Cross-Border Investing with Tax Arbitrage: The Case of German Dividend Tax Credits

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German dividends typically carry a tax credit which makes the dividend worth 42.86% more to a taxable German shareholder than to a tax-exempt or foreign shareholder. This results in a penalty for foreign investors who buy and hold German dividend-paying stocks. I document that, as a result of the credit, the ex-day drop exceeds the dividend by more than one-half of the tax credit, and show that futures and option prices embed more than one-half of the tax credit. The existence of the credit creates opportunities for cross-border tax arbitrage—in which foreign holders of German stock transfer the dividend to German shareholders—and implies that it is tax efficient for foreign investors to hold derivatives rather than investing directly in German stocks. The empirical findings are consistent with costly tax arbitrage activity by German investors, who face tax risk due to antiarbitrage rules. Since dividend tax credits exist in many other countries, the findings are potentially of broad interest.

The United States explicitly double-taxes corporate income, once when it is earned and a second time when it is received by shareholders. In many countries, however, the tax system is designed to reduce the total tax burden on corporate income by at least partially compensating shareholders for tax already paid by the corporation. This is called an "integrated" or "imputation" tax system.

Compensation to shareholders can take the form of a tax credit attached to dividend payments. For a taxable shareholder in the corporation's home country, this results in a \$1 dividend having a pretax value in excess of \$1. For example, in Germany from 1994 to 1998, most dividends carried a 42.86% tax credit, hence a dividend with a pretax value of DM 1 for a foreign investor would have a pretax value of DM 1.4286 to a taxable German investor.

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Tax laws of other countries generally do not recognize German tax credits. This creates an incentive for shares held by foreigners to be transferred to taxable German investors during the dividend period. Moreover, if the stock price in equilibrium even partially reflects receipt of the tax credit, a non-German investor who does not proactively manage stock holdings around the dividend date can be penalized, since the ex-dividend drop in the stock price would be more than the amount of the dividend received.

In order to assess the market valuation of the tax credit, this article uses stock, futures, and option prices to examine the effects of dividend payments on the ex-day behavior of German stocks. I conclude that the market value of the dividend tax credit exceeds half the credit. For a stock which pays a DM 1 dividend, the share price is expected to drop on average by about DM 1.26. This implies that a foreign investor incurs a cost of 26% of the value of the dividend from holding a German stock across the ex-dividend date. In the long run, a foreign investor following a buy-and-hold strategy in a company which makes payouts exclusively as dividends loses 26% of the value of the investment. This cost is also incurred when the share is held via a mutual fund or depository receipt. There is a corresponding benefit for the German investor since the share price drop (1.26) is less than the value of the dividend plus credit (1.4286). Evidence on trading volume and the behavior of the bid-ask spread is consistent with the existence of dividend arbitrage trading by German investors.

This finding provides evidence about the ex-dividend day equilibrium in an institutional setting different than the United States. Also, since German authorities would like to prevent trading in the tax credit, it provides a case study of market efficiency in the presence of costly arbitrage.[1] Finally, the article has immediate implications for portfolio management since the findings suggest that foreign investors may raise their return on German stocks by actively managing equity investments (e.g., selling shares cum-dividend and buying ex-dividend) or by holding derivatives—such as futures, options, and swaps—in lieu of direct equity investments.[2]

In October 2000, a German tax reform eliminated the imputation system. However, the general structure and issues are applicable to many other countries with an imputation system.[3] To take one prominent example, Australia in 1997 enacted extensive antiabuse provisions to prevent trade in the "franking credit," which is a dividend tax credit.[4]

[1] This motivation is similar to that in Cornell and Shapiro (1989), who studied the U.S. Treasury bond market, and Green and Rydqvist (1999), who looked at the ex-day behavior of Swedish lottery bonds.

[2] This conclusion of course depends on transaction costs of the derivatives strategy over the holding period not being substantially greater than transaction costs of investing directly in the stock.

[3] A partial list of countries with some kind of dividend-crediting mechanism includes Australia, Canada, Finland, France, Germany, Ireland, Italy, New Zealand, Norway, Singapore, Spain, Thailand, and the United Kingdom.

[4] Among other restrictions, Australia enacted a 45-day holding period—during which time the stock cannot be hedged—for receipt of the franking credit. Details of Australia's antiabuse measures can be found at http://www.treasurer.gov.au/Treasurer/PressReleases/1997/1997_0047.asp.

Since this article examines the credit by looking at the ex-day behavior of the stock price, it is closely related to the large literature on ex-day price effects, most of which uses U.S. data. In characterizing equilibrium, that literature emphasizes the tax heterogeneity created by different classes of investors having different relative tax rates for dividends and capital gains. The setting in this article is more complicated, since not only are investors heterogeneous with respect to tax rates, but because of the credit they are also heterogeneous with respect to the pretax value of the dividend.

To examine this heterogeneity, I adopt the costly arbitrage model of Kalay (1982) and Boyd and Jagannathan (1994). I also broaden their analysis by permitting stock loans as an additional route for undertaking arbitrage. The analysis implies that in the absence of tax restrictions against arbitrage, the *marginal* ex-day price drop should reflect the dividend plus credit; this is analogous to the Boyd and Jagannathan (1994) result that the marginal price drop in the United States should be one-for-one. I also show that the cost of borrowing stock across the ex-day is increasing in the dividend yield, and that the credit should also affect equity futures and option prices.

Empirical results using German stock and futures data show that the marginal price drop is greater than one-for-one, but generally by less than the full tax credit. Regressions suggest that between 55% and 85% of the credit is reflected in prices. The decline in the tax credit rate from 56.25% to 42.86% between 1993 and 1994 is evident in the futures data, and prior to 1994 we cannot reject the hypothesis that the full amount of the credit was reflected in the futures price. The fact that more recent evidence points to less than 100% of the credit being reflected in prices could be due to German arbitrageurs facing tax risk in undertaking tax credit arbitrage. To illustrate the effect of the credit on option prices, I examine the May 1998 Daimler-Benz special dividend, which was large enough (10%) to have a clear impact on option prices.

A handful of other studies have looked at the ex-day in imputation countries.[5] Most closely related to this article are Alphonse (1999), who finds evidence of tax credit effects in the pricing of the French CAC40 futures, and Dia and Rydqvist (2000), who examine the Norwegian imputation system and obtain results similar to ours. Brown and Clarke (1993) examined Australian ex-day effects, but were unable to find significant effects of the dividend tax credit. Lasfer (1995) focused on the effects of a 1988 U.K. tax reform which reduced the difference between capital gain and dividend tax rates. Michaely and Murgia (1995) examined relative ex-day price declines on two classes of differentially taxed shares in the Italian stock market.[6]

[5] Amihud and Murgia (1997) also study dividends in Germany but examine the dividend announcement effect rather than the ex-day. Their focus is on the corporate decision to retain or pay out cash, rather than the price impact of a dividend payment. Lasfer (1996) examined the same issue for the United Kingdom.

[6] Michaely and Murgia find a share price drop substantially less than one-for-one with the dividend, which they attribute to the “registration effect”: the predividend sale of the stock in order to avoid having to register as

There is also a small theoretical literature on imputation. Broadway and Bruce (1992) examine the effect of a dividend tax credit on saving and investment in a variety of settings. Monkhouse (1993) and Wood (1997) derive a capital asset pricing model (CAPM) assuming the existence of tax credits. Using an estimate for Australia that 40% of dividend tax credits go unclaimed, Wood predicts that tax credits will have a market value of 60% of their face value.

The results in this article also provide evidence on broader issues, such as the importance of tax barriers to international market integration [see, e.g., Bekaert (1995)] and tax policy, in particular effects on risk sharing and the cost of capital of using a dividend tax credit to achieve integration of the corporate and personal tax [Harris, Hubbard and Kemsley (1998)].

Section 1 explains the basic tax rules in Germany, including the dividend tax credit. Section 2 looks at the theoretical ex-day no-arbitrage bounds for the stock price drop for different classes of traders, and characterizes the equilibrium ex-day price drop and the cost of short selling shares. Section 3 discusses data sources. Section 4 looks at data on volume and the bid-ask spread, finding that volume increases significantly just before the dividend and that the reported last trade on last cum day is significantly closer to the ask price than on other days, evidence indicative of dividend capture activity. Section 5 shows that more than half of the tax credit is evident in the ex-day price drop and is embedded as well in prices of futures and options. Section 6 looks at the portfolio management implications for foreign investors. Section 7 concludes.

1. Taxation and the German Dividend Tax Credit

1.1 The rationale for a dividend tax credit

The German tax system entails taxing corporate earnings and then rebating this tax to shareholders with a dividend tax credit.[7] Why have Germany and other countries adopted this kind of system? Single taxation of corporate income could also be achieved by simply eliminating the corporate-level tax. However, taxation of unrealized capital gains is generally regarded as infeasible, and payment of dividends and sales of shares are elective for the corporation and shareholder. In principle, without either taxation of unrealized gains or a corporate-level tax, tax payments on corporate income could be deferred indefinitely if the corporation were to retain all earnings. A corporate-level

the owner. Since the registration requirement apparently leads to selling in advance of the ex-day, it would be interesting to look at price behavior over a longer window than just the ex-day. This longer-period excess return would presumably give results more directly comparable to the results in this article.

[7] Norway has an alternative scheme, discussed in Dai and Rydqvist (2000), in which dividends are tax exempt to the recipient, and there is an annual adjustment of the stock basis to reflect retained earnings. The basis adjustment is valuable to Norwegians and not to foreigners, hence it generates arbitrage trading like the German system.

tax eliminates the ability to defer the tax; integration is then achieved by rebating the corporate tax to shareholders when they pay tax on corporate distributions.[8]

Foreign holders of stock are generally not eligible for the credit in an imputation system. If imputation credits were made available to foreigners, the government would lose tax revenue since it cannot fully tax foreign holdings of the stock.[9] Governments with imputation systems therefore usually try to prevent trading in tax credits. Germany has rules, which we discuss below, aimed specifically at preventing such trading.

1.2 The dividend tax credit

This section briefly summarizes the mechanics of the dividend tax credit. A more detailed discussion of German tax law is in the appendix. Suppose a company has pretax income of x and is taxed at the rate τ_{corp}. This leaves $x(1 - \tau_{corp})$ to distribute. Suppose this amount is paid as a dividend. The dividend tax credit gives shareholders a credit for taxes already paid by the corporation. This is accomplished by giving shareholders a fractional credit of $\frac{\tau_{corp}}{1-\tau_{corp}}$ on the cash amount of the dividend.

Figure 1 illustrates the credit by computing the after-tax income of a shareholder who is taxed at the rate τ_s. Net of all taxes, the shareholder receives $x(1 - \tau_s)$, which is equivalent to having pretax corporate income taxed at the shareholder's tax rate. Note that in this example a foreign shareholder receives $x(1 - \tau_{corp})$ pretax and receives no tax credit.

We will refer to the cash dividend [$x(1 - \tau_{corp})$ in the above example] as the *net dividend*. The net dividend plus the tax credit (x in the above example) is the *gross dividend*.

Under current German law, the tax rate on earnings paid as a dividend is 30%. Thus the tax credit is $.3/(1 - .3) = .4286$. Prior to 1994 the corporate tax rate on distributed earnings was 36%, giving a credit of $.36/(1 - .36) = .5625$.

1.3 Restrictions on using the tax credit

There are at least three rules which, over the sample period of this study, restricted the ability of German investors to use the tax credit. Appendix A.2 contains more details about these rules.

First, only the economic owner of the stock is entitled to the tax credit. Depending on the interpretation of this rule, this obviously has the potential to defeat many arbitrage strategies. This prevents custodial banks, for example, from receiving the credit.

[8] A general problem with eliminating the tax on any particular class of income is that tax rate differentials across categories of income create tax arbitrage opportunities. Thus, as a practical matter, it can make sense to adopt a tax-cum-rebate scheme rather than simply exempting a category of income from tax.

[9] Withholding taxes permit the German government to tax foreigners on dividends, but withholding on dividends in Germany is approximately 25% and is typically reduced by tax treaty. Thus there would still be a net revenue loss were the credit paid to foreigners.

Cash Dividend Paid	$x(1-\tau_{corp})$
Dividend Tax Credit	$x(1-\tau_{corp})\frac{\tau_{corp}}{1-\tau_{corp}} = x\tau_{corp}$
Taxable Income	$x(1-\tau_{corp}) + x\tau_{corp} = x$
Personal Income tax @ τ_S	$x\tau_s$
Dividend plus credit less tax	$x(1-\tau_{corp}) + x\tau_{corp} - x\tau_s = x(1-\tau_s)$

Figure 1
Illustration of dividend tax credit
Firm earns x pretax, is taxed at the rate τ_{corp} on distributions, hence distributes $x(1-\tau_{corp})$. Shareholder receives tax credit of $x\tau_{corp}$, reports taxable income of x, pays tax of $x\tau_s$. The shareholder thus reports dividend income of $x(1-\tau_{corp})$, receives credit of $x\tau_{corp}$, and owes tax of $x\tau_s$. After taxes the shareholder receives $x(1-\tau_s)$.

