is expected because different stocks have different volatilities. To reduce non-normality, we remove eight observations for which the standardised residual exceeds 2.6. We then re-estimate (12). We obtain the following result:

$$\hat{\alpha} = 0.6676, \quad s(\hat{\alpha}) = 0.0464, \quad R^2 = 0.270, \quad N = 210$$

where $s(\hat{\alpha})$ is the standard error of $\hat{\alpha}$. The tax parameter is smaller than one and statistically significant, which suggests a preference for capital gains. The estimate is reasonably close to estimates of earlier studies that use Finnish data. The model is still heteroskedastic, but residual non-normality can be rejected at the 5 % risk level.[8]

Model (13) is non-linear and not differentiable everywhere. Also, the two parameters that we want to estimate are inside the integer term. Since analytic solutions for the estimators of α and δ are difficult to obtain, we use a grid search method. We let δ obtain values from 0 to 0.99 with steps of 0.01 and α obtain values from 0 to 1.5 with steps of 0.001. We repeat the search with smaller step sizes. For each parameter combination, we compute the sum of squared errors, given by

(14) $$\sum_{i=1}^{N}\left[r_i^* - (1-\hat{\alpha})\frac{D_i}{P_i} - \frac{(P_i - \hat{\alpha}D_i) - \langle P_i - \hat{\alpha}D_i + \hat{\delta}\rangle}{P_i}\right]^2,$$

where N is the sample size. The parameter combination that minimises this sum is chosen. We obtain the following parameter estimates:

$$\hat{\alpha} = 0.6821, \quad \hat{\delta} = 0.981, \quad N = 210.$$

The estimate of α is very close to that of the linear model. The estimate of δ, 0.981, is very high. It suggests that the market on average tends to round ex-dividend day stock prices up. This in turn implies that the tick size potentially has a large impact on ex-day returns. However, since we are unable to compute standard errors and conduct standard significance tests, we can not say whether the estimate of δ is statistically different from say, 0.49. Therefore, the empirical results have mostly illustrative value.

We re-estimate both models for a sub-sample of stocks whose dividends are multiples of the tick size. The results of the linear model are

$$\hat{\alpha} = 0.7244, \quad s(\hat{\alpha}) = 0.0564, \quad R^2 = 0.286, \quad N = 137$$

and the results of the non-linear model

$$\hat{\alpha} = 0.7093, \quad \hat{\delta} = 0.301, \quad N = 137.$$

Again the tax parameter in the linear model is significantly less than one. The tax parameter estimates of the linear and the non-linear models are very close to one another, and also very close to the ones obtained for the entire sample. However, the estimate of the rounding rule parameter is only 0.3 for the sub-sample, which is considerably less than 0.98 of the entire sample. The substantial gap between the estimates suggests that the rounding rule is probably highly sensitive to small changes in the tax parameter and therefore potentially very difficult to estimate.

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[8] The value of the Breusch-Pagan test statistic is 19.64, which is highly significant, while the value of the Bera-Jarque test statistic is 5.892.

6. Conclusions

Elton and Gruber (1970) were the first to show that stock prices on ex-dividend days can be used to infer the relative tax treatment of dividends and capital gains. They and subsequent research have shown that for given tax rates the ex-dividend day price drop is a linear function of the dividend amount. It follows that, first, the ex-dividend ratio, that is, the ex-dividend day price drop divided by the dividend, is constant for all dividend amounts and independent of stock price, and second, ex-dividend day stock returns are a linear function of dividend yield. This model implies that if dividends are taxed more (less) heavily than capital gains, stock prices on ex-days fall by more (less) than the dividend amount, and ex-day stock returns are positively (negatively) related to dividend yield.

This paper extends the basic ex-day model to take tick rules into account. We show that taking the tick size into account adds to the model a new parameter, which describes how the market rounds prices. Rounding is needed, because prices must change by multiples of given increments. At the same time, the original linear model transforms into a non-linear one.

The extended model yields a number of predictions. The ex-day price drop becomes a step function of the dividend amount. The points of discontinuity occur when the direction of rounding changes. It follows that the ex-dividend ratio is a piecewise, decreasing convex function of the dividend amount. For given tax rates, this pattern is independent of the stock price as long as the same tick size applies. For small dividends the ex-ratio can take a wide range of values, which suggests that the odds of getting misleading results must not be ignored. This is not a new result; ex-day studies have traditionally recognised that small dividends are a problem. What is a new result, however, is that there is no simple definition for a small dividend. We demonstrate that whether a dividend is small depends not only on the dividend amount, but also on tax rates and the cum-day stock price that determines the tick size.

For a given cum-day price, the ex-day return is a piecewise linear function of the dividend yield. The effect of the tick size on ex-day returns is measured by the height of the linear segments. In general, the tick effect decreases with stock price. Therefore, the (cross-sectional) cum-day price distribution is important for ex-day price behaviour, even though it has been ignored in earlier ex-day studies.

The extended ex-day return model implies that ex-day returns can be systematically positive or negative even in the absence of taxes. If dividends are taxed more (less) heavily than capital gains, the basic model predicts that ex-day returns are positive (negative), but the extended model predicts that when tick size is taken into account the possibility of negative (positive) ex-day returns can not be excluded.

The non-linearity and non-differentiability of the extended model make empirical work difficult. We use Finnish stock price data from 1989-95 to estimate the model by using a grid search method. The results suggest that the average ex-ratio is approximately 0.7 and that the market rounding rule is difficult to estimate. Since we are unable to perform significance tests, these results must be treated as illustrative only.

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Ex-Dividend Day Stock Price Behaviour, Taxes and Discrete Prices; A Simulation Experiment

Abstract

This paper examines how accurately the tax rate implicit in the ex-day price drop can be estimated with commonly used methods when stock prices are discrete. The results of our simulation experiment suggest the following. First, the GLS-estimator proposed by Michaely (1991) is the best statistic among the four statistics examined. It is unbiased and has the smallest variance. The traditional ratio of price drop to dividend performs the worst. Second, tick rules are important for ex-day studies only if the ex-day price drop does not have to be adjusted for overnight return. The effect of rounding on the ex-day price drop is always less than one tick, because prices are rounded to the nearest legitimate price. Errors made in estimating the overnight return may have an effect many times larger than that on the ex-day price drop. Indeed, if ex-day price drops are contaminated by overnight returns, tick rules do not affect the results of ex-day studies. Errors made in eliminating the overnight return dominate the errors caused by tick rules. In fact, as long as ex-day prices must be adjusted for overnight return, it does not matter whether prices are continuous or discrete. Finally, standard errors of commonly used test statistics are high enough to make the identification of tax clientele effects very difficult.

JEL classification codes: G12, G35

Key words: Asset pricing, Dividends, Taxation, Tick size

1 Introduction

In their seminal paper, Elton and Gruber (1970) show that ex-dividend day price drops can be used to estimate the tax rate of the marginal investor. If capital gains are taxed at a lower (higher) rate than dividend income, the ex-day price drop is smaller (larger) than the dividend.[1] Tax rates on dividend income and capital gains are important in corporate finance (for example in dividend policy and capital structure issues) but information about them is difficult to obtain. In this respect the ex-day method, which does not assume any particular asset pricing model, can be useful. Kalay (1982) notes that estimating the implicit tax rate may be difficult if two or more groups of investors differ substantially in their the tax treatment of capital income and one group of investors finds it profitable for tax reasons to either collect or avoid dividends. If trading because of the dividend is important, ex-day price drops reflect the tax rates of the investors engaged in dividend trading and not the more interesting tax rates of long-term investors. Dividend trading is expected to be more important among stocks with high yields, low bid-ask spreads (transaction costs), and high liquidity.

A large number of studies have applied the ex-day methodology to data from different countries and time periods. The empirical results are mixed. Barclay (1987) examines NYSE data from a period with no income tax in the U.S., 1900-1910, and another period after the introduction of the income tax, 1962-1985. Consistent with the tax explanation in 1900-1910, investors valued (before-tax) dividends and capital gains as perfect substitutes, but in 1962-1985 the value of dividends relative to capital gains was much lower due to a tax penalty on dividend income. Poterba and Summers (1984) report similar results for two dividend tax reforms in the U.K. Michaely (1991) and Robin (1991) examine the effect of the U.S. 1986 Tax Reform Act on ex-dividend behaviour and find conflicting results. Michaely finds abnormal return behaviour consistent with short-term trading around ex-days. Also, Lakonishok and Vermaelen (1983) and Booth and Johnston (1984) obtain conflicting results with Canadian data around the 1972 tax reform. Eades, Hess and Kim (1984) report statistically

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[1] This is equivalent to saying that ex-day returns increase (decrease) with dividend yield. Early empirical studies (see Campbell and Beranek (1955) and Durand and May (1960)) report that stock prices tend to fall on ex-dividend days by less than the amount of the dividend.

significant negative abnormal ex-day returns for non-taxable cash distributions that should have no tax consequences at all. This suggests that factors other than taxes may also influence ex-day return behaviour. One such factor may be a risk premium as suggested by Grammatikos (1989) and Fedenia and Grammatikos (1993). Karpoff and Walkling (1988) find strong evidence of short-term trading among high-yield stocks in the U.S. after a reduction in the costs of short-term trading following the introduction of negotiable commissions in 1975, and practically no evidence of short-term trading before.

