The effects of stamp duty on the level and volatility of UK equity prices

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Abstract

This paper investigates the effects of stamp duty - the UK securities transaction tax - on the level and volatility of equity prices. We examine the response of the equity market to announcements of changes in stamp duty rates and we compare the prices of two assets which are similar in all respects apart from their treatment for stamp duty purposes: American Depositary Receipts (ADRs) and their London Stock Exchange-traded stocks. Our findings are consistent with the hypothesis that stamp duty is capitalised in prices. Using univariate GARCH models, we find that stamp duty has no effect on volatility, contradicting the key hypothesis put forward by proponents of transaction taxes.

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1 Introduction

Ever since Tobin's influential proposal to use securities transaction taxes (STTs) to 'throw sand in the wheels of our excessively efficient international money markets' [Tobin (1974, 1978)], advocates of STTs have argued that they could be used to raise substantial tax revenue whilst discouraging destabilising speculative activity and curbing excess volatility.(1) Opponents of STTs, on the other hand, have doubted their effectiveness in raising substantial revenue, arguing that financial innovation and the global nature of financial markets would allow investors to substitute non-taxed securities for taxed ones, construct new securities with similar payoff structures which are not subject to the transaction tax, or shift their activity to alternative locations. Lybeck (1991), Umlauf (1993) and Campbell and Froot (1994) document such shifts for the case of Sweden, which experimented with a series of STTs during the 1980s.

In the literature, econometric studies estimating the elasticity of turnover with respect to the STT find evidence supporting the arguments against the tax. The original work was conducted by Jackson and O' Donnell (1985) using UK quarterly data. Their findings suggest that a 1% point cut in stamp duty from 2% to 1% leads to a dramatic 70% increase in equity turnover.(2) In similar studies, Lindgren and Westlund (1990) and Ericsson and Lindgren (1992) use Swedish and international panel data respectively, and find that, in the long run, a one percentage point increase in the STT leads

(1) Note that both Tobin's original proposal and some of the more recent papers [for example Eichengreen *et al* (1995) and Eichengreen and Wyplosz (1996)] have focused on the use of STTs to curb 'destabilizing speculative activity' in international currency markets. Other papers such as Tobin (1984), Summers and Summers (1989) and Stiglitz (1989) have used similar arguments in the context of equity markets. Destabilising speculators can be understood, for example, in the context of the 'positive feedback traders' of De Long *et al* (1990) who buy when prices are high and sell when prices are low. As a result, rational speculators will buy (sell) more than they would have done in their absence, in the hope that their trading would excite further positive feedback trading thereby pushing prices up (down) even further. Consequently, prices are positively correlated in the short term and mean-reverting in the long term, there is excessive trading and excess volatility. See Poterba and Summers (1988) and Lo and MacKinlay (1988) for empirical evidence on short term positive correlation and long term mean reversion of prices. See French and Roll (1986) for empirical evidence in support of the excess volatility hypothesis.

(2) Note that stamp duty (the UK STT on shares and debentures) was cut from 2% to 1% in April 1984.

to a decrease in turnover of between 50% and 70%.[3]

The finding that STTs have a negative effect on turnover does not provide *prima facie* evidence against the argument most commonly put forward by proponents of STTs: that is that 'destabilising' speculative activity induces excessive turnover which in turn induces excess volatility. The available theoretical work, however, casts doubt on this argument. Kupiec (1991) provides overlapping generations models, with one and two generations, which show that the sign of the effect of the transaction tax on conditional volatility is state-dependent, depending, in particular, on the age of noise traders. Kupiec argues (but does not prove) that in a multigenerational setting, conditional volatility would be monotonically increasing in the tax. Sibert and Ha (1996) study the effects of increased foreign exchange substitutability on foreign exchange volatility. Their simulation results suggest that, in the empirically relevant range of transaction costs, a transaction tax has little impact on foreign exchange volatility.[4]

Empirical investigations of STT effects on equity volatility have focused exclusively on the Swedish experience. Umlauf (1993) uses volatility ratios to test whether equity returns volatility decreased during the higher STT regimes in Sweden. Barr and Sellin (1996) use GARCH models to estimate STT effects on the conditional volatility of Stockholm Stock Exchange equity returns. Neither study finds any STT effects on volatility.