Second, §36 of the German Income Tax Law limits the use of the tax credit in cases where shares are borrowed from foreign investors. Stock loans provide an obvious mechanism for a temporary transference of the stock; this rule is aimed at reducing their value.

Third, §50c of the German Income Tax Law makes the capital loss on shares non-deductible to the extent they are attributable to a dividend payment if (i) the shares are not held at least 10 days or (ii) the position is hedged.

While interpretations of a tax rule depend on specific circumstances, the important point for our purpose is that German tax law can reduce the ability to use the tax credit, particularly in cases where stock has been borrowed from a foreigner. The restrictions are linked to the size of the dividend and the credit, hence for an arbitrageur with some probability of confronting the restrictions, their effect would be to reduce the expected tax credit. This interpretation will be important when we come to the empirical results.

1.4 Other relevant tax rules in Germany

All taxable investors pay tax on dividends, but the tax treatment of capital gains depends upon the classification of the owner. For corporations, capital gains are taxed as ordinary income. For individuals, capital gains are tax exempt if shares are held longer than 6 months,[10] and taxable as ordinary income otherwise. Short sales are always taxable.

1.5 The taxation of German dividends in foreign countries

To complete the description of how dividends paid by German firms are taxed, we must consider foreign holders of German stock. There are frequently special tax rules for large percentage holdings in a firm, so we consider only the tax treatment faced by a “small” (i.e., less than 10%) owner of

[10] The holding period was changed to 12 months in 1999.

the stock.[11] A global description of dividend taxation is far beyond the scope of this article, but it is possible to generalize about several important points.

First, there is generally no mechanism by which foreign investors can receive the dividend tax credit. This is true whether the stock is held directly, or via a mutual fund or depository receipt. Custodial holders of a stock (such as a German bank) are not eligible to receive the credit.

Second, foreign holders of German stocks generally are taxed more heavily on dividends than capital gains. La Porta et al. (1998, Table 3) summarize the relative taxation of dividends and retained earnings in more than 30 countries.[12] They find only three (Finland, Norway, and Sweden) which tax dividends less heavily than retentions. U.S. corporations, which are eligible for the dividend-received deduction (DRD), are often cited as one important class of taxpayer for which dividends are taxed less heavily than capital gains. However, for ownership shares of less than 10%, the DRD applies only to *domestic* stocks. Thus a U.S. corporation holding the stock of a German firm would face the same statutory tax rate on dividends and capital gains.

While we have not ruled out the possibility of a particular tax rule somewhere which might favor the receipt of foreign dividend income, it seems fair to conclude that for foreign investors in most major countries, German dividends are not tax favored relative to capital gains.[13]

2. The Tax Credit and the Pricing of Stock Transactions

If all shareholders were taxable German investors facing the same tax rate on dividends and capital gains, a DM 1 net dividend would be worth DM 1.4286 to all shareholders. For all practical purposes, such as computing the expected ex-day stock price drop or pricing derivatives, only the gross dividend (the dividend plus tax credit) would be relevant. In particular, we would expect the stock on the ex-day to drop by the amount of the gross dividend, and futures and options prices to reflect the gross dividend.

In practice, German shares are held in significant amounts by foreign investors and in small numbers by German tax-exempt investors.[14] This raises

[11] Large holders can face restrictions on trading their shares. They also sometimes face different tax rules than small holders. For example, in the United States, the dividend-received deduction is 70% for less than 20% holders, but 80% for 20% shareholders and 100% for 80% shareholders.

[12] This is not exactly the same thing as the relative taxation of dividends and capital gains. The La Porta et al. (1998) calculation takes into account different corporate tax rates for retentions and dividends. However, to the extent the payment of dividends results in a lower corporate tax (the typical situation), this calculation will *understate* the extent to which a shareholder faces greater taxation of dividends than capital gains. In their sample, only South Africa taxes retentions less heavily than payouts.

[13] Two foreign tax experts I consulted were unaware of any exceptions to this generalization.

[14] Edwards and Fischer (1994, Table 8.1, p. 180) provide an estimate that in 1988, 20% of German shares were held by foreigners. Deutsche Bundesbank (1995, p. 67) provides this breakdown of share ownership for 1994: households, 20.8%; nonfinancial enterprises, 34.3%; the public sector, 4.3%; institutional investors, 18.9%; and foreign holdings, 21.7%. Of German domestic holdings, nonprofits (included in household holdings) accounted for 1.3%.

the question of whether the net dividend, the gross dividend, or something in between is relevant for pricing stock transactions.

In this section we examine how tax rules and stock trading strategies interact to determine the price effects of a dividend payment, both in stocks and derivatives. For most of this section we ignore the specific restrictions aimed at preventing dividend capture; they are discussed at the end of the section.

2.1 A simple example of tax credit arbitrage

The most obvious form of tax credit arbitrage is a stock loan: a transfer of the shares from a foreign investor to a German investor on the cum-dividend date, with the shares returned ex-dividend and a payment made to the foreign investor to compensate for the lost dividend.[15]

Consider a simple example with two classes of risk-neutral investor, no transaction costs, and no institutional restriction against tax arbitrage. Suppose one investor is a U.S. tax-exempt owner of the stock, and the other is a German trading firm, taxed identically on dividends and capital gains at the rate τ. This implies that both the German and U.S. investors face the same relative after-tax valuation of dividends and capital gains.

Suppose the German stock sells for DM 100 and is about to pay a DM 5 net dividend. Assuming a dividend tax credit, k, of 42.86%, the gross dividend, $(1+k)D$, is 7.143. Let P_0 be the cum-dividend price and $E[P_1]$ the expected ex-dividend price. Suppose that if the U.S. stockholder lends the stock across the ex-date, they are paid the dividend plus the fraction γ of the tax credit, or $(1+\gamma k)D$.[16]

A plausible range for the equilibrium payment to the stock lender is between 5 and 7.143. In fact, the only equilibrium without arbitrage is one where

- $\gamma = 1$, that is, an investor borrowing the stock across the ex-day must pay the gross dividend, $(1+k)D = 7.143$, to the lender of the stock.
- the stock price on the ex-day must be expected to fall by the gross dividend, that is, $P_0 - E[P_1] = (1+k)D$.
- the tax-exempt investor always lends or sells the stock cum-dividend to the German investor, receiving or buying it back ex-dividend.

To verify that this is an equilibrium, first consider the tax-exempt investor. The tax-exempt investor has three alternatives: hold the stock across the ex-date, lend the stock, and sell cum-dividend and repurchase ex-dividend. As long as $\gamma > 0$, he prefers lending the stock, earning $(1+\gamma k)D$, to simply holding the stock, earning D. The sale cum-dividend and repurchase

[15] A swap could be used to achieve the same result as a stock loan.

[16] Generally a stock borrower (for example a short-seller) is responsible for making dividend payments to the lender of shares. However, the term “dividend payment” is ambiguous when there is a dividend tax credit. A taxable German lender of the shares who is a long-term holder of the stock would clearly require that the short-seller make a payment of the dividend plus the tax credit, or $D(1+k)$. A non-German lender—who does not receive the tax credit—would require at least the net dividend, D.

ex-dividend on average earns $P_0 - E[P_1]$. The tax-exempt investor will be indifferent between the stock loan and sale/repurchase strategies as long as

$$P_0 - E[P_1] = (1 + \gamma k)D. \tag{1}$$

In order to see that $\gamma = 1$, consider the German institutional investor, who can undertake a dividend capture strategy by borrowing the stock using a stock loan with payment $(1 + \gamma k)D$. The return to this is

$$\big[(1 + k)D - (1 + \gamma k)D\big](1 - \tau) = k(1 - \gamma)(1 - \tau)D.$$

If $\gamma < 1$, the German investor earns positive profits, while if $\gamma > 1$, he has a loss. The German investor will break even only if $\gamma = 1$, that is, the stock loan calls for paying the gross dividend, $(1+k)D$, to the stock lender.[17] Equation (1) then implies that the stock price drops on the ex-dividend day by $(1 + k)D$.

Since receipt of the tax credit requires physical possession of the shares, equilibrium necessarily involves a temporary transfer of shares to German investors at the time of the dividend.

This simple example provides a useful benchmark: despite investor heterogeneity with respect to the pretax value of the dividend, the ex-day price drop and derivatives prices should reflect the full amount of the gross dividend.

The empirical prediction in this setting is that a regression of the ex-dividend-day price drop on the dividend would have a slope of $1 + k$ and a zero intercept.

In practice there are three complications to this analysis: investors are heterogeneous with respect to the relative taxation of dividends and capital gains, there are transaction costs, and there are institutional restrictions to limit tax credit arbitrage. We now consider these effects.

2.2 No-arbitrage conditions with different investor classes

We first consider the role of tax rate heterogeneity and transaction costs. As in studies of the ex-dividend day, we seek an equilibrium in which trading decisions of various classes of investor (individuals, corporations,and broker-dealers) are consistent with the expected ex-day price drop.[18] I follow the Kalay (1982) and Boyd and Jagannathan (1994) costly arbitrage frameworks in deriving conditions under which different classes of investor do not have explicit arbitrage opportunities from either buying the stock cum-dividend and selling it ex-dividend (long arbitrage), or shorting cum-dividend and closing the short position ex-dividend (short arbitrage).

[17] Since the stock loan is equivalent to a sale and forward purchase of the stock, the forward price should reflect the dividend in the same way as the stock loan. We elaborate below on the pricing of forward contracts.

[18] For a review of this literature see Allen and Michaely (1995).

All investor classes also may accelerate or decelerate planned transactions in order to capture or avoid the dividend. We will refer to this as "implicit arbitrage."

In addition to modeling more complicated heterogeneity, I also extend previous analysis by explicitly considering the role of stock loans (essentially a sale coupled with a forward repurchase) as an alternative to buying or selling shares in the market.

As before, the net dividend is D, the gross dividend is $D(1+k)$, and a stock borrower pays the lender $D(1+\gamma k)$. Every purchase or sale of stock entails paying a tax-deductible cost of c per share. The cost of a stock loan is c_b, which we assume is borne by the borrower.[19] Consider transactions at time 0, cum-dividend, and at time 1, ex-dividend, with the expected time 1 share price, conditional on time 0 information, denoted $E[P_1]$. We assume this time is short so interest is ignored. The fraction of the credit received by a shareholder is ϵ (for German investors $\epsilon = 1$ and for foreign investors $\epsilon = 0$). Let τ_c denote the capital gains tax rate, τ_d the tax rate on dividend income, and ω the withholding tax rate. To avoid notational complications I assume that only the dividend net of withholding is taxable.[20] The goal is to create one expression which can be specialized to account for different cases.

2.2.1 General analysis. Consider first "long arbitrage": purchasing shares cum-dividend and selling ex-dividend. The shareholder pays $P_0 + c$ and receives gross proceeds of $P_1 - c$ upon sale. The after-tax capital gain is

$$P_1 - c - (P_0 + c) - \tau_c((P_1 - c) - (P_0 + c)) = (P_1 - P_0 - 2c)(1 - \tau_c).$$

The total expected after-tax return (dividend plus expected capital gain) is therefore

$$(E[P_1] - P_0 - 2c)(1 - \tau_c) + D(1 + \epsilon k)(1 - \tau_d). \tag{2}$$

This is nonpositive as long as

$$P_0 - E[P_1] \geq D(1 + \epsilon k)\frac{1 - \tau_d}{1 - \tau_c} - 2c. \tag{3}$$

Similarly, we can examine "short arbitrage," in which shares are borrowed cum-dividend and returned ex-dividend. A short seller, who must pay

[19] In this context, foreigners and German firms are natural counterparties, seeking to trade with each other. Costs should be largely administrative and small compared to the costs of an outright sale and repurchase of stock.

[20] In the examples we consider, investors will pay either withholding or the dividend tax, so this assumption makes no difference.

the lender the fraction γ of the dividend tax credit, receives $P_0 - c$ at the inception of the short position, and has an expected return of

$$(P_0 - E[P_1] - 2c)(1 - \tau_c) - D(1 + \gamma k)(1 - \tau_d). \tag{4}$$

This is nonpositive as long as

$$P_0 - E[P_1] \leq D(1 + \gamma k)\frac{1 - \tau_d}{1 - \tau_c} + 2c. \tag{5}$$

Requiring Equations (3) and (5) to both be satisfied gives[21]

$$D(1 + \epsilon k)\frac{1 - \tau_d}{1 - \tau_c} - 2c \leq P_0 - E[P_1] \leq D(1 + \gamma k)\frac{1 - \tau_d}{1 - \tau_c} + 2c. \tag{6}$$

In the analysis that follows I specialize this expression for different classes of shareholder.