This paper is motivated by two findings in the literature. First, some ex-day studies like Lakonishok and Vermaelen (1983) reveal that different ex-day methods yield sometimes quite different results even when exactly the same data is used.[2] Yet the literature gives little guidance as to what methods to use or how to judge existing empirical results on the basis of the method used. A second motivation comes from two recent papers, Bali and Hite (1998) and Frank and Jagannathan (1998), demonstrating that discrete prices may have a considerable effect on ex-day price behaviour. Frank and Jagannathan find that discrete prices cause prices in the Hong Kong stock market to fall on ex-days on average by less than the dividend amount even though neither dividends nor capital gains are taxed at all.

In our study, we run a simulation experiment to examine how accurately the tax rate implicit in the ex-day price drop can be estimated with commonly used methods, particularly when stock prices are discrete. We are not aware of previous studies addressing this issue. Unwilling to underestimate the ability of ex-day methods, we make several simplifying assumptions to generate extremely favourable conditions for an ex-day study. We assume that the ex-day price drop always reflects capital income tax rates to the extent that it is possible in a discrete price world. Taking cum-dividend prices, dividends and the tax rates as given, we compute ex-day prices such that we introduce noise only from two sources to the ex-day price. Without this noise all

[2] Lakonishok and Vermaelen (1983) have 555 and 671 Canadian shares in 1971 and 1972 with average dividend yields of 1.07 % and 1.13 %. The average ratio of ex-day price drop to dividend varies considerably from 0.26 to 0.46 in 1971 and from 0.07 to 0.33 in 1972, depending on the choice ex-day prices and whether prices are adjusted for overnight return or not. The respective ranges for the equally

variation in ex-day price drops could be explained by taxes only. The first source of noise is due to discrete prices. If the product of the tax rate and the dividend is not a multiple of the tick, the price drop reflects the tax rate with error. We use two distinct tick rules applied in the Helsinki Stock Exchange, one before 1996 and the other in 1996-98.

The ex-day price drop reflects both taxes and overnight return, which can be separated only by estimating the overnight return somehow. The second source of noise is the error with which the overnight return is estimated. It depends on return volatility and has a direct impact on how accurately the tax rate can be estimated. The question we ask is: how much does the noise, brought by discrete prices and the unknown overnight return, affect the estimate of the tax rate?

Our results show that the best statistic is the GLS-estimator first proposed by Michaely (1991). It is unbiased, also when prices are discrete, and has the smallest variance among the four candidates. The traditional average ex-ratio performs clearly the worst. It is sometimes systematically biased and has the largest variance. The results obtained with the GLS-estimator show that tick rules are an important factor in determining ex-day price behaviour and the effect depends on tick size. If the smallest price change is small, the tick rule has only a negligible effect on estimator variance, while the effect is considerable if the smallest price interval is large.

The results show that tick rules are important for ex-day studies if we can observe an ex-day price drop that only reflects capital income taxes, dividends and tick rules, and is not contaminated by any overnight return requiring adjustment. All test statistics perform significantly better in a small tick case than in a large tick case. On the other hand, if ex-day price drops are contaminated by overnight returns, which must be removed by using estimates of normal daily returns, tick rules do not matter any more. The errors made in estimating the ex-day price drop, which depend on the amount of daily stock return uncertainty, are far more fatal for ex-day studies than tick rules. In

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weighted portfolio statistic are much narrower, 0.39-0.48 in 1971 and 0.21-0.28 in 1972. Thus different methods can yield remarkably different results even with relatively large samples.

fact, as long as ex-day prices must be adjusted by normal return, it does not matter whether prices are continuous or discrete.

We find that the GLS-estimator of the ex-ratio always performs at least as well as the other statistics largely because it is the only statistic that takes both stock return volatility and dividend yield explicitly into account. The average price drop to dividend ratio takes neither dividend yield nor volatility into account and, therefore, has the poorest performance in the simulation experiment. The standard errors of this ratio are so large that it is doubtful whether a tax parameter of any reasonable magnitude can ever be found statistically different from one at conventional significance levels and sample sizes. Gagnon and Suret (1991) have previously argued the same.

We also apply the NYSE tick size of 0.125 to low dividend yield data comparable to that used earlier in tax clientele studies. The results suggest that even if we have 500 observations per dividend yield decile, use the GLS-estimator and assume a low volatility of stock returns, tax clientele effects can be identified reliably only if ex-day price behaviour in one decile is substantially different from that in other deciles.

Section 2 of the paper briefly reviews the ex-day model. The set-up and details of the simulation experiment are reported in Section 3. Section 4 reports the results and Section 5 concludes.

2 The framework

Define the before and after-tax ex-dividend day stock returns, r and r_{at}, as

(1)
$$r = \frac{P_{ex} - P_{cum} + D}{P_{cum}}$$

and

(2)
$$r_{at} = \frac{(1-\tau_g)(P_{ex} - P_{cum}) + (1-\tau_d)D}{P_{cum}}$$

where P_{ex} and P_{cum} are the ex-dividend and cum-dividend day stock prices, D is the dividend per share, and τ_d and τ_g are marginal tax rates on dividends and capital gains. The dividend is non-zero on ex-dividend days and zero otherwise. Manipulation of Equation (2) yields

$$\text{(3)} \qquad \frac{P_{ex} - P_{cum} + D}{P_{cum}} = \frac{r_{at}}{1-\tau_g} + (1-\alpha)\frac{D}{P_{cum}}$$

where $\alpha = (1-\tau_d)/(1-\tau_g)$ measures the relative value of dividends and capital gains and D/P_{cum} is dividend yield. Equation (3) implies that the expected stock return on non-ex-days is simply the grossed-up expected after-tax return. The ex-day return depends on the tax treatment of dividends and capital gains. Ex-day returns are positively (negatively) related to dividend yield if dividends are taxed more (less) heavily than capital gains, that is, if $\alpha < 1$ ($\alpha > 1$). Only when dividends and capital gains are effectively taxed at the same rate are ex-day returns unrelated to dividend yield.

Further manipulation of (3), ignoring the non-ex-day return, yields the familiar ex-dividend ratio first derived by Elton and Gruber (1970)

$$\text{(4)} \qquad \frac{P_{cum} - P_{ex}}{D} = \alpha .$$

Equation (4) predicts that stock prices fall on ex-days by less (more) than the amount of dividend if dividends are taxed more (less) heavily than capital gains. When dividends and capital gains are taxed at the same rate we expect that the ex-day price drop equals the dividend.

In real life, trading rules restrict the precision at which stock prices can be quoted (see Angel (1997) for tick sizes in different countries, and Anshuman and Kalay (1998) for a discussion of optimal tick size). When prices are discrete, the results derived above may not hold. For example, Dubofsky (1992) shows that due to NYSE and AMEX tick rules, ex-day returns may be positively related to dividend yield even in the absence of taxes. Sorjonen (2000) demonstrates that the tick rules in the Helsinki Stock Exchange have similar implications.

3 Simulation

3.1 The set-up

To create favourable conditions for an ex-day study, we make a number of simplifying assumptions. First, capital income tax rates are taken as given. For simplicity, we assume that all investors are taxed at the same rates.[3] Marginal tax rates on dividend income and capital gains are denoted by τ_d^* and τ_g^*, respectively. Secondly, stock prices fully incorporate capital income taxes. Third, the ex-dividend day price drop takes place during the night. Prices can be observed immediately before and after the ex-day price drop takes place. Thus, stock prices fall immediately after the market closes on the cum-dividend day, by exactly $\alpha^* D$, where $\alpha^* = (1-\tau_d^*)/(1-\tau_g^*)$ is the true value of the tax parameter. We take α^* as given and refer to $\alpha^* D$ as the true ex-day price drop. Under the assumptions made above, a study of stock price behaviour around ex-days should yield an estimate of the tax parameter exactly equal to α^*.