A different and potentially important consequence of STTs concerns their effects on the level of asset prices. Standard asset valuation arguments would predict that STTs would be capitalised in prices. If this is indeed the case, then a change in the rate of the STT could have interesting tax revenue implications. For example, if increases in the rate of the transaction tax result in decreases in the level of equity prices, then any negative effect on tax revenues caused by a decrease in

[3] Owing to the lack of well-specified models of volume these studies use *ad hoc* log-linear models of turnover with explanatory variables that may well be endogenously determined. These concerns, voiced at length by Campbell and Froot (1994), cast some doubt on the validity of their predictions.

[4] In a related paper, Bartolini and Bodnar (1996) apply recently developed asset price volatility tests which cast doubt on the assertion that currency markets are 'excessively' volatile. Similar doubts in the context of financial futures have been raised by Edwards (1992).

turnover may be reinforced by a reduction in revenues from other sources, such as taxes on capital gains. Moreover, lower equity prices may induce firms to substitute debt for equity. To the extent that higher corporate leverage induces higher stock return volatility, an increase in stamp duty may have a positive effect on volatility through its negative effect on price levels.[5] To our knowledge, the only studies which consider STT effects on the level of equity prices are Umlauf (1993), who looks at the response of the Swedish equity market to announcements of changes in STT rates, and Jackson and O' Donnell (1985) who estimate a simple model of asset prices and find that a 1% point increase in stamp duty would decrease prices by 10%.

The purpose of this paper is to add empirical content to the debate on securities transaction taxes by conducting an investigation of the effects of stamp duty on UK equity prices and volatility. The paper makes two contributions to the existing literature on STTs. First, it considers the effects of stamp duty on equity prices by comparing the prices of two instruments which are similar in all respects other than their treatment with respect to stamp duty. Second, it conducts the first empirical investigation of the effects of stamp duty on UK equity volatility.

In the first part of the paper, we investigate stamp duty effects on the level of prices. Similar to Umlauf (1993), we start by looking at announcement effects of stamp duty changes on equity returns. We find that announcements of stamp duty increases (decreases) were followed by negative (positive) equity returns. The behaviour of equity returns following budget announcements, however, may also be related to factors other than the change in the rate of stamp duty. In order to disentangle STT effects from other effects that could also influence the level of equity prices, we compare the price of a sample of underlying shares of UK-listed companies, which are subject to stamp duty, with the price of their US-listed ADRs (American Depositary Receipts), which are not subject to stamp duty. We find evidence that in the absence of extensive inter-market arbitrage between the ADR and the underlying markets, the asset which is not subject to stamp duty (the ADR) trades at a premium over the asset which is subject to stamp duty (the underlying asset). This finding is consistent with the

[5] See Goldberg (1985) for a similar argument in the context of margin requirements and their effects on corporate leverage.

hypothesis that stamp duty is capitalised in prices, and agrees with Umlauf's findings on Swedish equities.

In the second part of the paper, we focus on the effects of stamp duty on the volatility of UK equity returns which we measure using standard univariate GARCH models. Although our initial findings seem to support Kupiec's suggestion that stamp duty has a positive effect on returns volatility, more careful examination suggests that the result is due to the surge of volatility in the early 1970s which coincided with, but was unrelated to, the 1% point increase in the rate of stamp duty in May 1974. Our evidence, therefore, suggests that there is no stamp duty effect on UK equity volatility and is consistent with the findings of Umlauf and Barr and Sellin on STT effects on Swedish returns volatility.

The structure of the paper is as follows. In Section 2, we provide some background information about the UK experience with stamp duty. In Section 3, we analyse announcement effects of stamp duty on the FTSE-All Share return index. In Section 4, we compare the prices of a sample of ADRs, which are not subject to stamp duty, with the prices of their underlying shares, which are subject to stamp duty. In Section 5, we obtain further evidence of stamp duty effects on price by comparing expected returns on ADRs with expected returns on their underlying shares for an extended sample of companies. In Section 6, we investigate the effects of stamp duty on returns volatility and in Section 7, we conclude.