2.2.2 Fully taxable German investors. Both individual short-term and corporate German shareholders, as well as German broker-dealers, receive the tax credit ($\epsilon = 1$), receive full credit for withholding ($\omega = 0$), and are taxed at the same rate on dividends and capital gains ($\tau_d = \tau_c$). Imposing these assumptions on Equation (6) results in the following no-arbitrage condition:

$$D(1 + k) - 2c \leq P_0 - E[P_1] \leq D(1 + \gamma k) + 2c. \tag{7}$$

Note that because $\tau_d = \tau_c$, the absolute level of tax rates is irrelevant.

There are also conditions governing the desirability of borrowing stock. First, profit from the stock loan must be positive:

$$(1 + k)D > (1 + \gamma k)D + c_b. \tag{8}$$

Second, the stock loan must be compared to buying shares cum-dividend and selling ex-dividend. The cost of a purchase/resale strategy is $-P_0 + E[P_1] - 2c$, while the cost of borrowing stock is $-(1+\gamma k)D - c_b$. The German

[21] When the holding period is long enough that interest is nonnegligible, the counterpart to Equation (6) is

$$\begin{aligned} &FV_P[D](1 + \epsilon k)\frac{1 - \tau_d}{1 - \tau_c} - c\left(2 + r_{0,t}\frac{1 - \tau_i}{1 - \tau_c}\right) \\ &\leq P_0 - E[P_t] \leq FV_P[D](1 + \gamma k)\frac{1 - \tau_d}{1 - \tau_c} + c\left(2 + r_{0,t}\frac{1 - \tau_i}{1 - \tau_c}\right), \end{aligned}$$

where $r_{0,t}$ is the interest rate between time 0 and t, τ_i is the tax rate on interest, and $FV_P[D]$ is the future value of the dividend.

broker will prefer borrowing stock to a market transaction if

$$-P_0 + E[P_1] - 2c < -(1 + \gamma k)D - c_b$$

or

$$P_0 - E[P_1] > (1 + \gamma k)D - (2c - c_b). \tag{9}$$

Equation (9) can be satisfied—stock loans can be profitable for a German broker—even when market transactions in either direction are not profitable.

Finally, German brokers already planning to buy or sell the stock can perform implicit arbitrage, capturing the dividend by accelerating the purchase or decelerating the sale. They will do so if

$$-P_0 - c + D(1 + k) > -E\left[P_1\right] - c$$

or

$$D(1 + k) > P_0 - E\left[P_1\right]. \tag{10}$$

If the inequality is reversed, they will avoid the dividend.

2.2.3 German long-term shareholders. Long-term German shareholders, defined as individual investors holding the share at least 6 months, receive the tax credit and are taxed on the dividend but not on capital gains. By virtue of the 6-month holding period, the significant decision for this class of investors probably concerns implicit arbitrage: whether to trade the stock cum- or ex-dividend when it is bought or sold. Transaction costs are irrelevant, as they will be paid in either event.

Investors time the purchase to avoid the dividend if the cost of buying cum-dividend is higher than the cost of buying ex-dividend:

$$-P_0 - c + D(1 + k)(1 - \tau_d) < -E[P_1] - c.$$

Hence the individual trader will trade so as to avoid the dividend as long as

$$P_0 - E[P_1] > D(1 + k)(1 - \tau_d). \tag{11}$$

If the inequality is reversed, the investor will trade to capture the dividend. Notice that because capital gains are not taxed, the dividend tax rate enters in Equation (11). In Equation (7), by contrast, the absolute level of tax rates is irrelevant because capital gains and dividends are taxed at the same rate.

Individual investors are in different tax brackets. Since some long-term investors will want to capture the dividend and others avoid it, only the *net* trading of these individuals must be absorbed by other investor classes. Suppose traders in all tax brackets are equally likely to trade, and that τ_d^* is the tax rate of the median (with respect to shareholdings) long-term investor. Suppose the expected price drop is given by

$$P_0 - E[P_1] = D(1+k)(1-\tau_d^*). \tag{12}$$

Because τ_d^* is the median tax rate, Equation (12) tells us the price drop at which the quantity of stock being sold by dividend avoiders is equal to the quantity of stock purchased by dividend capturers. If the price drop is greater than that given by Equation (12), net transactions by long-term investors will reflect dividend avoidance.

As an empirical matter, it is likely that German long-term shareholders on average trade to avoid dividends. Since 1994, $k = \frac{.3}{1-.3}$; before that, $k = \frac{.36}{1-.36}$. Top individual marginal rates are 53% for single taxpayers, reached at an income of DM 120,000, and 47% for married couples, reached at an income of DM 200,000 [Ernst & Young (1991, Appendix 4) and Kniep (1997)]. As long as $\tau_d^* > .3$ (.36 before 1994), an expected price drop $\geq D$ will result in net dividend avoidance by long-term investors. Since low-marginal-tax individuals are less likely to own stock than high-marginal-tax individuals, and undoubtedly less likely to consider sophisticated trading strategies, it seems likely that $\tau_d^* > .3$, in which case long-term individual investors as a class will trade to avoid the dividend.

As the expected price drop increases, τ_d^* decreases. Suppose the expected price drop reflects half of the tax credit, that is, $P_0 - E[P_1] = D(1 + .5k)$. Then the individual tax rate at which Equation (12) is satisfied would be $1 - (1 + .5k)/(1 + k)$. For $k = .4286$, this equals 15%; for $k = .5625$, this equals 18%. It is hard to imagine a scenario where the median transacting *taxable* long-term shareholder is not in a tax bracket greater than this, in which case net trades would reflect dividend avoidance.

Shareholders in this category do not benefit by lending their stock, which generates taxable income equal to $(1 + \gamma k)D$, less than the $(1 + k)D$ they receive if they do not lend.

2.2.4 Foreign broker-dealers. U.S. and other broker-dealers do not receive the tax credit ($\epsilon = 0$), are taxed identically on dividends and capital gains ($\tau_c = \tau_d$), can deduct losses, and can receive a refund for withholding ($\omega = 0$). As a result, the no-arbitrage condition for U.S. broker dealers is exactly like Equation (7), except that the tax credit vanishes from the long arbitrage expression:

$$D - 2c \leq P_0 - E[P_1] \leq D(1 + \gamma k) + 2c. \tag{13}$$

Equation (13) also applies to German tax-exempts. Foreign broker-dealers do not receive the credit and hence would never borrow stock if $\gamma \geq 0$.

2.2.5 Foreign tax-exempt investors. Foreign tax-exempt investors do not receive the tax credit and typically are also subject to withholding tax on dividends. Since they are not taxed, there is no mechanism (such as the foreign tax credit) for them to receive a rebate of the withheld amount. Let ω denote the withholding tax rate. Then for foreign tax-exempt investors the no-arbitrage condition for market transactions is

$$D(1-\omega) - 2c \leq P_0 - E[P_1] \leq D(1+\gamma k) + 2c. \tag{14}$$

The no-short-arbitrage condition, given by the right-hand inequality in Equation (14), is also the condition determining whether tax-exempts prefer a stock loan or a sale/repurchase strategy. The return on the sale/repurchase strategy is $P_0 - E[P_1] - 2c$, and that of the stock loan is $D(1+\gamma k)$.[22] A long-term holder will lend stock if the return from lending exceeds that from the sale/repurchase strategy, or

$$P_0 - E[P_1] < (1+\gamma k)D + 2c. \tag{15}$$

The condition for there to be no short arbitrage, the right-hand inequality in Equation (14), is the same as the condition for the tax-exempt to prefer a stock loan to a sale and repurchase. As long as $\gamma > 0$, the stock loan is preferable to simply holding the stock across the ex-day.

Foreign investors planning to purchase the stock already can also perform implicit arbitrage. If a foreign investor buys cum-dividend, they can then lend the stock and earn $(1+\gamma k)D$. The foreign investor will wish to accelerate a purchase to capture the dividend if

$$-P_0 - c + (1+\gamma k)D > -E[P_1] - c$$

or

$$(1+\gamma k)D > P_0 - E[P_1]. \tag{16}$$

If the inequality is reversed, the foreign investor will trade so as to avoid the dividend.

2.2.6 Foreign long-term individual shareholders. As discussed above, foreign long-term taxable investors who are not broker-dealers are typically taxed more heavily on dividends than on capital gains, so that $\frac{1-\tau_d}{1-\tau_c} < 1$. The withholding tax is creditable, hence $\omega = 0$. As with long-term German shareholders, it is plausible that the main strategy for these investors is delay

[22] It is assumed that stock borrowers pay all transaction costs.

or acceleration of a transaction. This entails comparing the after-tax dividend to the after-tax capital gain. A shareholder would avoid the dividend if

$$P_0 - E[P_1] > D\frac{1-\tau_d}{1-\tau_c}. \tag{17}$$

Since we expect $\frac{1-\tau_d}{1-\tau_c} < 1$, foreign individuals avoid the dividend if the price drop exceeds the net dividend. Foreign long-term investors in this class, such as mutual funds, might benefit from lending stock, since, depending on relative tax rates, it is possible that Equation (17) holds so that dividends should be avoided, yet $D(1+\gamma k)\frac{1-\tau_d}{1-\tau_c} > P_0 - E[P_1]$, so that a stock loan is profitable.

2.3 Equilibrium

The interaction of the investor classes analyzed above determines the ex-day behavior of German stocks. Fully taxable German investors are always the most efficient participants in long arbitrage, since they receive the tax credit and can fully deduct capital losses. With short arbitrage, by contrast, all investors face the same costs of short-selling. Thus if explicit arbitrage is profitable for any investor class, it will be profitable for fully taxable German investors.

We assume that equilibrium is characterized by German brokers earning zero profits on market transactions and stock loans. The quantity of tax credit arbitrage on a given ex-day is limited to the quantity of stock held by foreign investors, plus net selling by German long-term investors. However, the capital available to fund arbitrage is potentially great, and capital can be deployed sequentially as different stocks go ex-dividend on different days. Competition will lead German professional arbitrageurs to break even.

When dividends are small relative to transaction costs, explicit arbitrage can become unprofitable. In this case we consider the effect of implicit arbitrage transactions, that is, acceleration or delay of planned purchases and sales to capture or avoid the dividend.

In characterizing equilibrium, we first consider market transactions, in which stock is explicitly purchased and sold, then stock loans.

2.3.1 Market transactions. The previous section derived restrictions on the dividend and expected ex-day price drop such that explicit arbitrage is not profitable. Figure 2 summarizes these no-arbitrage restrictions for the different investor classes,[23] plotting the expected percentage price drop on the ex-day against the dividend yield. An upward movement on the diagram represents an increase in the ex-day price drop for a given dividend yield,

[23] Since foreign individual investors are economically similar to German individual investors, there is no separate line for them.

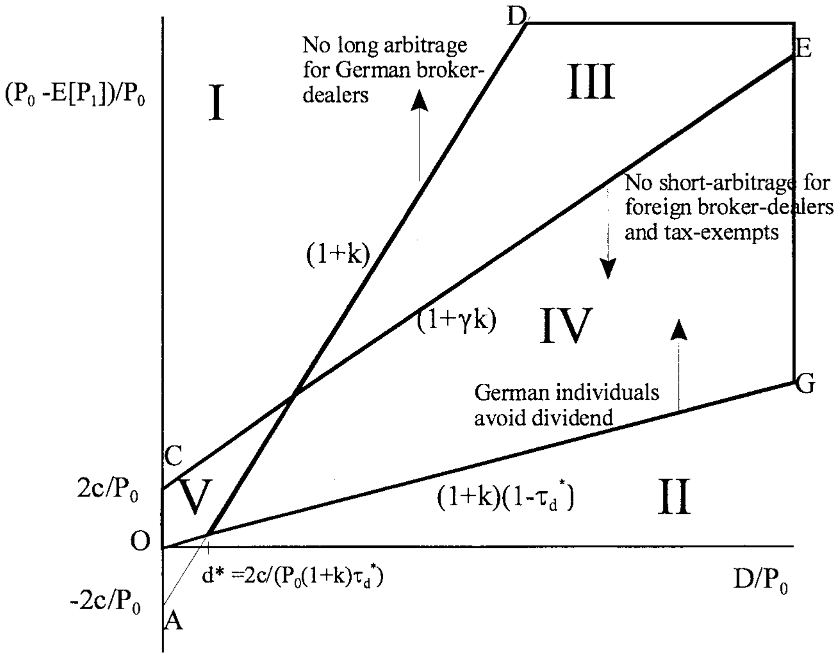

Figure 2
Depiction of no-arbitrage regions for different investor classes
In region I, all investors wish to avoid the dividend. In region II, all investors wish to capture the dividend. In region III, all investors wish to short the stock. In region IV, short selling is not profitable, but German individuals sell cum-dividend to German brokers. In region V, German individuals seek to avoid the dividend, but dividend capture is unprofitable. d^* is the dividend yield above which German broker-dealers find it profitable to buy from dividend-avoiding German individuals.

hence it is associated with a lower profit from long arbitrage and increased profit from short arbitrage. Similarly, a downward movement in the diagram represents decreased profit for long arbitrage and increased profit from short arbitrage. The figure is drawn taking γ as given; in equilibrium, different stocks may have different short-sale costs, an issue that we return to in discussing stock loans.