Many things contribute to the fact that we observe the ex-day price drop with some noise and may therefore estimate α^* with error. We examine two potential sources of noise. The first source of noise is the tick rule, i.e. discrete price intervals, which restricts the behaviour of stock prices in such a way that prices can not always fall exactly by $\alpha^* D$ on ex-days. If the actual price drop deviates from $\alpha^* D$, stock prices do not correctly reflect the tax rate. A second source of noise stems from the fact that the ex-day price immediately after the price drop may not be observed. What we observe, is the pure ex-day price, P_{cum} - $\alpha^* D$, plus a return earned during the night, r, so that the ex-day price, P_{ex} , which can be observed is

[3] Tax clienteles are assumed away. The distinction between long-term and short-term investors is also irrelevant in this paper.

(5) $$P_{ex} = (1+r)\left(P_{cum} - \alpha^{*}D\right).$$

The pure ex-day price is then given by P_{ex} / (1+r). Unfortunately, the overnight return, r, can not be observed separately from the ex-day price drop. Therefore, we generally do not observe the true price drop. This is also true for continuous prices. As an estimate for the overnight return, ex-day studies usually use an average historical stock or market return, or a return given by the market model.[4] Denoting the estimated overnight return by $\bar{r}$ the ex-day price drop is then estimated as

(6) $$P_{cum} - \frac{P_{ex}}{1+\bar{r}}.$$

The error in estimating the overnight return, r - $\bar{r}$, depends on return uncertainty and the tick rule, if discrete prices must be used in estimating $\bar{r}$. The rest of the paper concentrates on examining how well the price drop in (6) reflects capital income taxes.

3.2 Tick rules

The simulation experiment employs the tick rules of the Helsinki Stock Exchange (HeSE). The tick size at the HeSE was a step function of stock price before 1999.[5] There were four tick categories before 1996 and two tick categories in 1996-98. In the following, we refer to the rule applied before 1996 as 'Rule 1' and to the rule applied in 1996-98 as 'Rule 2'. Table 1 shows the stock price categories and the respective tick sizes both in Finnish markka and in approximate U.S. dollars to allow a comparison to the New York Stock Exchange (NYSE). Under Rule 2, the tick size in HeSE was smaller than in NySE at all stock price levels.[6] Under Rule 1, the HeSE tick

[4] For estimating expected returns, see Brown and Warner (1985).

[5] Since January 1999 all stocks are quoted in euros and the tick is one cent for all stocks regardless of the price.

[6] In the NYSE stocks less than \$0.50 trade in multiples of 1/32, stocks between \$0.50 and \$1.00 in multiples of 1/16 and stocks priced over \$1 in multiples of 1/8 (see Angel (1997)).

size was smaller than in the NYSE for stocks selling for less than FIM 100 and larger for more expensive stocks. The simulation experiment applies to both Rules 1 and 2.

Table 1: Tick size in the Helsinki Stock Exchange

Stock price		Tick size			
		RULE 1 - 31.12.1995		RULE 2 1.1.1996 - 31.12.1998	
FIM	*(USD)*	*FIM*	*(USD)*	*FIM*	*(USD)*
0.01- 10	(- 2)	0.01	(1/500)	0.01	(1/500)
10 - 100	(2 – 20)	0.10	(1/50)	0.10	(1/50)
100 - 1000	(20 – 200)	1	(1/5)	0.10	(1/50)
> 1000	(> 200)	10	(2)	0.10	(1/50)

3.3 Details

We start by creating artificial continuous price data free of any tick rules. First, we draw a cross-section of cum-day stock prices, $P_{i,cum}$, for a sample of N stocks (i = 1,...,N) from a uniform distribution. Since the accuracy of price quotations is not limited in any way, these prices are continuous by nature. We make a simplifying assumption that the returns of all N stocks are normally and identically distributed. For each of the N stocks we draw a full history of daily returns, r_{it}, for 121 trading days (t = -119,...,-1, *cum*, *ex*), where the ex-day return includes only the overnight return and not the ex-day price drop. Thus, a total of 121N daily returns are drawn. We interpret these returns as logarithmic price differences. Using the cum-day prices and the historic returns, we work out the continuous price history, P_{it} (t = -120,...,-1, *cum*), excluding the ex-day, for the N stocks. [7]

In practise, stock prices must obey a tick rule. The stock price history, P_{it}, includes continuous fundamental prices. To obtain the prices that conform to a tick rule, we

[7] Normally ex-day studies examine a particular ex-dividend period including, say, 5 to 45 trading days before and after the ex-day for examining abnormal return and volume behaviour. We have no particular role for the ex-day period. Therefore, we simply take it to cover only the ex-day.

round each of these prices to the closest legitimate price, and denote the stock price history, P_{it}, forced to conform to the tick rule j by P^j_{it} (t = -120,...,-1, *cum*) [8].

Dividend yields, δ_i, are randomly drawn from a uniform distribution for the N stocks. The cash dividend, DIV_i, is then given by $DIV_i = \delta_i P_{i,cum}$. In practise dividends are not continuous. Therefore, we round dividends to the nearest 0.01.[9] From now on dividends are at least 0.1 and always multiples of 0.01. We denote the rounded dividend by D_i. The observed dividend yields which are needed in estimating the tax parameter are then $d_i = D_i/P_{i,cum}$ for the continuous price case and $d^j_i = D_i/P^j_{i,cum}$ for the tick rule case.

With continuous prices, we observe stock returns r_{it} (t = -120,...,-1, *cum*). A different set of returns is observed when stock prices follow the tick rule j. We use the legitimate discrete prices, P^j_{it} (t = -121,...,-1, *cum*), to generate a new set of returns, r^j_{it}, that are observed in the presence of the tick rule j. These returns are given by

(7) $$r^j_{it} = \ln\left(\frac{P^j_{it}}{P^j_{it-1}}\right) \qquad t = -119,...,-1, cum.$$

Now we have created both a continuous price history and a price history conforming to tick rule j for days -120,...,-1, *cum*, thus excluding the ex-dividend day price data. In the continuous price case, the pure ex-day price, which we can not observe, is

(8) $$P_{i,cum} - \alpha^* D_i,$$

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[8] This means that ex-day prices 101.51 and 101.50 are rounded to 102 and 101, respectively.

[9] At first glance, it might seem that letting dividends be multiples of 0.01 (rather than, say, 0.05 or 0.1) almost guarantees that discrete prices practically never fall by exactly the dividend amount. This in turn would suggest that our choice of dividend accuracy by itself might lead to ex-day methods to produce biased results. A more careful look at the issue reveals that quite the opposite is true. To illustrate this, let dividends be multiples of 0.05, tick size 0.1 and $\alpha^* = 1$. Ex-day price drops should now be multiples of 0.05. Now we have a problem of how the market rounds prices. Let dividends be 0.05, 0.10, 0.15 and 0.2. If 0.05 is rounded downwards, then price drops will be 0, 0.1, 0.1 and 0.2, and ex-ratios 0, 1, 0.67 and 1. Ex-ratios would always be less than or equal to α^* and the average ex-ratio would be less than one. On the other hand, if 0.05 is rounded upwards, then price drops would be 0.1, 0.1, 0.2 and 0.2, and ex-ratios 2, 1, 1.33 and 1. Now ex-ratios would always be larger than or equal to α^*. In both cases it would appear that ex-ratios are systematically biased, the sign of the bias depending on the

whereas the observable ex-day price is

(9) $$P_{i,ex} = \left(1 + r_{i,ex}\right)\left(P_{i,cum} - \alpha^* D_i\right).$$

When prices follow tick rule *j*, the observed ex-day price, $P^j_{i,ex}$, is obtained by rounding

(10) $$\left(1 + r_{i,ex}\right)\left(P^j_{i,cum} - \alpha^* D_i\right)$$

to the closest legitimate price.[10] For eliminating the overnight return, we need an estimate of a normal daily return. We estimate the normal return as an average daily stock return using the return data from 120 days preceding the ex-dividend day (i.e days -119,...,-1, *cum*). The relevant ex-day price drops are

(11) $$P_{i,cum} - \frac{P_{i,ex}}{1 + \bar{r}_i}$$

for the continuous price case and

(12) $$P^j_{i,cum} - \frac{P^j_{i,ex}}{1 + \bar{r}_i^{\,j}}$$

for the tick rule case where the estimates of normal daily return are

$$\bar{r}_i = \frac{1}{120} \sum_{t=-119}^{cum} r_{it} \qquad \text{and} \qquad \bar{r}_i^{\,j} = \frac{1}{120} \sum_{t=-119}^{cum} r^j_{it}\,.$$

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rounding rule. In general, similar problems will arise whenever $\alpha^* D$ = ½ *tick*. Thus, even if the choice of letting dividends be multiples of 0.01 may seem exaggerated, it is done for a reason.

[10] Note that we actually assume here that investors always observe the cum-day price and then decide what the ex-day price should be.