2 The UK experience: institutional background

In the United Kingdom, investors pay stamp duty on purchases of shares and debentures. With the exception of Switzerland which charges a STT of 0.75%, UK stamp duty at 0.50% is currently the highest STT amongst countries with major financial markets. Germany, Sweden and Finland eliminated their transaction taxes in 1990, 1991 and 1992, respectively. France charges 0.30% on transactions below FFr 1 million and 0.15% on transactions above FFr 1 million. Recently, the Trésor introduced a cap of FFr 4,000 on the amount of transaction tax payable and exempted transactions going through the Nouveau Marché, the market for firms with small capitalisations. Japan and Italy charge their residents a 0.30% and 0.05% STT respectively. The Netherlands, Norway, Canada and the United States have no STTs.[6]

Stamp duty is effectively a tax on change of ownership, which must be registered in the United Kingdom. As a result and in contrast with the transaction taxes in a number of other countries (France, Italy, Switzerland, Japan) stamp duty cannot be avoided by trading overseas. The rate of stamp duty has varied over the years: in August 1963 the rate was lowered from 2% to 1%, increasing to 2% in May 1974, falling again to 1% in April 1984. On 27 October 1986 the government reduced the stamp duty rate to 0.50% and introduced the stamp duty reserve tax (SDRT) at the same rate as the stamp duty. The SDRT applied to transfers of beneficial ownership which were previously not picked up by stamp duty as they involved transfers of stocks without notification to the Registrar.[7] In 1990, the government announced its intention to abolish stamp duty when the new equity settlement system TAURUS was installed. The collapse of the project has allowed the undertaking to lapse but the government remained committed to the principle of abolition.

Currently, under the existing London Stock Exchange (LSE) dealer system, market-makers are exempt from stamp duty.[8] The LSE, however, plans to launch an order-driven system for FT-SE 100 stocks in October 1997. Under the new system, market-makers will no longer have any special role or obligation related to the stocks traded through the order book. For this and other reasons, the Chancellor announced on 25 July 1996 that a new relief on security transactions will be introduced to replace the existing stamp duty exemptions for

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[6] Most of these data are extracted from Table 6.1 of Cambell and Froot (1994). We thank the London office of SBF-Paris Bourse for the information on French transaction taxes.

[7] Examples of such transfers include round-trip transactions within the same accounting period, transfers in names of nominees and transfers between brokerage accounts without changing the name of the nominee. The SDRT accounted for 1.26% of total receipts from stamp duty on shares and debentures in the year of its introduction. Ever since, SDRT receipts have been steadily declining. In 1995/96, SDRT accounted for 0.83% of total receipts.

[8] Broker-dealers, who complete a round-trip transaction within a week, are also exempt from stamp duty.

Table A
Receipts from stamp duty on shares and debentures as a percentage of market capitalisation: 1965/66-1994/95

Period	Rate	Mean	Max	Min	St. Dev.	t Stat	P-Value
65/66-73/74	1%	0.169%	0.266%	0.118%	0.00051	n/a	n/a
74/75-83/84	2%	0.280%	0.332%	0.225%	0.00036	5.399	0.00005
84/85-85/86	1%	0.170%	0.176%	0.165%	0.00007	8.674	0.000006
86/87-94/95	0.50%	0.164%	0.254%	0.127%	0.00044	0.378	0.7138

Data source: Inland Revenue Statistics (1970/71 - 1995/96) and Commissioners of Inland Revenue Reports (106th, 110th).

market-makers. Under the new relief system, stamp duty exemption will be available to 'intermediaries' trading on any UK recognised investment exchange.(9)