Line AD depicts the long-arbitrage indifference condition for German brokers, the left-hand inequality in Equation (7). Above this line, dividend capture is unprofitable. Line OG is the aggregate no-trade condition for German long-term individual investors, given by Equation (12). Above this line, long-term German investors as a class trade to avoid the dividend, selling cum-dividend and buying ex-dividend. Finally, line CE is the short-sale indifference condition for German brokers, foreign brokers, and foreign tax-exempts, the right-hand inequality from Equations (7), (13), and (14). Below this line it is not worthwhile for these investors to short sell, given that $(1 + \gamma k)D$ is the borrowing cost of the stock. The lines described by

Equations (10) and (16), which characterize trade acceleration or deceleration by German brokers and foreign tax-exempt investors, are omitted from Figure 2 and will be introduced later.

Dividend yield–price drop pairs in regions I, II, III, and V give rise to one-sided markets or arbitrage opportunities and hence should not occur. In region I, dividend capture is unprofitable for all investors. In region II, all investors wish to capture the dividend. In region III, the payment on borrowed stock, $(1 + \gamma k)D$ is low enough that all investors wish to borrow the stock and sell to German brokers engaging in long arbitrage. In region V, German individuals sell to avoid the dividend, but dividend capture by German brokers is unprofitable.

Profitable trade can occur in region IV. There, German individuals sell cum-dividend to German brokers. The incentive in this region for German brokers to trade with German individuals is inescapable, since it is due to differences in taxation of the two groups. The quantity of this arbitrage is limited to the extent that there is a net sale of stocks by long-term individual German shareholders.

Below the dividend yield, $d^* = \frac{2c}{P_0(1+k)\tau_d^*}$ (at which AD and OG intersect), German brokers will find it unprofitable to buy shares from German long-term investors. The characteristics of the latter group are unobservable and can change over time, hence d^* may change over time. To develop a sense for the magnitude of d^*, suppose the one-way transaction cost, $c/P_0 = .3\%$ and $\tau_d^* = .4$. Then $d^* = 1.05\%$.

2.3.2 Stock loans. Figure 3 summarizes the market for stock loans. Above line CE, stock lenders will find a sale/repurchase strategy around the dividend more profitable than a stock loan [Equation (15)]. Below line BF, stock borrowers will prefer a purchase/resale strategy [Equation (9)]. Below the dividend yield d^{**}, Equation (8) is violated and stock loans are unprofitable for the borrower. Thus stock loans can occur in the shaded region. As mentioned earlier, long-term German investors would never lend their shares.

The plausible parameter restriction implicit in Figure 3 is that $c_b < 4c$, that is, the cost of a stock loan is less than twice the round-trip transaction cost on the stock. This ensures that a stock loan has lower total transaction costs than arbitrage using market transactions (which requires a round-trip transaction from two participants).

Note that, for a given dividend yield, there is a range of expected price drops for which stock loans can occur. The stock loan market by itself therefore does not "tie down" the expected price drop.

2.3.3 Equilibrium ex-day price behavior. Figure 4 depicts lines AD and BF from Figures 2 and 3. (Other lines, characterizing conditions for implicit arbitrage, will be discussed below.)

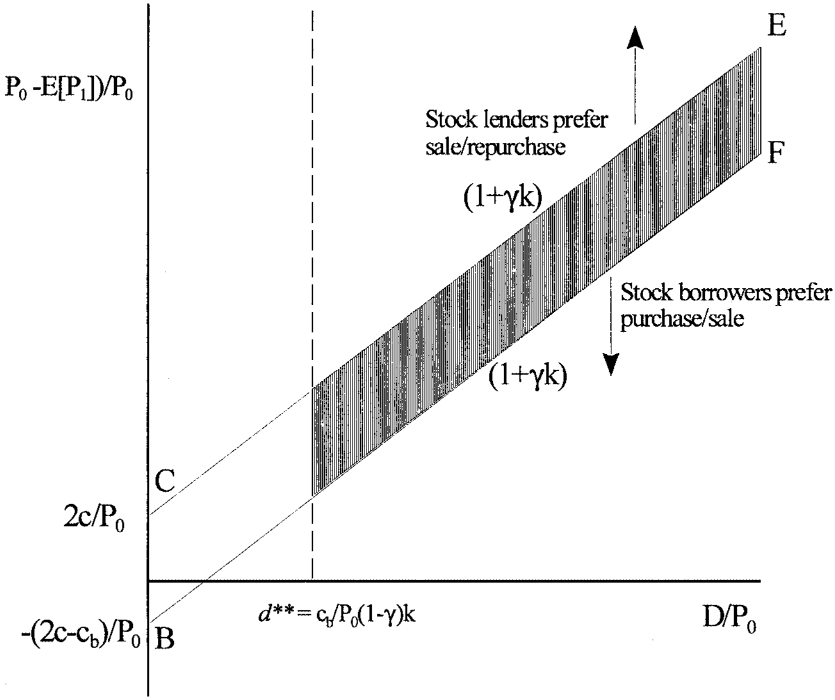

Figure 3
Depiction of region in which it is profitable for foreigners to lend stock to Germans
Below d^{**}, the loan is not profitable [Equation (8) is not satisfied]. Above d^{**}, in the shaded region, both Equations (9) and (15) are satisfied, and both stock lenders and borrowers earn positive profits on the transaction.

The assumption that German brokers break even on stock loans enables us to characterize γ. Suppose that the dividend is "large" relative to transaction costs. Profit on a stock loan is given by

$$(1+k)D - (1+\gamma k)D - c_b.$$

This implies that stock loans have zero profit if

$$\gamma = \frac{kD - c_b}{kD}. \tag{18}$$

At this γ, the intersection of lines AD and BF (point Q) occurs at the current dividend yield, d_0.[24]

[24] The equation for line BF is

$$P_0 - E[P_1] = -(2c - c_b) + (1+\gamma k)D.$$

Substituting Equation (18) for γ gives

$$P_0 - E[P_1] = -2c + (1+k)D,$$

which is the equation for line AD.

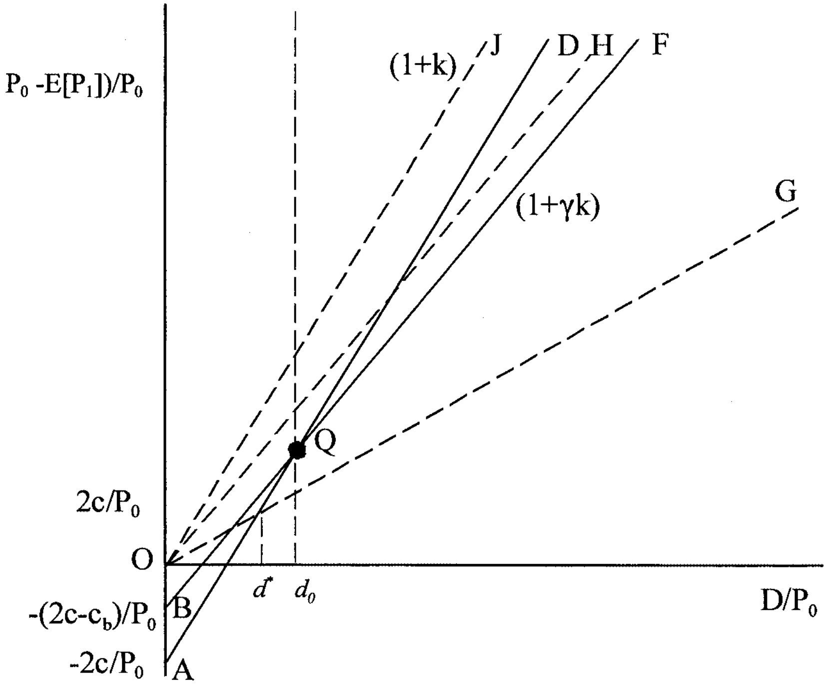

Figure 4
Zero-profit equilibrium for German investors
For a dividend yield of d_0, Q represents the point at which German brokers earn zero profit on market transactions (line AD) and also earn zero profit on stock loans (line BF). The dashed lines, OJ (with slope $1+k$), OH (with slope $1+\gamma k$), and OG [with slope $(1+k)(1-\tau_d^*)$], represent price drop/dividend yield pairs at which German brokers, foreign tax-exempts, and German long-term investors, respectively, are indifferent about accelerating purchases or sales of stock to capture dividends.

German brokers therefore earn zero profit on both market transactions and stock loans if price-drop/dividend pairs lie on line AD, with γ adjusting endogenously according to Equation (18). As the dividend increases, γ increases as well, in such a way that lines AD and BF intersect at the higher dividend; point Q slides up line AD in order to maintain the zero-profit condition for both market and stock loan transactions. Points below AD generate positive arbitrage profits for German brokers and hence are ruled out.

Figure 4 also displays indifference lines for implicit arbitrage: lines OH [Equation (16) for foreign investors] and OJ [Equation (10) for German brokers]. Between these lines, foreign tax-exempt investors will trade to avoid the dividend (above line OH) and fully taxable German investors will trade to capture the dividend (below line OJ).

Point Q lies between lines OJ and OG, therefore implicit arbitrage can occur along line AD. As long as the volume of implicit arbitrage is small

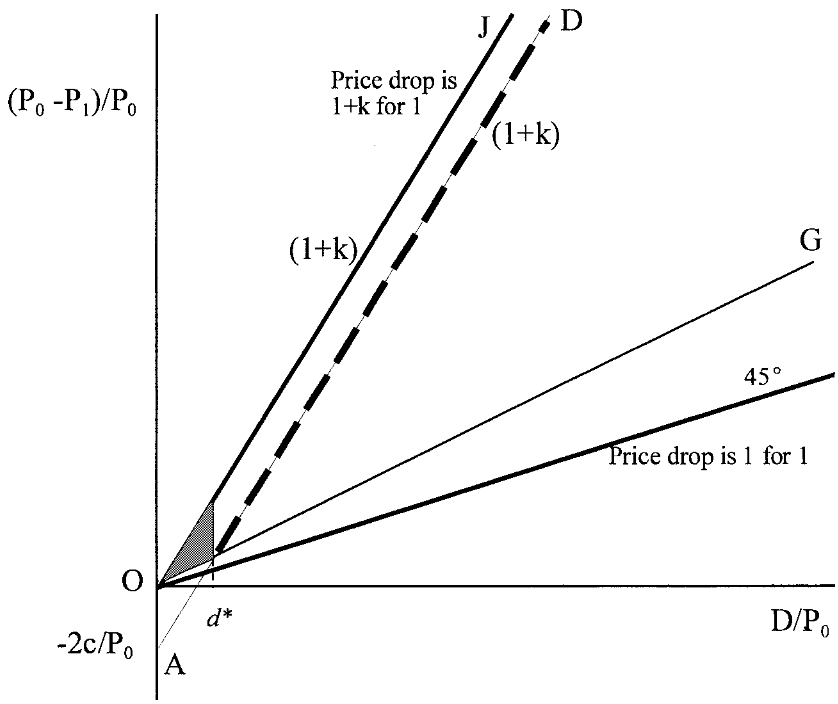

Figure 5
Depiction of equilibrium when γ is endogenized
At very low dividend yields, profits from explicit dividend capture are less than transaction costs and equilibrium is determined by acceleration/deceleration of purchases and sales in order to capture dividends. Possible dividend yield/price drop pairs are denoted by the shaded region. At dividend yields above d^*, dividend capture leads to points on the heavy dashed line, with γ increasing endogenously at higher dividend yields.

relative to other transactions,[25] the dividend/price-drop relationship should nevertheless lie on AD.

If the dividend is "small," transaction costs may make explicit arbitrage unprofitable. Below d^*, arbitrage transactions represented by line AD become unprofitable and only implicit arbitrage transactions occur in the market. In this case the region between lines OG and OJ and below d^* represents possible dividend/price-drop pairs. Stock loans may still occur in this region, however, these have no effect on observed market transactions.

Figure 5 summarizes this discussion. For dividend yields above d^*, dividend/price-drop pairs should lie along line AD. This is depicted in Figure 5 by the heavy dashed line. For dividend yields below d^*, there is an indeterminacy: dividend/price-drop pairs should lie between OG and OJ.

[25] This means that acceleration of planned purchases by German fully taxable investors is less than the quantity of stock being sold by dividend avoiders. We discuss this assumption below.

The equilibrium price drop for low dividends could be anywhere in the shaded region in Figure 5.[26]

2.3.4 Summary of equilibrium. Here is a summary of key features of the equilibrium as described in Figure 5:

- For dividends larger than d^* (which is plausibly around 1%), the average stock price drop is more than 1 for a DM 1 net dividend, but less than $1 + k$. The marginal price drop is $1 + k$.
- For dividends smaller than d^*, the stock price drop is indeterminate within a range.
- Above d^*, German brokers engage in dividend capture transactions in the market.
- The fraction of the tax credit paid to stock lenders, γ, is increasing with the dividend yield.
- Foreign investors who already own German stock prefer lending stock to selling/repurchasing to avoid the dividend; however, in either case they earn positive profits compared to simply holding the stock.
- Foreign investors who are planning to buy or sell German stock for reasons unrelated to the credit may time their purchase or sale to capture the dividend and lend the stock.