In the simulation experiment, the true tax parameter takes values $\alpha^* = \{0.8, 1, 1.2)$, ranging from a clear capital gains preference ($\alpha^* = 0.8$) to an equally clear preference for dividend income ($\alpha^* = 1.2$). We assume that dividend yields are uniformly distributed and control the distribution by choosing the mean dividend yield from three alternatives. In the low yield case $\delta_i \sim U(0,0.02)$, in the middle yield case $\delta_i \sim U(0,0.06)$, and in the high yield case $\delta_i \sim U(0,0.10)$, so that average dividend yields are roughly 1, 3 and 5 per cent. The continuous cum-dividend stock prices at the closing are also drawn from uniform distributions. We use two alternatives, $P_{cum} \sim U(1,200)$ and $P_{cum} \sim U(1,500)$. The average cum-prices are thus roughly 100 and 250. For simplicity, we assume that all stocks have the same annual mean return, $\mu = 0.15$. All return uncertainty, whatever its source might be, is assumed to be captured by daily volatility, σ. We work with three alternative assumptions about σ. The daily volatility is either constant for all stocks ($\sigma = 0.01$ or $\sigma = 0.02$), or is uniformly distributed ($\sigma_i \sim U(0.005,0.02)$). Daily volatility of 0.01 (0.02) corresponds to annual volatility of 16 % (32 %). Time varying moments of the return distribution are ruled out. Finally, we let the sample size N be 20, 50, 100 or 200. These sample sizes are very moderate from the U.S. perspective. However, they are quite realistic when price data from European stock exchanges are used. In addition, often sub-samples have to be used in examining dividend clienteles.[11]

For every parameter combination $\{\alpha^*, \delta_i, \sigma, P_{cum}, N\}$, we generate 10,000 data sets. Dividend yields and cum-dividend prices are drawn separately for each of the 10,000 data sets, but the distribution from which they are drawn is always the same. Each of the 10,000 data sets is used to estimate the tax parameter α with four methods for five cases, which we describe in detail below. The 20 estimates are recorded. There will thus be one distribution of α's, with 10,000 observations, for every parameter combination, for each of the four methods and for each of the five cases. It is these distributions and especially their first two moments that we are interested in. These

[11] Finnish ex-day studies offer a good example of small samples. Hietala and Keloharju (1995) have a sub-sample of 59 unrestricted shares, the entire sample of Hedvall, Liljeblom and Löflund (1998) consists of 122 observations, Sorjonen (1988) has usually less than 30 observations annually and less than 100 observations during longer periods, and Sorjonen (1995) has less than 70 observations per sub-period.

distributions are used to assess the unbiasedness and efficiency of the four statistics in estimating the true tax parameter, α^*, in the absence and presence of tick rules when the characteristics of the sample are taken as given.

In a simulation experiment with 10,000 repetitions, the variance of the estimator often becomes very small, as we shall see soon. In such cases, extremely small deviations of the mean from α^* can turn out to be statistically significant, thus judging the estimator biased. Such precision has little relevance here. In empirical ex-day studies, only the first two decimals of α are usually interesting. Therefore we take the pragmatic, ad hoc view that if the average estimate falls in the range $\alpha^* \pm 0.01$, the estimator is unbiased and biased otherwise.

The five cases we examine are the following. In the first case, stock prices are continuous. Pure ex-day prices can not be observed and therefore the observed ex-day price must be discounted with the overnight return estimated from past continuous prices as the average daily return. Any deviation of estimates from α^* is caused by errors in estimating the overnight return. Next, the same continuous stock prices are rounded so that they conform to tick rules 1 and 2. The tick rule is the only reason why ex-dividend day stock price drops can not precisely reflect capital income taxes. In the absence of a discrete price rule we would always estimate α^* correctly. Any deviation of the estimates from α^* can be attributed to the tick rule only. The rounded cum-day prices are common knowledge. The ex-day price is computed by reducing $\alpha^* D_i$ from the known rounded cum-day price and then rounding to the nearest legitimate price.[12] Finally, the two tick rule cases are extended by assuming that the pure ex-day price drop can not be observed. To estimate the ex-day price drop, the observed ex-day price must be discounted with the overnight return estimated from past discrete (or rounded) prices as the average daily return.

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[12] Since it is assumed that prices can be observed immediately after the ex-day price drop, we have no role for the price history and do not estimate the overnight return nor return volatility.

3.4 Methods

Four closely related models are used to estimate the tax parameter, α. We denote the four alternatives simply by α_1, α_2, α_3 and α_4, where α_1 is the average ex-dividend day ratio of Elton and Gruber (1970), α_2 is the GLS estimator of the average ex-ratio first proposed by Michaely (1991), α_3 is the equally weighted portfolio statistic of Lakonishok and Vermaelen (1983), and α_4 is the OLS estimator of the tax rate obtained from the return specification (3). The models that we estimate are (13), (15), (17) and (18) below.

A useful starting point for deriving these models is the return specification (3). If the normal return is taken into account already in computing the ex-day price drop, as we do in Equations (11) and (12), the empirical version of (3) can be written without a constant term as

(13) $$\frac{P_{i,ex} - P_{i,cum} + D_i}{P_{i,cum}} = (1-\alpha_4)\frac{D_i}{P_{i,cum}} + \varepsilon_i \quad , \qquad \varepsilon_i \sim N(0,\sigma_i^2)$$

where ε_i is the unexpected ex-day return. Usually return volatilities differ across stocks. Therefore, the variance of ε_i is not constant and the model is heteroskedastic when cross-sectional data are used. The OLS estimator is still unbiased but inefficient. Lakonishok and Vermaelen (1983) suggest an alternative formulation of (13), which does not solve the heteroskedasticity problem. Rearranging terms and letting ΔP_i = $P_{i,cum}$ - $P_{i,ex}$ and $d_i = D_i / P_{i,cum}$ they rewrite (13) as

(14) $$\frac{\Delta P_i}{P_{i,cum}} = \alpha d_i + \varepsilon_i \, .$$

Taking averages of both sides and solving for α yields the equally weighted portfolio statistic

(15) $$\alpha_3 = \overline{\left(\frac{\Delta P}{P}\right)} \Big/ \bar{d}$$

where $\bar{d}$ and $\overline{(\Delta P/P)}$ are simple averages of d_i and $\Delta P_i \,/\, P_{i,cum}$, respectively.

To correct for heteroskedasticity, both sides of (13) must be divided by σ_i so that

(16) $$\frac{1}{\sigma_i}\frac{P_{i,ex} - P_{i,cum} + D_i}{P_{i,cum}} = (1-\alpha_2)\frac{d_i}{\sigma_i} + \eta_i, \qquad \eta_i \sim N(0,\sigma^2).$$

Rearranging terms yields the *GLS*-estimator of the ex-dividend ratio

(17) $$\frac{d_i}{\sigma_i}\frac{\Delta P_i}{D_i} = \alpha_2 \frac{d_i}{\sigma_i} + \eta_i \qquad , \qquad \eta_i \sim N(0,\sigma^2).$$

Both formulations, (16) and (17), can be used to estimate α_2. Note that if we do not have information about σ_i and can not make the correction for heteroskedasticity, (17) reduces to (13), in which case α_2 is always equal to α_4. Also, if there is only little variance in σ_i , α_2 and α_4 yield similar results.

Finally, the traditional ex-day ratio of Elton and Gruber (1970), which corresponds to Equation (4), is obtained by dividing both sides of (17) by d_i/σ_i

(18) $$\frac{\Delta P_i}{D_i} = \alpha_1 + \xi_i \qquad , \qquad \xi_i \sim N(0,\sigma_i^2/d_i^2).$$

The average ex-dividend ratio can thus be estimated by regressing the relative price drops $\Delta P_i \,/\, D_i$ on a constant only. α_1 is an unbiased estimator of the tax parameter. The residual is heteroskedastic though, because differences in return volatilities and dividend yields are not taken explicitly into account.

When dividend yields and return volatilities of all stocks are close to one another, we expect that all four methods perform equally well. When the data display variance in dividend yields, we expect α_1 to be outperformed by the three statistics, α_2, α_3 and α_4, which take dividend yield explicitly into account. Finally, if return volatilities of stocks differ, we expect that α_2 outperforms all other statistics, because it is the only statistic that takes volatility into account.

4 Results

4.1 Only a tick rule

We start from the simplest case where the only noise in the observed ex-day price drop is caused by a tick rule. Under the simplifying assumptions made, any deviation of average test statistics from α^* can be interpreted as a systematic bias caused by the tick rule. In addition, the standard error can be interpreted as the risk, caused by the tick rule, of getting misleading estimates of α^*.[13]

The calculations are based on the assumption that the pure ex-day drop can be observed (with noise caused by tick requirements), and therefore no correction for overnight return is required. Historic return behaviour and volatility have no role here. In GLS-estimation, we simply set the volatility parameter equal to one, so that, essentially, α_2 is always equal to α_4. We choose to report only α_2. The means and standard errors (s_1, s_2 and s_3) of the three test statistics (α_1, α_2 and α_3) are reported in Table 2 for tick rules 1 and 2 when $P_{cum} \leq 500$. The means are independent of sample size, N, and therefore we report them only once, for $N = 200$.