In the top panel of Chart 1 we plot nominal receipts from stamp duty on shares and debentures over the period 1954/55-1995/96. As we can see, the Inland Revenue raised £1.3 billion from stamp duty on shares of debentures in 1994/95, some 0.18% of GDP. To obtain an idea of how receipts varied across stamp duty regimes, the bottom panel of Chart 1 plots receipts as a percentage of equity market capitalisation over the period 1965/66-1994/95,(10) and Table A reports summary statistics and the results of tests of equality of means between successive periods with different stamp-duty regimes. The tests suggest that the doubling of the rate of stamp duty in 1974 led to significantly higher mean receipts than the mean receipts collected in the previous regime period and that the halving of the rate of stamp duty in 1984 produced mean receipts that were significantly lower than the receipts collected under the previous regime. However, the halving of the stamp duty rate in 1986 did not lead to significantly lower receipts.(11) To gain some intuition as to why this should be, we plot in Chart 2 the velocity of

(9) Neither the definition of intermediaries nor the timing of the implementation of the new system have yet been settled. However, it has been argued that the definition should include agents which supply the market with 'natural' liquidity in the course of their normal business.

(10) We could not obtain earlier market capitalisation data.

(11) Note that in October 1986, stamp duty on all debt instruments (except convertible bonds) was abolished. Unfortunately, a breakdown of stamp duty receipts between equity and debt instruments is not available. As a result, the pre-Big Bang

Chart 1
Receipts from stamp duty on shares and debentures

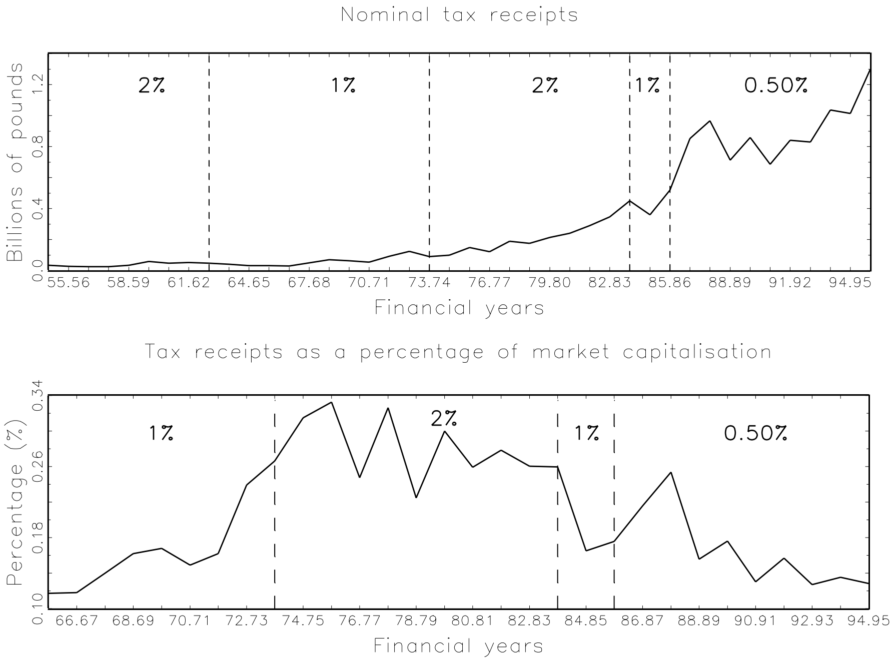
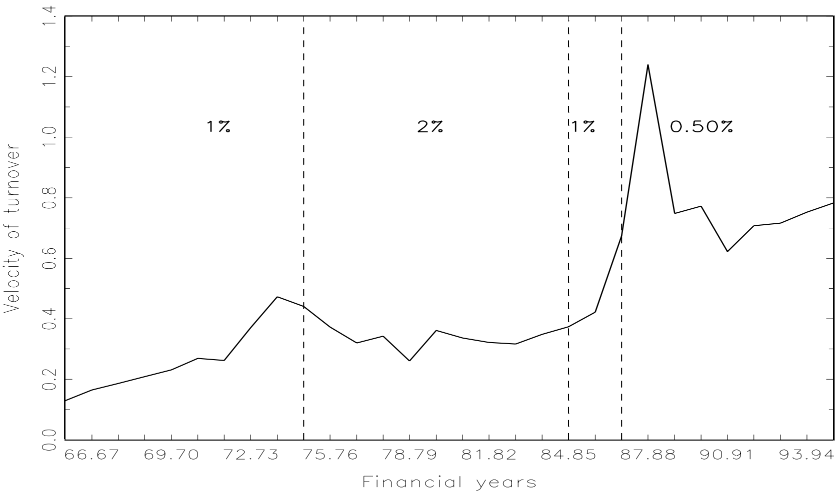