This particular equilibrium relies on several assumptions. First, we have assumed that zero economic profits are earned by arbitrageurs. One could imagine alternative equilibria in which German brokers have market power, earning positive profits. If the profit per transaction were a fixed dollar amount, it would play the role of an extra transaction cost, and the marginal price drop would continue to be $1 + k$. If the profit per transaction were a fixed percentage of the dividend, then line AD would be less steep than $1+k$. Otherwise the general character of the equilibrium should be the same.

Second, we assumed that when the dividend exceeds d^*, the expected price drop is determined by the zero-arbitrage condition, line AD, not by the implicit arbitrage breakeven condition, line OJ. It seems empirically plausible that implicit arbitrage would be relatively unimportant.[27] However, even if implicit arbitrage were important, the character of the equilibrium would be similar to that depicted in Figure 5. Explicit arbitrage would eliminate points below line AD. Large amounts of dividend capture due to implicit arbitrage

[26] Figure 5 is drawn as if line OG has a slope greater than 1; this is not necessarily the case.

[27] In order for there to be implicit arbitrage, several conditions must be satisfied. First, the planned transaction must be close to an ex-dividend date, and must be occurring for reasons unrelated to the dividend. Second, the motive for trade must be such that the investor is willing to accept the risk arising from changing the timing of the transaction; that is, the investor must not require "immediacy." Third, the investor must be sophisticated enough to be aware of the implicit arbitrage. Whereas professional arbitrageurs are in the business of managing and absorbing the risk associated with arbitrage trades, most investors are not. And any attempt to hedge the price risk from implicit arbitrage would incur transaction costs, in which case the trade would no longer be implicit arbitrage.

could result in a dividend/price-drop pair between lines AD and OJ. This would still result in a price drop increasing with the dividend at roughly the rate $1 + k$, but the actual relationship could be nonlinear and time varying.

2.4 Derivatives and the tax credit

The impact of taxes on derivative prices in the absence of a tax credit was studied by Scholes (1976) and Cornell and French (1983), who showed that prices depend upon taxes when capital gains, dividends, and interest are taxed at different rates. Broker-dealers are taxed symmetrically on all forms of income, hence their fair price is independent of taxes. Since broker-dealers are likely to be marginal in most derivatives markets, it is plausible that taxes should not affect derivatives prices. Cornell (1985) shows empirically that taxes do not seem to affect the pricing of S&P 500 futures contracts.[28] Consistent with this, in practice and in textbooks, the standard formulas for forward and option prices are presented and used with no adjustment for taxes.

The imputation tax credit, however, represents a form of income. German broker-dealers receive the tax credit, are taxed symmetrically on all income, and can deduct losses. Hence if they are the marginal investor, any derivatives price should embed the gross dividend but reflect no other tax considerations.

We will analyze this by considering the pricing of a stock index futures contract. Since prices of both futures and options are determined by a delta-hedging argument, essentially the same argument works for options.

2.4.1 DAX index futures. The German DAX index is a "performance index," constructed assuming that *net* dividends are reinvested in the individual stock paying the dividend; the tax credit is ignored. Details on the construction of the index are in Appendix B.

In the absence of a dividend tax credit, a futures contract based on a performance index would have a price equal to the future value of the current index. Dividends would not affect the futures price. (With the S&P 500, by contrast, dividends are not reinvested in the index and hence are subtracted from the risk-free rate in calculating the futures price.) To see how the DAX futures are priced in the presence of a tax credit, I derive no-arbitrage bounds using standard cash and carry transactions in which one buys the index and shorts a futures contract, or the reverse.

Consider first a cash-and-carry, that is, borrowing to buy the index and shorting the futures contract. If the value of the performance index is P_0 at time 0, then at expiration, time t, it will be $P_t + FV_P[D]$, where $FV_P[D]$

[28] Scholes and Wolfson (1992), for example, assume this to be the case in some of their examples.

denotes the future value of the reinvested net dividends. Pretax returns on the short futures position at expiration are

$$F_{0,t} - (P_t + FV_P[D]). \tag{19}$$

Let τ_{bd} denote the broker-dealer tax rate, and $r_{0,t}$ the interest rate from time 0 to t. The return to a broker-dealer from buying the index and shorting the forward contract is obtained by adding Equations (2), modified to take account of interest since the carry period is longer, and Equation (19). It is assumed that the broker reinvests all dividends in the index. The no-arbitrage condition is that this profit be nonpositive, or

$$\begin{bmatrix} E[P_t] - P_0 - 2c + FV_P[D](1 + \epsilon k) - r_{0,t}(P_0 + c) \\ + F_{0,t} - (P_t + FV_P[D]) \end{bmatrix} (1 - \tau_{bd}) \leq 0. \tag{20}$$

From Equation (20), the ability of a broker-dealer to profit from a cash-and-carry is independent of the tax rate.

The no-arbitrage condition for a reverse cash-and-carry is obtained by requiring that Equation (4) minus Equation (19) be nonpositive:

$$\begin{bmatrix} P_0 - E[P_t] - 2c - FV_P[D](1 + \gamma_{Index} k) + r_{0,t}(P_0 - c) \\ - F_{0,t} + (P_t + FV_P[D]) \end{bmatrix} (1 - \tau_{bd}) \leq 0. \tag{21}$$

The no-arbitrage bound for the futures price is obtained by combining Equations (20) and (21):

$$\begin{aligned} FV_P[D]\varepsilon k - c(2 + r_{0,t}) \leq\ & P_0(1 + r_{0,t}) - F \\ & \leq FV_P[D]\gamma k + c(2 + r_{0,t}). \end{aligned} \tag{22}$$

Equation (22) looks similar to Equations (7) and (13). This is not surprising, since a stock loan is equivalent to a sale and forward purchase. As before, the no-arbitrage bounds are wider for non-Germans. German brokers, for whom $\varepsilon = 1$, are the most efficient at long arbitrage, while all broker-dealers have the same opportunity for short arbitrage.

2.5 Tax risk

The preceding discussion has assumed that there are no restrictions against tax-credit trading. In practice, German authorities are concerned with preventing the sale of tax credits to foreigners. The specific effects of these restrictions, mentioned in Section 1.3, are not easy to characterize since firms may try to avoid detection of transactions they believe will be challenged, and tax authorities have leeway to challenge transactions deemed particularly abusive. It is also hard to know how rules are likely to be applied in the absence of specific details. Issues related to detection include

- Firms can hold shares in Germany and hedge offshore.
- Even when all legs of a transaction are undertaken domestically, proving that the different legs of a hedged position are in fact part of one position can be difficult.
- Transactions with foreigners accomplished on an exchange are hard to trace.

There appear to be no restrictions that would prevent firms from engaging in dividend capture on the open market, and it seems likely that the hedging restriction of §50 is at a minimum difficult to enforce.[29]

If the tax restrictions are binding with some probability, they reduce the probability that an arbitrageur will obtain the full credit. Thus stock and derivative prices will reflect less than the full credit. In general, the reduction in return is linked to the magnitude of the dividend, so it seems a reasonable approximation to say that the tax rules should reduce the expected tax credit for a firm engaging in tax credit arbitrage.[30]

3. Data

3.1 Data and sources

German stock prices, net dividends, futures, and options price data were obtained from Datastream, and information on the tax credit from Bloomberg. Most data were collected for the period from January 1989 to February 1998. The first year for which Bloomberg reports dividend information on German stocks is 1989. Here are precise data definitions:

Stock price. Daily closing price, in DM, adjusted for splits, from Datastream. There were ticker symbols for 356 German stocks contained in the DAX composite index, trading on the Frankfurt Stock Exchange. Based on inclusion at some point between 1989 and 1998 in the DAX index (composed at any one time of 30 stocks), we grouped observations into the "DAX 30" and all remaining stocks. Bid and offer prices were also obtained for the DAX stocks for the period November 1996 (the first available date) to February 1999.

Volume. Trading volume for the DAX stocks, from 1989 to 1998.

Dividend. Net dividend payments, adjusted for splits, from Datastream.

[29] For a US parallel, consider the requirement that in order to receive the dividend-received deduction (DRD), US firms must not have hedged their stock-holdings. Suppose a corporation buys 29 of the 30 stocks in the MMI or Dow index, shorts the appropriate index futures contract, and claims the DRD. Since the 29 stocks are not *exactly* the same as the index, the corporation can argue that the position has not been hedged. This transaction reportedly occurs.

[30] While writing this article I spoke with participants in the tax credit trading market, all of whom requested anonymity. Their feeling was that being identified would increase official scrutiny, with adverse tax or regulatory consequences.

Gross dividends. Gross dividend payment, adjusted for splits, from Bloomberg. German firms pay dividends annually. The vast majority of dividends in the sample include the tax credit. Among the 245 DAX 30 observations, 6 were for a dividend that did not include the tax credit; of the remaining 1950 observations, 16 did not include the tax credit.

Option prices. The last traded price of American-style stock options, traded on the Deutsche Terminborse (DTB), from Datastream. "Last traded price" means the last trade if it occurred within the final hour of trading, otherwise it is a settlement price determined by the exchange.[31] Datastream had no option price data prior to April 1997.

Futures. Daily settlement prices for the DAX 30 futures contract. Expiration months are March, June, September, and December. The DAX 30 index is a market capitalization-weighted "performance index," which means that it is designed to reflect total returns, including dividends, from holding the index; thus in constructing the index it is assumed that dividends are reinvested as they are paid.

DAX 30 dividend. The dividend yield reported by Datastream is an annual average; in order to compute the futures price it is necessary to know the exact dates on which dividends are payable on the cash index. To compute dividends paid on the index over specific periods we reconstructed the index using data on 29 of the 30 stocks.[32] Details of the index construction are covered in the appendix.

Market return. The return on the composite DAX (CDAX) index, from Datastream, which is broad based, market weighted, and contains approximately 500 stocks.

3.2 Summary statistics

Table 1 shows the number of firms in the sample over time along with statistics on dividend yields. About one-third of the firms have a dividend yield between 2% and 4%. The dividend yield on the DAX index of 30 stocks decreases by half between 1992 and early 1998.

Dividend payments also exhibit seasonality. More than two-thirds of dividend payments in the sample occur in May, June, or July. The significance of this for regression analysis is that dividend payments will often decrease on the same day. To account for this, all ex-day returns are computed as excess returns, over and above the return on the Composite DAX (CDAX) index.

4. Evidence on Trading Around the Ex-Date

Theory suggests that German shares should change hands around the dividend ex-date. To the extent that market transactions are used to transfer

[31] This is the data description provided by a Datastream representative.

[32] Data were unavailable for Metallgesellschaft, which was in the index from September 1990 until November 1996.

Table 1
Summary statistics

Year	No. of firms	Percentage of firms with given dividend yield 0%	<2%	2–4%	>4%	Average yield (%) Sample	DAX 30
1990	261	7.28	50.96	35.25	6.51	1.99	2.27
1991	278	7.91	40.65	44.60	6.83	2.36	2.57
1992	289	11.76	30.80	45.33	12.11	2.54	2.61
1993	296	16.89	33.78	42.57	6.76	2.52	2.32
1994	304	20.07	36.18	35.86	7.89	2.61	1.89
1995	309	16.83	30.10	43.37	9.71	2.53	2.04
1996	319	19.12	26.33	41.69	12.85	2.68	1.88
1997	330	18.79	38.79	32.12	10.30	2.41	1.47

For the sample by year, showing number of firms in the sample, percentage of firms with a given dividend yield, average dividend yield of sample firms (this is the average dividend divided by the cum-dividend price for all dividend observations in a given year), and yearly average for the DAX 30 index. Dividend yield statistics are omitted for 1989 and 1998, which are only partial years in the sample. DAX dividend yields in those years were 2.44% (1989) and 1.31% (1998).

Table 2
Distribution of dividend payments by month

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Number	19	21	124	110	331	528	669	152	32	31	10	168
Percentage	0.87%	0.96%	5.65%	5.01%	15.08%	24.05%	30.48%	6.92%	1.46%	1.41%	0.46%	7.65%

shares, and purchases and sales are timed to either capture or avoid the dividend, we would expect to see abnormal volume around the ex-date. (Transfers of stock using derivatives would not be measurable using ordinary volume statistics.) In addition, since the incentive to trade the tax credit is greater for high dividend-yield stocks, we would expect greater volume around the ex-day for higher yield stocks. Both effects have been found in U.S. data by Lakonishok and Vermaelen (1986) and Michaely and Vila (1996).