A general finding is that not all estimation techniques are equally reliable. The best test statistics, α_2 and α_3, are on average very accurate. For example, with Rule 1 the

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[13] If in our simplistic world prices were continuous, ex-day prices would exactly reflect capital income taxes and each of the four test statistics would always estimate α^* correctly. Thus, in an experiment of 10,000 trials each test statistic would average α^* and have a variance of zero. Indeed, this is the ideal that our results must be compared to.

95 % confidence interval of α_2 is [0.757, 0.849] when $\alpha^* = 0.8$, $N = 20$ and $\delta \leq 0.02$, and much narrower with larger samples and higher dividend yields. The GLS-estimator has a lower variance. An ordinary F-test reveals that the difference between variances is statistically significant. The variances do not seem to depend on α^*.

The average ex-ratio, α_1, has the largest variance among the three test statistics and is systematically biased when Rule 1 is applied. For example, in the low yield case, the average α_1 is 0.753 when $\alpha^* = 0.8$ and 1.15 when $\alpha^* = 1.2$. In the high yield case, α_1 performs much better but is nevertheless somewhat biased. The bias falls with dividend yield but is, surprisingly, unaffected by the sample size. By using α_1, one can obtain misleading results even with relatively large samples especially when dividend yields are small.[14] [15]

When Rule 2 is applied, the biases are negligible and the tax parameter can be estimated with much greater precision than with the more restrictive Rule 1. If Rule 1 is replaced by Rule 2, s_2 and s_3 fall to approximately one third, and s_1 falls to one fifth or less. The change in variances is statistically significant at high significance levels. In general, both the bias and the standard errors tend to decrease with dividend yield. This is not a new result. The ex-dividend literature has long ago recognised that small dividends may distort results.

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[14] A finding that α_1, the most often used statistic in ex-day studies, is biased when the only market imperfection is a tick rule, is a strong one. It immediately raises the question of whether this result is an artefact. It turns out that the result can be replicated in repeated experiments. Our computer runs produce as by-products several tick rule experiments with the same parameter values. The results are almost identical, the difference in means and standard deviations of α_1 always being of magnitude 0.001.

[15] Problems may arise when two periods are compared according to estimated α_1's. For example, assume Rule 1 and two periods with 50 shares and α^*s of 1 and 1.2. When $\alpha^* = 1$ and dividend yield $\leq$ 2 per cent we obtain an estimate larger than 1.042 in 2.5 % of the cases, while $\alpha^* = 1.2$ is estimated less than 1.045 in another 2.5 % of the cases. There is a fair chance that a comparison of these two periods reveals no changes in the ex-day ratio even though there is a large one. Other comparisons might suggest that there are changes in the ex-day ratio when there in fact are none.

4.2 Tick rule and overnight return adjustment

Our results suggest that the average ex-ratio is biased under the simplifying and perhaps somewhat unrealistic assumption that a tick rule is the only disturbing factor in estimating α^*. To introduce more noise we next assume that the pure ex-day price can not be observed. To estimate it we have to correct the observable ex-day price with an estimate of overnight return (see (6)), which is approximated by an average historic return. The ex-day price drop will be estimated with error if the realised overnight return deviates from the one estimated from price history. We employ exactly the same price and dividend data as before and, therefore, the new results can be compared to those in Table 2. We find that all test statistics are unbiased for all parameter combinations examined, and the standard errors of all statistics are largely independent of α^*. Therefore, we report the standard errors only for $\alpha^* = 0.8$, and do not report the average test statistics at all. Table 3 shows the results for $P_{cum} \leq 500$.

The standard errors in Table 3 are considerably higher than the ones in Table 2. The differences of variances in the two tables are statistically significant at high significance levels. The standard errors in Table 3 do not depend on the tick rule used at all. Thus, tick rules have no effect on the performance of the four test statistics. Only the amount of return uncertainty is important. Increasing daily return volatility from 0.01 to 0.02 doubles the standard errors.

The standard errors of α_1 are so large that a tax parameter of 0.8 can never be found statistically different from one. The best performing test statistics are α_2 and α_4. Due to the return adjustment, the 95 % confidence intervals are wide. With $N = 200$ and $\delta \leq 0.06$ the interval for α_2 is [0.76, 0.84] when $\sigma = 0.01$, and [0.722, 0.878] when $\sigma = 0.02$. When daily stock return volatility is allowed to vary between 0.5 % and 2 % (see Panel (c)), α_2 has the lowest standard errors. This is not surprising, considering that α_2 is the only statistic that takes volatilities explicitly into account. In Panels (a) and (b) volatility is basically constant and, therefore, α_4 performs just as well as α_2. Taking the volatilities into account reduces the variances by statistically significant amounts.

Table 2: Simulation results with tick rules 1 and 2 ($P_{cum} \leq 500$)

Panel (a): Means

			Rule 1			Rule 2		
α^*	$\delta\,(\%)$	N	α_1	α_2	α_3	α_1	α_2	α_3
	≤ 2	200	0.753	0.803	0.800	0.808	0.801	0.802
0.8	≤ 6	200	0.785	0.801	0.801	0.803	0.800	0.800
	≤ 10	200	0.791	0.800	0.800	0.802	0.800	0.800
	≤ 2	200	0.949	1.002	0.999	1.004	1.002	1.003
1	≤ 6	200	0.983	1.001	1.001	1.002	1.001	1.001
	≤ 10	200	0.990	1.001	1.001	1.001	1.001	1.001
	≤ 2	200	1.146	1.202	1.198	1.192	1.199	1.198
1.2	≤ 6	200	1.183	1.201	1.201	1.197	1.200	1.200
	≤ 10	200	1.190	1.201	1.200	1.198	1.200	1.200

Panel (b): Standard deviations

			Rule 1			Rule 2		
α^*	$\delta\,(\%)$	N	s_1	s_2	s_3	s_1	s_2	s_3
		20	0.0656	0.0230*	0.0269	0.0134	0.0076*	0.0080
	≤ 2	50	0.0417	0.0141*	0.0167	0.0087	0.0047*	0.0050
		100	0.0293	0.0097*	0.0117	0.0060	0.0032*	0.0035
		200	0.0207	0.0069*	0.0084	0.0043	0.0023*	0.0025
		20	0.0390	0.0078*	0.0092	0.0081	0.0026*	0.0030
0.8	≤ 6	50	0.0245	0.0049*	0.0057	0.0051	0.0016*	0.0018
		100	0.0171	0.0034*	0.0040	0.0037	0.0012*	0.0013
		200	0.0122	0.0024*	0.0028	0.0026	0.0008*	0.0009
		20	0.0304	0.0047*	0.0055	0.0064	0.0016*	0.0018
	≤ 10	50	0.0188	0.0029*	0.0034	0.0041	0.0010*	0.0011
		100	0.0135	0.0021*	0.0024	0.0028	0.0007*	0.0008
		200	0.0096	0.0015*	0.0017	0.0020	0.0005*	0.0006
		20	0.0727	0.0226*	0.0267	0.0118	0.0076*	0.0078
	≤ 2	50	0.0466	0.0136*	0.0164	0.0074	0.0045*	0.0048
		100	0.0329	0.0095*	0.0116	0.0053	0.0032*	0.0034
		200	0.0231	0.0067*	0.0082	0.0036	0.0022*	0.0024
		20	0.0430	0.0077*	0.0090	0.0072	0.0026*	0.0029
1	≤ 6	50	0.0272	0.0048*	0.0056	0.0045	0.0016*	0.0018
		100	0.0191	0.0034*	0.0040	0.0032	0.0011*	0.0013
		200	0.0136	0.0024*	0.0028	0.0022	0.0008*	0.0009
		20	0.0334	0.0046*	0.0055	0.0055	0.0015*	0.0018
	≤ 10	50	0.0211	0.0029*	0.0033	0.0035	0.0010*	0.0011
		100	0.0151	0.0020*	0.0024	0.0025	0.0007*	0.0008
		200	0.0106	0.0014*	0.0017	0.0017	0.0005	0.0005
		20	0.0816	0.0228*	0.0272	0.0153	0.0077*	0.0084
	≤ 2	50	0.0511	0.0139*	0.0167	0.0098	0.0047*	0.0053
		100	0.0359	0.0096*	0.0116	0.0067	0.0032*	0.0037
		200	0.0253	0.0068*	0.0083	0.0048	0.0023*	0.0026
		20	0.0480	0.0078*	0.0092	0.0091	0.0026*	0.0030
1.2	≤ 6	50	0.0301	0.0048*	0.0056	0.0058	0.0016*	0.0019
		100	0.0212	0.0034*	0.0040	0.0041	0.0012*	0.0013
		200	0.0149	0.0024*	0.0028	0.0029	0.0008*	0.0009
		20	0.0365	0.0046*	0.0054	0.0071	0.0016*	0.0018
	≤ 10	50	0.0235	0.0028*	0.0034	0.0045	0.0010*	0.0011
		100	0.0165	0.0020*	0.0023	0.0032	0.0007*	0.0008
		200	0.0117	0.0014*	0.0017	0.0023	0.0005*	0.0006

* The estimator is unbiased and none of the other estimators have a lower variance at the 1 % risk level.