Chart 2
Velocity of turnover: 1965/66-1994/95



turnover in the period.[12] Clearly, velocity increased dramatically during the period following the 1% cut in 1984 and increased even further after Big Bang and the implementation of the 0.50% stamp duty regime. After reaching a peak in 1987/88,[13] however, velocity tailed off, at levels that were similar to the 1984/85-1985/86 stamp duty-regime period, but clearly higher than those of the 1965/66-1973/74 and 1974/75-1983/84 stamp-duty regime periods.

stamp duty receipts reported in Table A overestimate the adjusted equity receipts. The substance of the observation, however, that the stamp duty cut of 1986 did not produce significantly lower stamp duty receipts than the previous stamp duty-regime period, remains unaffected by the narrowing of the tax base.

(12) 'Velocity of turnover' is defined as the ratio of turnover to market capitalisation and is alternatively referred to as 'turnover rate' or 'average holding period'. In what follows, the three terms will be used interchangeably.

(13) Some major privatisations occurred during the financial year 1987/88. Moreover, the crash of October 1987 was followed by 'abnormally' high activity.

3 Announcement effects of stamp duty changes

Standard asset valuation arguments would predict that a rise (fall) in the equity transaction tax would result in a decrease (increase) in asset prices. As a result, we would expect the announcement of an increase (cut) in the rate of transaction tax to cause a fall (rise) in the equity market. In this section, we investigate whether market prices responded in the predicted way, by analysing the response of the UK equity return index to the announcement of changes in the stamp duty rate. Our analysis is similar to that conducted by Umlauf (1993) on the Swedish equity market.

We first perform an exercise similar to Umlauf's in order to capitalise the effect of a 1% point decrease in the rate of stamp duty under some restrictive assumptions. The average annual turnover rate and dividend yield over the period 1974/75-1994/95 were 53.48% and 4.98%, respectively. If investors expected perpetual turnover rates of 53.48%, a constant required return on the index and a perpetual dividend yield of 4.98%, then the effect on the return index of a 1% point decrease in stamp duty would be equal to the present value of the expected increase in outlays, that is 10.73%.(14) If we exclude, however, the high turnover period of 1986-96, which followed the exogenous structural changes caused by Big Bang, we obtain a mean turnover rate of 35.14% and a mean dividend yield of 5.63% which gives an expected index rise of 6.24%.

Table B lists announcement effects on the FTSE-All Share return index of the three most recent changes of the stamp duty rate. Our data consist of continuously compounded daily FTSE-All Share equity index returns for the period 2 January 1969 to 26 June 1996.(15) The index decline of -3.33% which followed the 1974 budget is dramatic. A test of equality with the sample mean of 0.055% yields a t-statistic of 158.12. The index rise of 0.5558% which followed the announcement of the halving of the stamp duty rate in 1984 is smaller in magnitude, but

(14) The calculation is: $\frac{1\% \times 53.48\%}{4.98\%}$.

(15) The daily FTSE-All share index is an equally-weighted index calculated on the basis of the difference in the closing midquotes of all stocks listed on the London Stock Exchange between two consecutive days.

Table B
Announcement effects of stamp duty changes

Date	Event	Index return	30-day Index return
27 March 1974	Increase of stamp duty rate	-3.33%	-15.41%
	from 1% to 2% announced	(158.12)†	(727.03)
14 March 1984	Decrease of stamp duty rate	0.558%	3.12%
	from 2% to 1% announced	(22.76)	(120.12)
19 March 1986	Decrease of stamp duty rate	1.054%	16.10%
	from 1% to 0.50% announced	(44.42)	(680.83)

† t-Statistics of tests of equality with the sample mean.
The mean and standard deviation for daily returns is 0.0517% and 0.0204 respectively. The number of observations is 7170.
Data source: Datastream.

still significantly different from the sample mean of returns. The index rise of 1.054%, following the announcement of a further half-point cut in the rate of stamp duty, is also very substantial and significantly different from the sample mean return. These figures could underestimate the impact of the announcement on the index as there may have been some prior expectations of the announcement during the month before and up to the budget. Calculating the cumulative index return for the 30-day period up to and including the announcement yields an index decline of 15.41% in 1974, an index rise of 3.12% in 1984 and an index rise of 16.10% in 1986.