4.1 Trading volume

Figure 6 depicts average normalized trading volume for the 33 DAX index stocks in the sample, computed as

$$v_t = \sum_{i=1}^{33} \frac{volume_{i,\hat{t}_i+t}}{\sum_{i=1}^{33}\sum_{t=-125}^{125} volume_{i,\hat{t}_i+t}} \qquad t = \{-125, 125\},$$

where $\hat{t}_i$ is the dividend ex-day for the ith stock and $volume_{i,\hat{t}_i+t}$ is daily trading volume for the ith stock, t days from the ex-dividend day. By definition the mean of this series is 1; the standard deviation is .1217. Trading volume from day -5 to the ex-day is greater than 1 at a 5% confidence level, as is trading on days -40 and -31.

To clarify the figure, specific values around the ex-day are reported in Table 3. Normalized volume is significantly greater than 1 for the 5 days preceding the dividend, along with the ex-day.

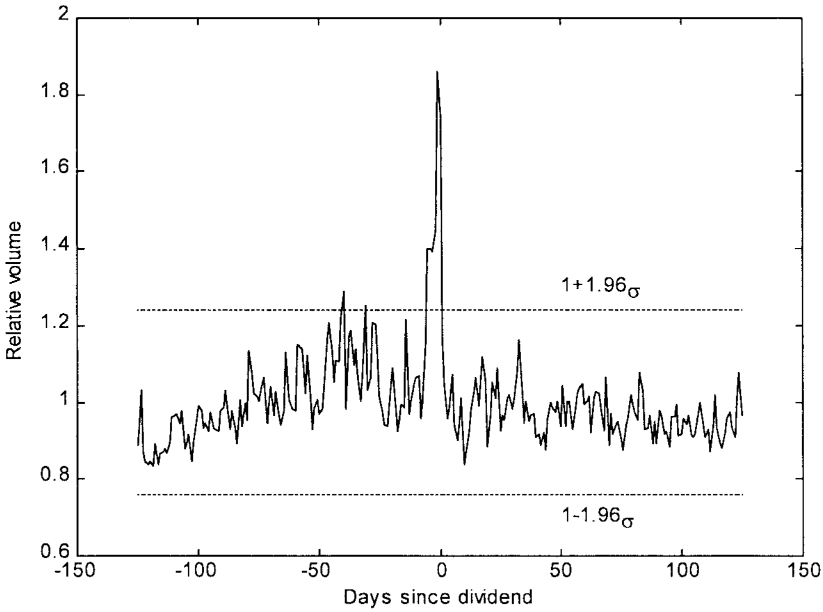

Figure 6
Average daily trading volume around the divident ex-date, divided by average trading volume over the 125 days before and after the ex-date, averaged across the DAX stocks
By definition, average volume over all observations is 1. Horizontal lines denote $1 \pm 1.96 \times \sigma$, where $\sigma = .1217$ is the standard deviation of average daily volume.

A simple test of the relationship between volume and dividend yield is to regress on the dividend yield the average daily volume over some window around the ex-day. Figure 6 suggests using a window of $\{-5, 1\}$ days around the ex-day.[33] Doing this using weighted least squares,[34] we obtain

$$\underset{}{Volume_{i,-5,1}} = \underset{(.1135)}{.7619} + \underset{(1.7539)}{21.7703} \times \frac{D_i}{P_{i,0}} \qquad R^2 = .3776. \tag{23}$$

The dividend yield coefficient implies that a 1 percentage point increase in the dividend yield raises average normalized volume over the 7-day period by .217, or 21.7% of average daily volume.

[33] The findings are similar if a different window around the ex-date is used. As would be expected, the more days are averaged in the volume variable, the lower the slope coefficient in Equation (23).

[34] Since stocks are likely to differ in the volatility of their volumes, the observations in Equation (23) were weighted by the annual volatility of volume. Ordinary OLS results were very similar.

Table 3
Average normalized trading volume and average buy ratio

Days since dividend ex-date	−4	−3	−2	−1	0	1	2	3	4	5
Average normalized trading volume	1.40	1.40	1.39	1.45	1.86	1.74	1.16	1.05	0.96	0.98
Average buy ratio	0.49	0.56	0.46	0.47	0.66	0.42	0.48	0.51	0.48	0.50

Data are for the DAX stocks, for 11 days around the ex-day (day 1 in the table). By construction, the mean of the trading volume series is 1; the standard error is .1217. Volume on days −4 through 1 is significantly greater than 1 at a 1% significance level. The mean of the buy ratio is .4989, with a standard error of .0553. The buy ratio is significantly greater than .5, at a 1% significance level, on day 0.

4.2 Bid and ask prices

Figure 6 demonstrates that there is abnormal trading around (principally before) the dividend, but this does not demonstrate whether the trading is initiated by investors wishing to capture the dividend or to avoid the dividend. We examine bid and ask prices to gain insights into this.

Bid and ask prices exist for 27 of the 30 DAX firms which paid 55 dividends between November 1996 and January 1999. Over this time, the average bid-ask spread as a fraction of the bid was 33 basis points. However, there is sporadically missing data for a number of the DAX firms and the average rises over time, probably reflecting inclusion of less liquid firms in the dataset. For the early part of the sample the average is 25 basis points; for the latter part of the sample, it is 40 basis points.

A measure of whether a transaction is initiated by the buy side or sell side is to see whether the transaction price is closer to the bid or ask. Define the buy ratio for firm i on date t as

$$Buy\ Ratio_{i,t} = \frac{Last\ traded\ price_{i,t} - Closing\ bid\ price_{i,t}}{Closing\ ask\ price_{i,t} - Closing\ bid\ price_{i,t}}.$$

Figure 7 displays the buy ratio for 55 dividend events, averaged across firms for each of the 125 days before and after a dividend payment.[35] The average of the buy ratio across all observations is .4989, with a standard deviation of .0553. Figure 7 and Table 3 show that on the day before the ex-day, the average was .6644, significantly greater than .5, and visibly higher than on any other day. On eight other days, none of which seem to have special significance, the buy ratio was also significantly different from .5.

These findings are consistent with buyer-initiated dividend capture trading just prior to the ex-date, suggesting that German brokers buy stock to engage in dividend capture.

[35] Several cases required special handling. In a few cases the last traded price was greater than the ask or lower than the bid. The average was significantly affected by these cases, so the ratio was set to 1 (last trade greater than ask) or 0 (last trade less than ask). None of these cases occurred on the last cum-dividend day. Also, for a few dates the bid was reported equal to the ask—these cases were treated as having no data available.

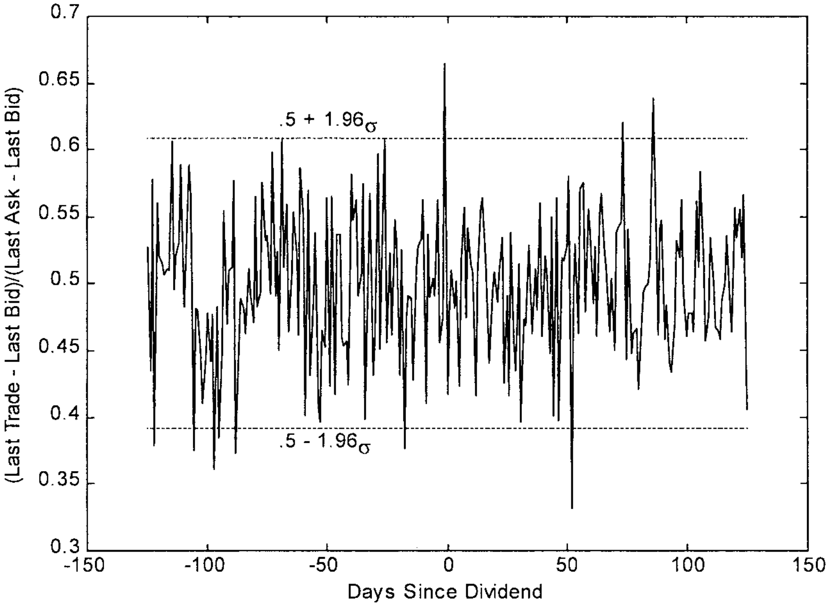

Figure 7
Average of last traded price minus bid price, relative to the bid-ask spread (the "buy ratio"), over the 250 days around the dividend
The sample contains 55 dividends for 27 of the DAX stocks. Horizontal lines denote $1 \pm 1.96 \times \sigma$, where $\sigma = .0553$ is the standard deviation of the average buy ratio.

5. The Market Valuation of the Tax Credit

We now examine the extent to which the tax credit is embedded in market prices of stocks, futures, and options.

5.1 Stocks

We analyze the ex-day behavior of stocks using a regression analysis as in Boyd and Jagannathan (1994), using the dividend yield, $\frac{D_{i,t}}{P_{i,t}}$, to explain the ex-day price drop, $\frac{P_{i,t}-P_{i,t+1}}{P_{i,t}}$. Since German company dividends are seasonal, there are some days in which more than one firm goes ex-dividend. On such a day, when the market rises, all ex-day firms will have smaller than expected price drops. To remove this correlation from common ex-days, we add to the ex-day price drop the return on the CDAX index from day t to $t+1$, $r_{t,t+1}^{CDAX}$. Thus, the basic regression equation is

$$\frac{P_{i,t} - P_{i,t+1}}{P_{i,t}} + r_{t,t+1}^{CDAX} = \alpha + \beta \frac{D_{i,t}}{P_{i,t}} + u_{i,t}. \quad (24)$$

The costly arbitrage theory discussed earlier makes specific predictions about α and β in Equation (24). Given the equilibrium depicted in Figure 5,

Table 4
OLS estimates for DAX 30 and non-DAX 30 stocks

		All observations		Price drop $\neq 0$			
	Window	α	β	α	β	No. of observations	R^2
DAX 30	1	−0.0056	1.2578			245	0.396
		(0.0025)	(0.0997)				
	5	−0.0114	1.4410			245	0.213
		(0.0045)	(0.1776)				
Non-DAX 30	1	−0.0055	0.9867			1950	0.313
		(0.0010)	(0.0331)				
	1			−0.0054	1.1504	1572	0.399
				(0.0011)	(0.0356)		
	2	−0.0071	1.1442			1950	0.284
		(0.0012)	(0.0411)				
	2			−0.0068	1.2427	1679	0.320
				(0.0013)	(0.0442)		
	3	−0.0075	1.2509			1950	0.259
		(0.0014)	(0.0479)				
	3			−0.0069	1.3132	1731	0.279
				(0.0015)	(0.0508)		
	4	−0.0076	1.2977			1950	0.224
		(0.0016)	(0.0547)				
	4			−0.0066	1.3427	1772	0.236
				(0.0017)	(0.0574)		
	5	−0.0068	1.2997			1950	0.201
		(0.0017)	(0.0588)				
	5			−0.0061	1.3368	1797	0.209
				(0.0018)	(0.0614)		

Estimates are of Equation (24): $\frac{P_{i,t}-P_{i,t+1}}{P_{i,t}} + r^{CDAX}_{t,t+1} = \alpha + \beta \frac{D_{i,t}}{P_{i,t}} + u_{i,t}$. Dependent variable is ex-day price drop plus ex-day return on the CDAX index; independent variable is dividend divided by cum-day stock price. Window is the number of days around the ex-day over which the price drop is measured, beginning on the last cum-dividend day. Estimates in columns labeled "Price drop $\neq$ 0" omit those observations for which the change in the stock price over the window is zero. Standard errors are in parentheses.

we expect that, for a sufficiently large dividend yield, $\alpha < 0$, with α equal to twice proportional transaction costs. The slope coefficient, β, should equal $1+k$ if dividend capture arbitrage is unrestricted, and could be lower if such transactions entail tax risk.

5.1.1 Basic results. Table 4 reports the results of estimating Equation (24) for stocks which at some point were in the DAX 30, and separately for all other stocks. Results for the DAX firms using a 1-day window to compute the ex-day price drop show that the marginal stock price drop is 1.26 times the dividend, significantly greater than 1. The intercept is $-.0056$, negative as predicted. The intercept should measure $2c$, suggesting that the one-way proportional transaction cost is 28 basis points for DAX stocks. This is close to the average bid-ask spread reported in Section 4.2.

Results for non-DAX firms in the sample show no effect of the tax credit (the slope is insignificantly different from 1) when the price drop is computed from the last cum-day to the ex-day. However, of the 1950 observations for the non-DAX stocks, there were 378 observations where the price on the ex-dividend day did not change from the previous day (there were no such observations for the DAX stocks). This suggests the possibility of stale prices in the data due to nontrading.[36]

To check for this, Equation (24) was estimated with the price drop computed over windows of 2, 3, 4, and 5 days. When the price drop is computed using a 5-day window, the ex-day drop for non-DAX firms is 1.2997 times the dividend, significantly greater than one. Table 4 shows that the slope coefficient increases consistently as the price drop is computed using a larger window.

As a diagnostic, regressions were also estimated omitting those observations where the price did not change across the ex-day. We would expect this to increase the estimated slope coefficient, but it is interesting that over a 5-day window, the slope coefficient is very close to that for DAX firms, and also close to the slope coefficient obtained when the zero-change observations are included. Purely for comparison, we also report the regressions for DAX firms using a 5-day window. The dividend coefficient is slightly greater and still significantly greater than 1. We conclude that nontrading seems likely to account for the estimates for the non-DAX sample.