Table 3: Simulation results with tick rules and return adjustment ($P_{cum} \leq 500$)

Panel (a): $\sigma = 0.01$

α^*	$\delta(\%)$	N	Rule 1 s_1	Rule 1 s_2	Rule 1 s_3	Rule 1 s_4	Rule 2 s_1	Rule 2 s_2	Rule 2 s_3	Rule 2 s_4
	≤ 2	20	1.100	0.193*	0.222	0.192*	1.090	0.192*	0.220	0.191*
		50	0.701	0.119*	0.139	0.118*	0.697	0.118*	0.138	0.117*
		100	0.501	0.083*	0.099	0.083*	0.499	0.083*	0.098	0.082*
		200	0.355	0.058*	0.068	0.058*	0.352	0.058*	0.068	0.058*
0.8	≤ 6	20	0.642	0.064*	0.075	0.063*	0.640	0.063*	0.074	0.063*
		50	0.415	0.040*	0.047	0.040*	0.413	0.040*	0.046	0.040*
		100	0.288	0.029*	0.033	0.028*	0.287	0.029*	0.033	0.028*
		200	0.204	0.020*	0.023	0.020*	0.203	0.020*	0.023	0.020*
	≤ 10	20	0.496	0.038*	0.045	0.037*	0.494	0.037*	0.044	0.037*
		50	0.320	0.024*	0.028	0.023*	0.318	0.024*	0.028	0.023*
		100	0.227	0.017*	0.020	0.017*	0.226	0.017*	0.019	0.016*
		200	0.161	0.012*	0.014	0.012*	0.160	0.012*	0.014	0.012*

Panel (b): $\sigma = 0.02$

α^*	$\delta(\%)$	N	Rule 1 s_1	Rule 1 s_2	Rule 1 s_3	Rule 1 s_4	Rule 2 s_1	Rule 2 s_2	Rule 2 s_3	Rule 2 s_4
	≤ 2	20	2.260	0.389*	0.449	0.386*	2.260	0.389*	0.448	0.386*
		50	1.390	0.236*	0.275	0.234*	1.390	0.236*	0.274	0.234*
		100	1.000	0.167*	0.196	0.165*	1.000	0.167*	0.196	0.165*
		200	0.707	0.117*	0.136	0.116*	0.706	0.116*	0.136	0.115*
0.8	≤ 6	20	1.270	0.129*	0.149	0.128*	1.260	0.128*	0.148	0.127*
		50	0.830	0.080*	0.092	0.079*	0.829	0.080*	0.092	0.079*
		100	0.570	0.058*	0.066	0.057*	0.570	0.057*	0.066	0.057*
		200	0.415	0.039*	0.046	0.039*	0.414	0.039*	0.046	0.039*
	≤ 10	20	1.040	0.075*	0.088	0.075*	1.030	0.075*	0.087	0.075*
		50	0.636	0.047*	0.055	0.046*	0.635	0.047*	0.055	0.046*
		100	0.452	0.033*	0.039	0.033*	0.451	0.033*	0.039	0.033*
		200	0.321	0.023*	0.028	0.023*	0.320	0.023*	0.028	0.023*

Panel (c): $0.005 \leq \sigma \leq 0.02$

α^*	$\delta(\%)$	N	Rule 1 s_1	Rule 1 s_2	Rule 1 s_3	Rule 1 s_4	Rule 2 s_1	Rule 2 s_2	Rule 2 s_3	Rule 2 s_4
	≤ 2	20	1.490	0.198*	0.290	0.250	1.480	0.196*	0.289	0.249
		50	0.938	0.120*	0.183	0.155	0.935	0.119*	0.183	0.155
		100	0.666	0.083*	0.131	0.109	0.663	0.083*	0.130	0.109
		200	0.466	0.059*	0.092	0.077	0.464	0.059*	0.091	0.076
0.8	≤ 6	20	0.860	0.067*	0.099	0.083	0.857	0.066*	0.098	0.083
		50	0.556	0.041*	0.062	0.053	0.554	0.041*	0.062	0.053
		100	0.386	0.029*	0.043	0.037	0.384	0.028*	0.043	0.037
		200	0.274	0.020*	0.031	0.026	0.273	0.020*	0.030	0.026
	≤ 10	20	0.652	0.039*	0.059	0.050	0.648	0.039*	0.059	0.050
		50	0.434	0.024*	0.037	0.031	0.433	0.024*	0.037	0.031
		100	0.301	0.017*	0.026	0.022	0.300	0.017*	0.026	0.022
		200	0.209	0.012*	0.018	0.015	0.208	0.012*	0.018	0.015

* The estimator is unbiased and none of the other estimators have a lower variance at the 1 % risk level.

4.3 Continuous prices and overnight return adjustment

Next we ask how the results (in Table 3) change if we remove tick rules 1 and 2 so that prices become essentially continuous. We continue to assume that the pure ex-day price is unobservable. Table 4 presents both the means and standard errors of the test statistics in the continuous price case. We find that α_3 is biased at low dividend yields. However, the size of the bias does not depend on sample size. The variance of α_1 is large and exactly the same as in Tables 3 and 4. Thus, the performance of α_1 does not depend at all on tick rules as long as the overnight return adjustment is necessary.

Under the assumption of constant return volatility, the best performing statistics are, again, α_2 and α_4. With non-constant volatility, the best statistic is α_2 alone. At low dividend yields, s_2 and s_4 are higher with continuous prices than with tick rules, and the difference of variances is statistically significant. At higher dividend yields there is no difference in standard errors. The conclusion is that as long as it is necessary to adjust the ex-day price drop by an estimate of overnight return, it does not matter whether stock prices are discrete or not. The effect of errors made in estimating the ex-day price drop is far more important than the effect of any tick rules.

4.4 Intuitive interpretation of the results

Sections 4.1 to 4.3 above show that the importance of tick rules for ex-day studies depends on the nature of the ex-day price drop that we observe. First, if ex-day price drops only reflect capital income taxes, dividends and tick rules, and are not contaminated by overnight returns requiring adjustment, tick rules have a negative impact on our ability to estimate the tax parameter. A smaller tick allows us to estimate the implicit tax rate more accurately than a larger tick.

On the other hand, if the ex-day price drop is contaminated by overnight return, which must be removed by using an estimate of normal daily return, tick rules have no effect on our ability to estimate the tax parameter. In this case, only the amount of return uncertainty is important, because it determines how large errors are potentially made in estimating the overnight return. These errors can have a much larger effect on the estimated ex-day price drop than the tick rules.

The intuition of these results is straightforward. Because of tick rules, prices are rounded to the nearest legitimate price either below or above. The effect of rounding on the ex-day stock price and the ex-day price drop is therefore less than one tick. The effect of overnight return correction on the ex-day price drop can be much larger than that. Assume that the actual overnight return is one standard deviation, say one percentage point, smaller or larger than the expected return. One percentage point of a price of, say 80, is 0.8, which is eight times the relevant tick size, 0.1 (see Table 1).

4.5 The effect of prices

We expect that the smaller the tick size the smaller the error in estimating α^*. With tick rules 1 and 2, the average percentage tick sizes are 0.48 % and 0.16 % when $P_{cum} \leq 200$, and 0.37 % and 0.08 % when $P_{cum} \leq 500$.[16] Due to a lower average tick size, we expect Rule 2 to be less restrictive than Rule 1 and thus have a smaller effect on the estimation results of the simulation experiment. To test this hypothesis, we let $\alpha^* = 0.8$, $N = 200$ and $\sigma_i \sim U(0.005,0.02)$, repeat the simulation experiment for two cum-day price ranges, $P_{cum} \leq 200$ and $P_{cum} \leq 500$, and use an ordinary F-test to test the equality of the variances of each statistic in the two price ranges.