The above figures should be treated with caution, as the behaviour of the index could be related to other budget announcements. A look at the relevant budget statements reveals that the 1974 increase in stamp duty was accompanied by significant rises in income tax rates. Similarly, the 1986 cut was accompanied by significant decreases in the income tax rate, increases in personal allowances, an increase in the threshold level of inheritance tax, but also increases in capital gains tax. Apart from an increase in personal allowances, however, the stamp duty cut was by far the most important announcement that was made in the 1984 budget. Given these considerations, the expected index rise of 6.24% calculated in the paragraph above, compares favourably with the 30-day cumulative index which we observe prior to and including the one point cut announcement in 1984.

4 Stamp duty effects on share price: ADRs versus underlying shares

A natural way to obtain more reliable evidence on the effects of stamp duty on the level of prices is to compare two instruments which are identical in all respects other than their treatment with respect to stamp duty. A good example of two such instruments are the shares of UK-registered companies listed on the London Stock Exchange and their corresponding American Depositary Receipts (ADRs) listed on a US exchange.

ADRs are dollar-denominated negotiable bearer instruments representing ownership of a fixed number of shares of the underlying security which are held by a custodian. Underlying shares are convertible to ADRs at the cost of SDRT which is chargeable at the special rate of 1.5%, three times the rate of stamp duty. Similarly, ADRs can be converted back to the underlying shares at the cost of a cancellation fee which is set by the custodian. Any trading of the ADRs in the US market is, however, stamp-duty free.

In this section we obtain evidence of stamp duty effects on price by examining the ADR and underlying quotes of a sample of four companies cross-listed on the London Stock Exchange (LSE) and on NASDAQ: Burmah Castrol, Rank Group PLC, Reuters Holdings and Rexam PLC. In this way we control for differences in ADR and underlying quotes that may be caused by differences in trading mechanism.(16) Table C reports 1995 market capitalisation and turnover data for the underlying stocks and the ADRs of the four companies in our sample. Our data set includes ADR and underlying quotes for each of the four stocks in our sample for every fifteen minutes during the market overlap between 30 September and

(16) Both the LSE and NASDAQ share the same dealer trading mechanism based on market-makers who compete for order flow by setting firm quotes on both sides of the markets. In contrast, the trading mechanism of the NYSE is based on a combination of an order-driven system with brokers submitting orders on the NYSE floor and a quote-driven system operated by a monopolist specialist. There is a voluminous literature on the effects of market microstructure on price formation. For an overview of the literature see O'Hara (1995).

29 November 1996. We adjust for the foreign exchange component contained in the ADR quotes by dividing the ADR per share dollar ask (bid) with the synchronous sterling against US dollar bid (ask).(17)

Table C
Turnover, market capitalisation and velocity: 1995

Company		Capitalisation (£mn)	Turnover (£mn)	Velocity
Burmah Castrol	underlying	1876.30	1001.00	0.533
	ADR	16.01[1]	9.13	0.568
Rank Group	underlying	3848.00	2683.00	0.697
	ADR	26.91	30.65	1.139
Reuters Holdings	underlying	9844.00	5080.00	0.516
	ADR	2618.00	6311.00	1.555
Rexam PLC	underlying	1814.40	1242.00	0.684
	ADR	2.50	2.42	0.967

[1] The ADR capitalisation and turnover figures have been converted into sterling using the USD against sterling end of December 1995 rate of 1.5505 (Bank of England, ONS database).
Data sources: Datastream, NASDAQ, Quality of Markets Factsheets.