5.1.2 Controlling for the tax rate. There are three complications ignored in Table 4. First, for a handful of observations, the dividend did not include a tax credit. Although we have not discussed this case, a natural benchmark for the ex-day price drop for these observations is 1:1. Considerations familiar from the literature on the ex-day in the United States could lead to a lower price drop.[37] Second, the tax credit rate dropped from 56.25% in 1993 to 42.86% in 1994. Third, the specific predictions about α and β obtain for a sufficiently large dividend yield; for small dividend yields we expect a reduction in the slope coefficient.

The first two considerations can be addressed in a single regression. Define the dummy variables D_{credit} equal to 1 when a dividend has a credit, D_{94^-} equal to 1 when the dividend precedes 1994, and D_{94^+} equal to 1 when the dividend is in 1994 or later. Consider a modified version of Equation (24):

$$\begin{aligned}\frac{P_{i,t}-P_{i,t+1}}{P_{i,t}}+r^{CDAX}_{t,t+1}=\alpha_0+\alpha_1 D_{credit}&\\ &+\left(\beta_0+\beta_1 D_{credit}D_{94^-}+\beta_2 D_{credit}D_{94^+}\right)\frac{D_{i,t}}{P_{i,t}}\\ &+u_{i,t}. \qquad (25)\end{aligned}$$

[36] Spot checks of reported volumes for the non-DAX 30 revealed that for these stocks, volume numbers are often either unavailable or small.

[37] As discussed in Section 1.5, there is no obvious clientele which should lead to a price drop of greater than one-for-one. The tension between individual investors and brokers, however, could lead to a less than one-for-one price drop.

Table 5
OLS estimates for DAX 30 and Other (non-DAX 30) stocks

	α_0	β_0	$\alpha_0+\alpha_1$	$\beta_0+\beta_1$	$\beta_0+\beta_2$	$\beta_1-\beta_2$	No. of observations	R^2
DAX 30	0.0086	−0.0761	−0.0051	1.2574	1.2319	0.0254	245	0.405
	(0.0242)	(1.2771)	(0.0026)	(0.1007)	(0.1274)	(0.0886)		
Other	0.0167	0.9443	−0.0065	1.2408	1.3231	−0.0823	1950	0.202
	(0.0261)	(0.8456)	(0.0018)	(0.0770)	(0.0620)	(0.0688)		

Estimates are of Equation (25): $\frac{P_{i,t}-P_{i,t+1}}{P_{i,t}}+r^{CDAX}_{t,t+1}=\alpha_0+\alpha_1 D_{credit}+\left(\beta_0+\beta_1 D_{credit} D_{94-}+\beta_2 D_{credit} D_{94+}\right)\frac{D_{i,t}}{P_{i,t}}+u_{i,t}$ using a 1-day (DAX 30) and 5-day (other) window to compute the ex-day drop. $\alpha_0+\alpha_1$ is the intercept for a dividend which has a credit attached, in any year. $\beta_0+\beta_1$ is the slope coefficient for a pre-1994 dividend with credit, while $\beta_0+\beta_2$ is the slope coefficient for a post-1994 dividend with credit. α_0 and β_0 are the intercept and slope for dividends with no credit. Standard errors are in parentheses.

The regression assumes that dividends bearing a credit have the same intercept in all years, but allows for a change in the slope coefficient when the tax rate changes. α_0 and β_0 are the intercept and slope coefficient for creditless dividends in any year. For a pre-1994 dividend with credit, the intercept is $\alpha_0+\alpha_1$ and the slope coefficient is $\beta_0+\beta_{1.}$ For a post-1994 dividend with credit, the slope coefficient is $\beta_0+\beta_2$.

Table 5 reports the results from estimating Equation (25). The table reports those coefficients and combinations of coefficients that are relevant, along with standard errors.

Because of the small number of observations where there is no credit, the price-drop coefficient for those cases is imprecisely estimated. For both the DAX and non-DAX samples, the hypothesis that the intercept is 0 and the slope coefficient is either 0 or 1 cannot be rejected. More interesting are the coefficients reflecting the slope coefficient pre- and post-1994. For all cases the slope coefficients are in the range 1.23–1.32, and the hypothesis that the two coefficients are equal in a given regression cannot be rejected. The stock data thus does not identify the change in the tax credit rate between 1993 and 1994.

To address the issue of different ex-day behavior for stocks with small dividend yields, regressions similar to Equation (25) were run with a dummy variable for dividends below 1%. The results are not reported. The regression coefficients reflecting the effects of larger dividends were similar to those in Table 4. The coefficients for smaller dividends were imprecisely estimated, with the intercept not significantly different from 0 and the slope coefficient not significantly different from 0 or 1.

5.2 Futures

As discussed in Section 2.4.1, holders of the DAX index futures contract do not receive the tax credit, and it is not reflected in the calculation of the DAX index. From the no-arbitrage bounds in Equation (22), we can compute a *minimum* theoretical futures price. Suppose that transaction costs are zero,[38] and that Germans performing a cash-and-carry arbitrage (long index, short futures) can receive the credit, hence $\varepsilon = 1$. From Equation (22), the minimum price is

$$F_{0,t} = P_0(1 + r_{0,t}) - FV_P[Dk]. \tag{26}$$

The intuition for this expression is that the stock price reflects the receipt of the tax credit, but not the forward price. Thus the forward price is lower by the future value of tax credits not received over the life of the contract.

Using Equation (26), we can specify a regression that permits us to test whether the interest rate, dividends, and the credit enter the forward price as predicted. Let $r_{t,T}$ be the DM-denominated LIBOR interest rate over the period until expiration (computed using the interest maturity closest to matching the maturity of the futures contract), and $FV_{t,T}(D)$ the future value of dividends, calculated using the same LIBOR rate, payable on DAX 30 stocks between time t and time T, the futures expiration.[39] It is assumed that dividends actually paid were expected to be paid. We then estimate the regression

$$\frac{F_{t,T}}{P_t} = \alpha_0 + \alpha_1 D_{94-} + \beta_0 r_{t,T}\left(\frac{T-t}{T}\right) + \left(\beta_1 + \beta_2 D_{94-}\right)\frac{FV_{t,T}(D_t)}{P_t} + u_t. \tag{27}$$

As before, D_{94-} is a dummy variable that is 1 before 1994. As with stocks, we permit the slope coefficient on dividends to vary with the change in the tax credit. From Equation (22), we expect that changes in the interest rate are on average reflected one-for-one in the futures price and that the intercept is one. Thus we expect $\alpha_0 = 1$, $\alpha_0 + \alpha_1 = 1$, and $\beta_0 = 1$. The dividend coefficients will depend on whether there is tax risk associated with arbitrage, but in any event we expect $0 > \beta_1 > -.4286$, and $0 > \beta_1 + \beta_2 > -.5625$.

Table 6 reports the results of estimating Equation (27). Results for the full sample (beginning on November 23, 1990) indicate that the futures price is reduced by approximately 55% of the tax credit. The coefficient on the interest rate, however, is significantly less than 1, which indicates that the theoretical futures pricing formula does not hold.[40] This is due to some characteristic of the data during the first year of the contract.

[38] The transaction costs associated with index arbitrage are potentially quite low. According to one market participant, many arbitrages in the DAX are effected using index basket trades and an exchange of physical for futures (EFP), in which an investor can close out the futures contract by delivering the cash index directly to a counterparty. This avoids many of the usual costs of exchange and market transactions.

[39] It should be noted that because of seasonality in dividend payments there is significant variation in the dividend variable. For approximately 25% of the observations, the dividend yield is 0. The estimated pricing relationship is the same when these observations are excluded.

[40] The regression using the full sample also had positively serially correlated errors, assessed using the regression approach suggested in Davidson and MacKinnon (1993, pp. 357–358). The three regressions with early observations omitted, however, displayed no significant first-order serial correlation.

Table 6
OLS regression

Start date	α_0	$\alpha_0+\alpha_1$	β_0	β_1	$\beta_1+\beta_2$	No. of observations	R^2
11/23/90	1.0007	0.9999	0.8972	−0.2491	−0.2959	1771	0.399
	(0.0002)	(0.0003)	(0.0293)	(0.0400)	(0.0431)		
11/26/91	1.0003	1.0000	0.9829	−0.2740	−0.3799	1522	0.402
	(0.0002)	(0.0004)	(0.0344)	(0.0408)	(0.0525)		
6/1/92	1.0002	1.0000	1.0058	−0.2806	−0.4878	1397	0.375
	(0.0003)	(0.0005)	(0.0384)	(0.0422)	(0.0671)		
11/26/92	1.0002	1.0001	1.0113	−0.2822	−0.5072	1272	0.299
	(0.0003)	(0.0005)	(0.0459)	(0.0434)	(0.0720)		

Estimates of Equation (27): $\frac{F_{t,T}}{P_t} = \alpha_0 + \alpha_1 D_{94-} + \beta_0 r_{t,T}\left(\frac{T-t}{T}\right) + (\beta_1 + \beta_2 D_{94-})\frac{FV_{t,T}(D_t)}{P_t} + u_t$. Dependent variable is the futures premium, $F_{t,T}/P_t$, the daily closing futures price for the nearest-to-expiration DAX 30 futures contract, divided by the cash value of the DAX 30 index. Independent variables are interest over the life of the contract (β_0) and the future value of the dividend yield over the life of the futures contract post-1993 (β_1) and the future value of the dividend yield over the life of the futures contract pre-1993 ($\beta_1+\beta_2$). Expiration months are March, June, September, and December. Dividend yield on cash index constructed by author. Data is daily from "start date" in the table to December 12, 1997, the expiration of the December 1997 futures contract. Standard errors are in parentheses.

Table 6 reports results with the first 250 observations (1 year), 375 observations (1.5 years), and 500 observations (2 years) removed.[41] In all three cases the interest rate coefficient and all intercepts are insignificantly different from 1, thus the low interest rate coefficient for the full sample is due to the first year of data. Moreover, in two of the additional regressions, the estimated effect of the tax credit is significantly greater for the early than the late years, and insignificantly different from the tax credit of .5625 for the years prior to 1994. Point estimates suggest that between 65% and 89% of the credit is reflected in the futures price prior to 1994, and about 65% thereafter.

The results are consistent with the futures price obeying the theoretical pricing formula. Unlike with stocks, the 1994 change in the tax credit is apparent and prior to 1994, we cannot reject the hypothesis that the full tax credit is impounded into the futures price. This suggests that the tax risk of undertaking arbitrage transactions may have increased since 1993. In addition, if more of the tax credit was impounded in futures, it may be that prior to 1994, futures arbitrage was preferred to stock trading as a way to exploit the tax credit.

5.3 Options

Option prices should reflect the tax credit in the same way as the futures prices. In theory one should be able to examine a set of option prices and infer the volatility and dividend implicit in prices, yielding an implied tax credit. However, data on German equity options is only sporadically available from Datastream and appeared to be of variable quality. Attempts to obtain

[41] Regression results did not change appreciably when the data was started still later.

Table 7
American put and call prices for Daimler-Benz options

Put premiums May 27 Stock price = 197.7			Call premiums May 25 Stock price = 195.6			Call premiums May 26 Stock price = 201	
Strike	Premium	Volume	Strike	Premium	Volume	Premium	Volume
200	32.26	1248	140	57.63	3503	58.51	7715
210	41.85	0	150	47.63	3658	48.52	13125
220	51.71	0	160	37.63	1603	38.52	6219
230	61.59	2178	170	27.63	2251	28.52	2371
240	71.51	238	180	17.63	1607	18.52	12642
250	81.50	23686	190	8.17	8216	8.52	3547

Prices are for options on May 25, May 26, and May 27, 1998. Daimler-Benz was to pay a DM 21.6 dividend with an ex-date of May 28. Options expired June 19. Source: Datastream.

reliable implied volatility and implied dividend estimates using this data had only mixed success.[42]

Fortunately, however, Daimler-Benz in May 1998 paid an unusually large dividend of DM 21.60 on a share price of DM 197.7, providing an unambiguous example of the tax credit being embedded in option prices. This one example does not provide a precise point estimate of γ, but it does make clear the tax credit effect in option prices.

Table 7 displays put and call prices for June 1998 Daimler-Benz options, just prior to the May 28 ex-date. Exercise of American-style stock options in Germany is not permitted on the last cum-dividend day, hence May 26 is the last day on which a call can be exercised cum-dividend.[43] Puts are unaffected since they are optimally exercised ex-dividend.

Reported call prices are close to intrinsic value on May 25, and slightly below intrinsic value on May 26, suggesting that early exercise prior to the dividend is expected.[44] The in-the-money call prices provide no information about the size of the dividend.