Table 5 reports the p-values for the F-tests. The results show the following. First, only with tick rules 1 and 2, the variances of all statistics are always larger when the narrower price range is used, and the F-test is highly significant. This is consistent with our hypothesis that the relative tick size is important. Second, when overnight return adjustment is necessary, the variance of α_1 is always larger for the wider price

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[16] Let the price, x, ranging from a to b, follow a univariate distribution so that $x \sim U(a,b)$. The density function of x is $f_x(x) = 1/(b-a)$ when $x \in [a,b]$ and $f_x(x) = 0$ otherwise. Assume the tick size is, say, 1, so that the relative tick size is given by $y = 1/x$. The density function of y is $f_y(y) = f_x(x)/y^2$ when

range. The difference in variances is highly significant. The explanation is the following. The size of the ex-day price drop caused by dividend stripping depends only on taxes and the dividend amount but is independent of the cum-day price. Taking tax rates and the dividend as given, the higher the cum-day price the higher the ex-day price. The higher the ex-day price is, the larger is the overnight return adjustment to the price drop, for a given ex-day price drop and for a given normal daily return. Therefore, the variance of α_1 is higher for $P_{cum} \leq 500$ than for $P_{cum} \leq 200$.

Third, when prices are continuous, the variances of α_2, α_3 and α_4 do not depend on the range of P_{cum}. This is consistent with our prediction. Cum-day prices are not supposed to affect the variances when there are no restrictions on the smallest price increment. Fourth, with tick rules and return adjustment, the variances of α_2, α_3 and α_4 are independent of the cum-day price change except when dividends are small. When dividends are small the variances are higher for the wider price range. The explanation is the same as for α_1 above. With small dividends, the overnight adjustment has a larger effect on the ex-day price drop if prices are high. For higher dividend yield classes, the variances of α_2, α_3 and α_4 do not depend on the level of stock prices.

These results suggest that the level of stock prices may be an important factor for ex-day price behaviour. Cum-day prices appear to be important when low dividend yield data are studied and always when the test statistic used is α_1.

$y \in [1/b, 1/a]$ and $f_y(y) = 0$ otherwise. The average relative tick is the expectation of y. The numbers above are obtained by properly weighting the average relative ticks of the relevant price categories.

Table 4: Simulation results with continuous prices and return adjustment ($P_{cum} \leq 500$)

Panel (a): $\sigma = 0.01$

α^*	δ (%)	N	α_1	α_2	α_3	α_4	s_1	s_2	s_3	s_4
		20	0.790	0.798	0.826	0.794	1.090	0.197*	0.235	0.197*
	≤ 2	50	0.804	0.801	0.829	0.797	0.697	0.124*	0.149	0.123*
		100	0.793	0.799	0.826	0.795	0.499	0.087*	0.105	0.087*
		200	0.798	0.800	0.827	0.796	0.352	0.061*	0.072	0.061*
		20	0.799	0.800	0.804	0.799	0.640	0.063*	0.076	0.063*
0.8	≤ 6	50	0.800	0.800	0.804	0.800	0.413	0.040*	0.047	0.040*
		100	0.804	0.800	0.804	0.800	0.287	0.029*	0.034	0.028*
		200	0.798	0.800	0.804	0.799	0.203	0.020*	0.024	0.020*
		20	0.808	0.799	0.801	0.799	0.494	0.037*	0.045	0.037*
	≤ 10	50	0.798	0.800	0.802	0.800	0.318	0.024*	0.028	0.023*
		100	0.804	0.800	0.802	0.800	0.226	0.017*	0.020	0.016*
		200	0.799	0.800	0.801	0.800	0.160	0.012*	0.014	0.012*

Panel (b): $\sigma = 0.02$

α^*	δ (%)	N	α_1	α_2	α_3	α_4	s_1	s_2	s_3	s_4
		20	0.766	0.795	0.820	0.792	2.260	0.399*	0.465	0.399*
	≤ 2	50	0.790	0.799	0.824	0.795	1.390	0.244*	0.285	0.243*
		100	0.793	0.798	0.825	0.794	1.000	0.173*	0.204	0.173*
		200	0.787	0.797	0.824	0.794	0.707	0.122*	0.142	0.121*
		20	0.782	0.801	0.804	0.801	1.260	0.129*	0.150	0.128*
0.8	≤ 6	50	0.798	0.801	0.805	0.800	0.829	0.080*	0.093	0.080*
		100	0.803	0.802	0.805	0.801	0.569	0.058*	0.066	0.057*
		200	0.800	0.800	0.804	0.799	0.414	0.039*	0.046	0.039*
		20	0.793	0.798	0.799	0.798	1.030	0.075*	0.088	0.075*
	≤ 10	50	0.793	0.800	0.802	0.800	0.635	0.047*	0.055	0.046*
		100	0.796	0.800	0.801	0.800	0.451	0.033*	0.039	0.033*
		200	0.800	0.800	0.802	0.800	0.320	0.023*	0.028	0.023*

Panel (c): $0.005 \leq \sigma \leq 0.02$

α^*	δ (%)	N	α_1	α_2	α_3	α_4	s_1	s_2	s_3	s_4
		20	0.804	0.801	0.832	0.799	1.480	0.201*	0.304	0.257
	≤ 2	50	0.798	0.799	0.827	0.795	0.935	0.123*	0.192	0.161
		100	0.799	0.801	0.828	0.797	0.663	0.086*	0.137	0.115*
		200	0.801	0.800	0.827	0.796	0.464	0.062*	0.096	0.081
		20	0.801	0.800	0.803	0.798	0.856	0.066*	0.100	0.083
0.8	≤ 6	50	0.795	0.800	0.805	0.800	0.554	0.041*	0.063	0.053
		100	0.799	0.800	0.805	0.800	0.384	0.028*	0.044	0.037
		200	0.801	0.800	0.804	0.799	0.273	0.020*	0.031	0.026
		20	0.807	0.800	0.801	0.800	0.648	0.039*	0.059	0.050
	≤ 10	50	0.800	0.800	0.801	0.800	0.433	0.024*	0.037	0.031
		100	0.807	0.800	0.802	0.800	0.300	0.016*	0.026	0.022
		200	0.802	0.800	0.802	0.800	0.208	0.012*	0.018	0.015

* The estimator is unbiased and none of the other estimators have a lower variance at the 1% risk level.

Table 5: p-values for the F-test that variances of test statistics are the same for $P_{cum} \leq 200$ and $P_{cum} \leq 500$

($\alpha^* = 0.8, N = 200, 0.005 \leq \sigma \leq 0.02$)

Tick rule 1

δ (%)	α_1	α_2	α_3
≤ 2	0.000	0.000	0.000
≤ 6	0.000	0.000	0.000
≤ 10	0.000	0.000	0.000

Tick rule 2

δ (%)	α_1	α_2	α_3
≤ 2	0.000	0.000	0.000
≤ 6	0.000	0.000	0.000
≤ 10	0.000	0.000	0.000

Continuous prices and return adjustment

δ (%)	α_1	α_2	α_3	α_4
≤ 2	0.000	0.435	0.073	0.085
≤ 6	0.000	0.309	0.054	0.352
≤ 10	0.000	0.500	0.293	0.500

Tick rule 1 and return adjustment

δ (%)	α_1	α_2	α_3	α_4
≤ 2	0.000	0.000	0.000	0.000
≤ 6	0.000	0.500	0.162	0.351
≤ 10	0.000	0.500	0.292	0.500

Tick rule 2 and return adjustment

δ (%)	α_1	α_2	α_3	α_4
≤ 2	0.000	0.000	0.000	0.000
≤ 6	0.000	0.308	0.161	0.500
≤ 10	0.000	0.199	0.291	0.500

4.6 Clientele test with NYSE tick rules

Tables 3 and 4 demonstrate that even with 200 observations standard errors of ex-day test statistics are fairly large when dividend yield is at most 2 %. Since low dividend yield data are very common in ex-day studies and especially in tax clientele studies, the reliability of ex-day tests using low-yield stocks deserves some further investigation. For example, in the U.S., average dividend yields in the lowest yield decile can be lower than 0.3 % and typically exceed 1 % only in the 3 or 4 highest yield deciles, implying that at least 60 % of shares have dividend yields less than 1%.[17]

Table 6 shows the results of a clientele test simulation. The set-up of the experiment is exactly as before except that, this time, the smallest price increment is 0.125 as in the NYSE. The average dividend yields in dividend yield deciles are taken from Michaely (1991). Using the decile means we construct the lower and upper bounds of the yield classes and for each class we draw the dividend yields from a uniform distribution. There are 500 stocks in each decile and the true tax parameter is $\alpha^* = 0.8$. Cum-day stock prices are drawn from a uniform distribution with prices ranging from 5 to 100 dollars. Dividends are computed as the product of dividend yield and cum-day price and rounded so that they are always at least 0.10 and always multiples of 0.01. Stock return volatilities are drawn from a uniform distribution with $\sigma_i \sim U(0.005,0.02)$. The experiment is repeated 10,000 times. Table 6 reports the results for only two statistics, α_1, which is commonly used, and α_2, which had the best performance in earlier simulations.