The relationship between the underlying and ADR quotes depends (i) on differences in transaction costs in the two markets and (ii) on the extent of inter-market linkage between the underlying and the ADR markets.(18) Under the assumption that ADRs and underlying instruments are perfect substitutes, we distinguish between two types of arbitrage which link the underlying market to the ADR market and *vice versa*:

- The first type of arbitrage affects the pool of ADRs that exist at any point in time and determines the arbitrage limits within which the bid and ask prices of the ADR must lie. If the ask price of an ADR per share, P_a^{ADR}, exceeds the ask price of the underlying stock, P_a^{UND}, plus the per share cost of creating an ADR, more ADRs would be created as a firm could obtain better

(17) Owing to the difficulty in obtaining high frequency foreign exchange data, the easiest way to collect synchronous ADR, underlying and foreign exchange quote data was to do so in 'real time' using one of the information providers (we used Reuters).
(18) There is a growing number of empirical studies that examine the extent of inter-market linkage between markets for cross-listed stocks. In general, the studies find a degree of segmentation between markets. See, for example, Werner and Kleidon (1996), Domowitz, Glen and Madhavan (1996) and Froot and Dabora (1995).

prices for their stocks in the ADR market. This would increase the pool of ADRs and push their price down so that in equilibrium the inequality

$$P_a^{ADR} \leq P_a^{UND} \times (1 + \text{SDRT rate}) \tag{1}$$

is satisfied. Similarly, if the bid price of the ADR per share, P_b^{ADR}, plus the cancellation fee was less than the bid price of the underlying stock, P_b^{UND}, ADRs would be cancelled. This would decrease the size of the ADR pool and increase the ADR bid price so that in equilibrium the inequality

$$P_b^{ADR} \geq P_b^{UND} - \text{cancellation fee}, \tag{2}$$

is satisfied.

- The second type of arbitrage is a pure tax arbitrage.[19] Notice that both inequalities could be consistent with the ask (bid) price of the underlying asset being lower than the ask (bid) price of the ADR due to the difference in expected outlays caused by stamp duty.[20] Now if this were the case, stamp duty exempt investors (market-makers, under the present trading system) could short-sell ADRs to the stamp duty-paying investors and cover their position with the underlying stock - at the expense of the Inland Revenue. This would cause the price of the ADR to decrease and that of the underlying stock to increase so that in equilibrium the ask and bid prices of the two instruments are equal and given by

$$\begin{aligned} P_a^{ADR} &= P_a^{UND} < P_a^{UND} \times (1 + \text{SDRT rate}) \quad \text{and} && (3) \\ P_b^{ADR} &= P_b^{UND} > P_b^{UND} - \text{cancellation fee}. && (4) \end{aligned}$$

[19] See Schaefer (1981) for a discussion of pure tax arbitrage in the context of government bonds.

[20] Notice that we abstract from any other transaction costs differences (eg differences in settlement costs and commissions) other than stamp duty differences. There is evidence that stamp duty is by far the greatest component of the difference between US and UK direct trading costs. For example, Campbell and Froot (1994) report an average difference between US and UK direct trading costs paid by a group of US institutional investors in 1992 of 66 basis points. Clearly, most of the difference is accounted for by stamp duty (50 basis points).