Puts are optimally exercised ex-dividend, thus their premiums reflect the ex-dividend value of the stock. Without considering the tax credit, the theoretical upper bound for the price of an American put with strike price E and time to expiration T is [see Cox and Rubinstein (1985)]

$$Put(E, T) \leq Call(E, T) - P + E + D,$$

where P is the stock price and D is the present value of dividends remaining over the life of the option.

[42] Potential problems include data errors (reporting errors, bid/ask effects, stale prices) and the use of a pricing model which does not account for volatility skew. There were also occasional obvious data problems such as reported option prices below intrinsic value.

[43] I am grateful to a trader at Hull Trading for clarifying this point.

[44] Of course, American option prices below intrinsic value should not be observed. The low May 26 prices may reflect non-synchronous prices or bid-ask effects of net sales of calls as owners try to avoid having to exercise and acquire the stock just before the dividend date.

The 250-strike put on May 27 had a price of 81.50 when the stock price was 197.7. The 250-strike call had a price of DM .11. The theoretical upper bound for the put price was

$$.11 - 197.7 + 250 + 21.60 = 74.01.$$

The actual option price of 81.50 is 7.49 greater than the upper bound. In order to make sense of the price, the tax credit embedded in the option price must be at least 7.49, which implies a credit of $\frac{7.49}{21.60} = 34.7\%$.

The day following the dividend, the stock price was 180 with a put price of 72.60, 2.60 above the intrinsic value of 70.[45] On June 2 the stock price was 177.90 and the option price was 73.50, 1.40 above intrinsic value. Even if we assume conservatively that on May 27 the option was mispriced by DM 3, the implied credit is still 4.49, or 21%. Similar patterns are followed by the other put prices in Table 7.[46] Even with a sizable bid-ask spread, it seems impossible to explain the prices of Daimler-Benz puts on May 27 without recourse to the tax credit.

Option volume is also consistent with tax credit trading. Daily volume for the 250-strike put, for example, averaged 2762 contracts between May 11 and June 10, and 0 from then until expiration. It was 8.5 times this amount on May 27. Daily volume for the five other puts in Table 7 averaged only 227 contracts over this period.

6. Implications for Portfolio Management

The results in this article suggest that, all things being equal, it is more tax efficient for foreign investors to use derivatives instead of investing directly in German stock. The empirical results allow us to quantify the gains from not holding cash stocks directly over the dividend period.

Consider a tax-exempt foreign investor in the DAX index who can invest via stocks or futures. If the investor buys the stocks in the index at time 0 and reinvests the dividend proceeds, the cost is P_0 and the value at time t is

$$P_t + FV_P(D). \tag{28}$$

Alternatively an investor can go long on DAX index futures and invest the present value of the futures price in Treasury bills. Using the slope coefficient of $-.28$ in Table 6, the cost of this is

$$\frac{F_{0,t}}{1 + r_{0,t}} = P_0 - .28PV_P(D).$$

[45] Using the binomial model with an interest rate of 3.1%, 22 days to expiration, and 100 binomial steps, the put should rationally have been early exercised at this point for volatilities less than 57%, and hence worth its intrinsic value. An implied volatility calculated separately for the full set of option prices was 23%.

[46] Repeating the implied credit calculation on May 22, 25, and 26 gave implied credits of 33.9%, 13.6%, and 42.7%.

The return on this strategy is

$$F_{0,t} + (P_t + FV_P(D) - F_{0,t}) = P_t + FV_P(D).$$

Thus the DAX futures strategy pays the same as a cash index investment but costs less by 28% of the dividends paid over the life of the futures contract. With a 1.5% dividend yield, this is a 42 basis point reduction in cost. Index futures commonly have lower transaction costs than the cash index over short holding periods, so lending and going long on index futures is more efficient than buying the cash DAX index for the same holding period.

For an investor who owns shares, the strategy of lending stock cum-dividend has been discussed in earlier sections. However, stock loans are over-the-counter transactions which might be traced to foreign counterparties. An alternative that accomplishes the same goal is to use in-the-money options. Consider, for example, the following strategy with an in-the-money put option on a stock that is about to go ex-dividend:

- a U.S. investor sells the shares on the open market and simultaneously writes a publicly traded deep-in-the-money put.
- a German investor buys the shares on the open market and buys a publicly traded deep-in-the-money put

The key to this transaction is that the deep-in-the-money put will be optimally exercised ex-dividend. The U.S. investor has sold the shares and simultaneously contracted to buy them back ex-dividend at the strike price. Similarly the German investor has bought shares with a commitment to sell them ex-dividend for the strike price. This is equivalent to a stock loan. The price of a deep-in-the-money, close-to-expiration put is[47]

$$K - [S_0 - D(1 + \gamma k)].$$

The return to the U.S. investor from selling the shares, selling the put, and having the put exercised ex-dividend is

$$+S_0 + [K - S_0 + D(1 + \gamma k)] - K = D(1 + \gamma k).$$

For the German investor who receives the dividend plus credit, the cash flows are

$$-S_0 - [K - S_0 + D(1 + \gamma k)] + D(1 + k) + K = Dk(1 - \gamma).$$

The net effect is as if the U.S. investor kept the share and received a dividend of $D(1+\gamma k)$, and the German investor makes an arbitrage profit of $Dk(1-\gamma)$. In the case of the Daimler-Benz dividend discussed above, the U.S. investor

[47] For simplicity, interest is ignored in this example.

would have earned 35% of the dividend, or about DM 7 (3.5% of the stock price) from following this strategy.

A similar strategy, outlined in Hartmann (1998), entails using European calls.[48] In this case the German investor buys the stock and sells a near-to-expiration in-the-money European call, while the foreign counterparty sells the stock and buys the call. The cash flows are identical to those for the put strategy.

7. Conclusions

This article provides evidence that approximately one-half to two-thirds of the value of the dividend tax credit is reflected in prices of German stocks and equity derivatives. The evidence is consistent with the existence of tax-motivated trading occurring around the dividend date, and with German arbitrageurs facing tax risk associated with dividend capture transactions.

There are policy issues associated with the tax credit which this article may shed light on, but which are beyond its scope. Probably the most important question is how the dividend tax credit affects the cost of equity capital and capital formation in Germany. Boadway and Bruce (1992) show that imputation may not alleviate the effect of the corporate tax. In a certainty model, they show that the investment-distorting effects of the corporate tax are still present in a small open economy with imputation because returns on investment and savings are set in world markets. The dividend tax credit reduces the tax on savings, but the required pretax return to corporate investment is unaffected by the credit since in an open economy the marginal investor is foreign. The ability of foreign investors to share in the credit via the mechanisms outlined in this article can change this result. Consistent with this, Harris, Hubbard and Kemsley (1998) provide evidence that the imputation credit in Germany is in fact capitalized into share prices. While it is tempting to use the ex-day estimates in this article to measure the degree to which the imputation credit is capitalized, the findings of Poterba (1986) on the two share classes in Citizens Utilities suggests that caution is required in using ex-day effects to assess valuation.

Our discussion of the tax credit also suggests issues that arise when risk sharing is taken into account. The dividend tax credit creates a wedge between the returns to domestic and foreign investors. While the tax credit itself lowers the cost of capital to German firms, the cost of capital should increase as a result of Germany's preventing trade in the tax credit. It is interesting that a willingness by the German government to permit unencumbered tax arbitrage would (at the expense of tax revenue) rectify this result, increasing market integration by permitting foreign investors to receive the tax credit and lowering the subsidy to domestic investors.

[48] The calls must be European to ensure they are exercised ex-dividend.

Appendix A: The German Tax System

A.1 Tax rates

The corporate tax rate in Germany was 56% before 1990, 50% from 1990 to 1993, and has been 45% since 1994.[49] The tax on earnings distributed as dividends was 36% before 1994, and 30% thereafter. Individuals had a top marginal rate of 56% prior to 1990, and 53% since.

Figure 1 illustrates the dividend tax credit for earnings paid as dividends. There is an additional complication—a corporate-level credit—not illustrated in the figure, but which comes into play when earnings are first retained and then later paid as dividends. In 1997, for example, the corporate tax rate was 45%; thus a corporation would have paid tax of DM 45 on earnings of DM 100. However, at the point when these earnings are distributed, there is a *corporate-level* credit of DM 15, which results in a net DM 30 tax on earnings paid as dividends. Shareholders receive the DM 70 dividend along with a DM 30 tax credit.

A.2 Rules restricting dividend capture

Both tax rules and court rulings affect the ability of German firms to engage in dividend capture.[50]

A.2.1 §50c of the German Income Tax Law. This section disallows in some circumstances the tax deductibility of capital losses due to the payment of a dividend.[51] The loss is always disallowed if the shares are not acquired on an exchange. If shares are exchange traded, since 1994 the loss is disallowed if (i) the shares are not held for at least 10 days, or (ii) if the market risk of the position is limited (e.g., the position is hedged).[52]

A.2.2 §36 of the German Income Tax Law. §36 addresses stock-lending transactions. If German resident A lends stock to German resident B, B can take the dividend tax credit. However, if the lender is not a German resident, B can take the tax credit only on the pro rata amount by which the gross dividend exceeds lending fees. Since lending fees will always include at least the net dividend, this reduces the ability of the German resident to use the tax credit if the lender is foreign.

Simple stock loans are rendered unprofitable by these rules. For example, consider a stock loan around the ex-date for a company that pays a DM 100 dividend. Suppose the German borrower agrees to pay the lender 120. Under §36, the German borrower would be able to use only the fraction $(142.86 - 120)/142.86$ of the tax credit. The German borrower would therefore receive only $100 + 42.86 \times (22.86/142.86) = 106.86$, while paying 120.

Let k be the tax credit rate and γk the fraction of the credit paid by the borrower to the lender in a stock loan. If a German investor borrows the stock at rate γk to earn the tax credit k, the borrower profit is

$$k\frac{1 + k - (1 + \gamma k)}{1 + k} - \gamma k.$$

[49] Since 1995 there has also been a 7.5% surcharge, the so-called unification tax or solidarity surcharge affecting all corporate and personal taxes. Thus the corporate rate in 1997 was actually .45(1.075) = 48.375%. This surcharge dropped to 5.5% in 1998. The surcharge did not affect the amount of the tax credit, however.

[50] The material in this section draws heavily on correspondence with Jurgen Hartmann as well as Hartmann (1998). I have omitted specific rules which are not directly related to the discussion in this article.

[51] The notion of a loss "due to payment of a dividend" is ambiguous since one could in theory impute a loss whatever the actual change in the stock price, and use this imputed loss to adjust the basis of the position. For example, if there were a DM 1 dividend, it would be reasonable to impute a capital loss in the range DM 1 – 1.4286. In practice, however, the restriction binds only if there is an actual loss on the stock. Thus if a dividend were paid and the stock price happened to rise, the investor would receive the full credit.

[52] In addition, capital losses attributable to a dividend are always nondeductible if the stock is acquired other than by exchange trading.

Table 8
Additions and deletions to the DAX index of 30 stocks, 1990–1998

Date	Firm added	Firm dropped
11/19/96	Deutsche Telekom AG (DTE)	Metallgesellschaft AG (MET)
09/23/96	Muenchener Rueckver AG (MUV2)	Continental AG (CON)
09/18/95	SAP AG - Vorzug (SAG3)	Deutsche Babcock AG (DBC)
09/03/90	Preussag AG (PRS)	Nixdorf Computer (NIX3)
09/03/90	Metallgesellschaft AG (MET)	Feldmuhle Nobel (FDN)

Source: Bloomberg.

This is positive only if γ, the fraction of the credit paid to the lender, is less than $\frac{k}{1+2k} = .2308$. The lender must therefore be paid no more than 1.0989 of the net dividend. Given our empirical findings that $\gamma > .5$, stock loans taxed under this rule will not be profitable.

Appendix B: The DAX Index

Once a year, in September, weights of firms in the DAX index are set based on current market capitalization, subject to the constraint that no firm's weight exceed 10% of the index. Over the course of the year, dividends paid by a given stock are assumed to be reinvested in that stock. Since firms have different dividend yields, this dividend reinvestment causes the index to depart from being capitalization weighted. This continues until weights are reset the following September. The construction details of the DAX index were used to reconstruct the daily cash dividend yield on the index.

The following firms were in the DAX 30 index of stocks as of March 1998: alv (Allianz Hldg.), bas (BASF), bay (Bayer), bhw (Bayer.Hypbk.), bvm (Bayerische Vbk.), bmw (BMW), cbk (Commerzbank), dai (Daimler-Benz), dgs (Degussa), dbk (Deutsche Bank), dte (Deutsche Telekom), drb (Dresdner Bank), hen3 (Henkel Pref.), hoe (Hoechst), kar (Karstadt), lin (Linde), lha (Lufthansa), man (Man), mmw (Mannesmann), meo (Metro), muv2 (Munch.ruck.Regd.), prs (Preussag), rwe (Rwe), sag3 (Sap Pref.), sch (Schering), sie (Siemens), thy (Thyssen), veb (Veba), via (Viag), and vow (Volkswagen). Table 8 lists the index changes over the sample period.

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