When the pure ex-day price can be observed, both α_1 and α_2 perform well only in the two highest deciles. In these deciles, they are both unbiased and have the same standard errors. However, in the lowest seven deciles both estimators are severely biased. Since both estimators have very small standard errors, the true tax parameter, α^*, falls outside the 95 % confidence interval. In addition, the average estimates give

[17] Examples of clientele studies include Booth and Johnston (1984), Grammatikos (1989), Michaely (1991) and Robin (1991), among others. In these studies, stocks are grouped according to dividend yield and the tax parameter is estimated separately for each group.

the impression that α falls with dividend yield even though α^* is constant at all dividend yields. This finding shows that tick rules can have a major effect on estimating α^*. This result is consistent with the findings of Bali and Hite (1998).

The poor results for the lowest yield deciles are partly explained by our requirement that dividends are not smaller than 0.10. This is clear by considering decile 1. Dividend yields range from 0.09 % to 0.25 % and cum-day prices from 5 to 100. The highest possible dividend is then 0.25. With the average dividend yield of 0.17 %, the cum day price would have to be 59 to make the dividend higher than 0.10, and 74 to make the dividend 0.125. The majority of dividends are thus rounded to 0.10. With α^* = 0.8, the true price drop would be 0.08, implying that the majority of ex-day prices are rounded down in the experiment. This explains why average ex-ratios are so large in the lowest deciles. Note, however, that setting the minimum dividend requirement to 0.125 would not solve this problem. With $\alpha^* = 0.8$ the true price drop would be 0.10 and the majority of ex-day prices would still be rounded down. The average ex-ratios would still overestimate the true tax parameter, but by less than that reported in Table 6.

The results change dramatically when discrete ex-day prices are adjusted for the overnight return. Both methods are unbiased at all dividend yields. However, standard errors are much larger now, and α_1 has a significantly higher variance than α_2 in all yield deciles. When prices are continuous both α_1 and α_2 perform well in all yield deciles. The standard errors of α_1 are the same for continuous and discrete prices (with return adjustment). Therefore, it does not matter whether prices are continuous or discrete. This result holds for α_2 only in deciles 5 to 10. In deciles 1 to 4, the variances are higher with continuous prices than with the NYSE tick, suggesting that at low dividend yields tick rules may actually be helpful.

Table 6 demonstrates that identifying a tax clientele effect is very difficult even if one has 5,000 ex-day observations available (500 observations in each decile). The standard errors of the most commonly used test statistics are large and the confidence intervals wide. The evidence suggests that one can identify a tax clientele effect reliably only if average ex-ratios in the yield deciles are substantially different from one another. We obtain this result even when the estimator with the smallest variance is used. Further, note that this result is obtained assuming a fairly modest level of stock return volatility, ranging from only 8 % to 32 % annually. When the annual return volatility of all stocks is assumed to be 32 %, the standard errors of α_1 are almost two times as high as the ones reported in Table 6.

Table 6: Simulation results with NYSE tick rules (P_{cum} $\leq$ 100)

($\alpha^* = 0.8$, $N = 500$, $0.005 \leq \sigma \leq 0.02$)

Decile	Dividend yield, %	*NYSE tick rule* α_1	*NYSE tick rule* α_2	*NYSE tick rule + return adjustment* α_1	*NYSE tick rule + return adjustment* α_2	*Continuous prices + return adjustment* α_1	*Continuous prices + return adjustment* α_2
1	0.09 - 0.25	1.117 (0.009)	1.222 (0.004)	0.799 (0.277)	0.801 (0.110)	0.799 (0.277)	0.798 (0.202)
2	0.25 - 0.39	0.947 (0.011)	1.122 (0.013)	0.802 (0.170)	0.803 (0.098)	0.801 (0.169)	0.800 (0.125)
3	0.39 - 0.51	0.893 (0.0010)	1.028 (0.017)	0.801 (0.125)	0.802 (0.085)	0.800 (0.125)	0.800 (0.095)
4	0.51 - 0.62	0.868 (0.009)	0.964 (0.017)	0.800 (0.100)	0.800 (0.071)	0.800 (0.100)	0.799 (0.074)
5	0.62 - 0.73	0.854 (0.008)	0.919 (0.015)	0.800 (0.086)	0.801 (0.064)	0.800 (0.085)	0.800 (0.065)
6	0.73 - 0.85	0.843 (0.007)	0.887 (0.013)	0.801 (0.074)	0.801 (0.055)	0.801 (0.074)	0.800 (0.054)
7	0.85 - 1.06	0.831 (0.006)	0.855 (0.010)	0.800 (0.061)	0.800 (0.048)	0.799 (0.061)	0.799 (0.048)
8	1.06 - 1.425	0.819 (0.005)	0.827 (0.007)	0.800 (0.048)	0.800 (0.036)	0.800 (0.048)	0.800 (0.036)
9	1.425 - 2.05	0.807 (0.004)	0.807 (0.004)	0.800 (0.035)	0.800 (0.026)	0.800 (0.034)	0.800 (0.025)
10	2.05 - 2.85	0.799 (0.003)	0.799 (0.003)	0.800 (0.0243)	0.800 (0.019)	0.800 (0.024)	0.800 (0.019)

5. Conclusions

We conduct a simulation experiment, which grants favourable conditions for an ex-day study and examines how well commonly used ex-day methods estimate a given implicit tax rate. Ex-day prices are assumed to reflect capital income taxes as far as it is possible when prices are discrete. We examine three cases. In the first case, the true ex-day price drop caused by dividend stripping can be observed and there is no need to worry about the return earned by the stock overnight. In the second case, we assume that the true ex-day price can not be observed. To estimate it, the overnight return earned by the stock must be estimated from past returns. In the third case, stock prices are continuous and the overnight return must be estimated. We use two different tick rules. The first one was used in the Helsinki Stock Exchange before 1996 and the second in 1996-98. Tick size during the former period was larger than that of the NYSE for stocks whose prices exceeded an equivalent of 20 dollars, while the tick size during the latter period was always smaller than the NYSE tick of 12.5 cents.

The results show that the importance of tick rules for ex-day studies depends on the nature of the ex-day price drop that we observe. First, we find that tick rules are important if we can observe an ex-day price drop that only reflects capital income taxes, dividends and tick rules, and is not contaminated by any overnight return requiring adjustment. The standard errors of all test statistics are significantly smaller in the small tick case than in the large tick case. Therefore, a smaller tick allows us to estimate the implicit tax rate more accurately than a larger tick. Furthermore, when the larger tick is used some test statistics, most notably the average ex-ratio, are systematically biased. The size of the bias falls with dividend yield but is unaffected by sample size. Second, if the ex-day price drop is contaminated by overnight return, which must be removed by using an estimate of normal daily return, tick rules do not matter any more. Only the amount of return uncertainty is important. The effect of errors made in estimating the ex-day price drop is far more important than the effect of any tick rules. The standard errors of the test statistics do not depend on the tick rules at all. Furthermore, removing tick requirements altogether has hardly any effect on standard errors. Thus, from an ex-day study point of view it does not matter whether prices are continuous or discrete as long as ex-day prices are adjusted by normal return. Tick rules are not important in this case.

Not all ex-day methods are equally reliable. Knowing this can be very useful in interpreting empirical results when alternative statistics are used. We find that the GLS-estimator of the ex-ratio always performs at least as well as the other statistics largely because it is the only statistic that takes both stock return volatility and dividend yield explicitly into account. If return volatility is the same for all stocks, the model that explains ex-day stock returns by dividend yield performs equally well. The traditional ex-dividend day ratio of Elton and Gruber (1970) takes neither dividend yield nor volatility into account and, therefore, has the poorest performance in the simulation experiment. The standard errors of the average ex-ratio are so large that it is doubtful whether a tax parameter of any reasonable magnitude can ever be found statistically different from one at conventional significance levels and sample sizes. Gagnon and Suret (1991) have previously argued the same. The equally weighted portfolio statistic of Lakonishok and Vermaelen (1983) performs almost as well as the ex-day return model, but has higher standard errors.

We further investigate the performance of ex-day methods when the NYSE tick size of 12.5 cents is applied to low dividend yield data that are comparable to those used in earlier tax clientele studies. The evidence suggests that even if one has access to 5,000 ex-day observations, tax clientele effects can be identified reliably only if ex-day price behaviour in one decile is substantially different from that in other deciles. We obtain this result even when the GLS-estimator is used and when only a modest level of stock return volatility is assumed.

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