Chart 3
ADR quotes versus underlying quotes: Burmah Castrol and Rank

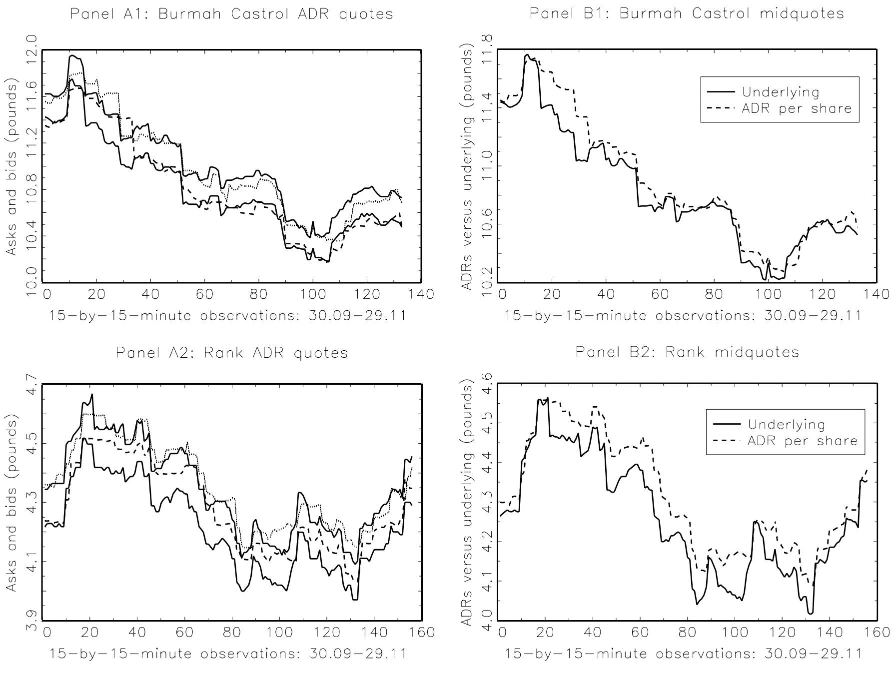
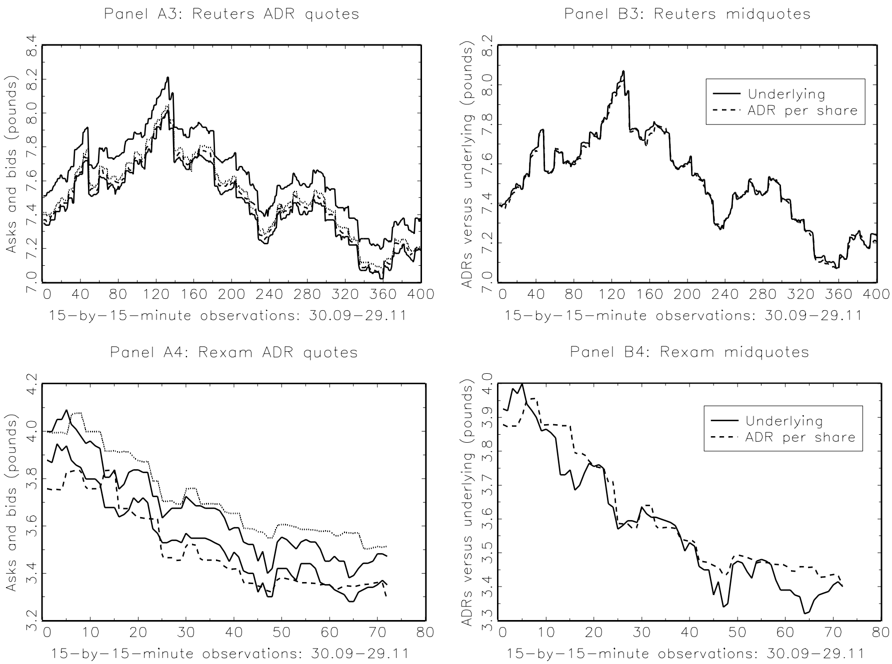


Chart 4
ADR quotes versus underlying quotes: Reuters and Rexam



In panels A1, A2, A3, A4 of Chart 3 and 4 we plot the sterling-equivalent ADR per share ask and bid prices for Burmah Castrol, Rank, Reuters and Rexam respectively. The solid lines represent the upper and lower arbitrage limits given by the right hand sides of inequalities (**1**) and (**2**) respectively.[(21)] The charts depict a variability in the extent to which different stocks satisfy the arbitrage inequalities. This is confirmed by Table D below, where we list the percentage of observations that satisfy inequalities (**1**) and (**2**).

Table D
Do ADR quotes lie within the arbitrage limits?

Company	Observations	Percentage of observations within arbitrage limits
Burmah Castrol	133	19.55%
Rank Group	156	32.69%
Reuters Holdings	400	97.25%
Rexam PLC	72	00.00%

Data source: Reuters.

In the case of Reuters Holdings, the ADR quotes are almost always within the arbitrage limits suggesting that the underlying and ADR markets for this stock are consolidated. By contrast, in the case of Rexam, the ADR quotes are never within the arbitrage limits suggesting that the ADR and the underlying markets are segmented. In the case of Burmah Castrol and Rank, there are times when inequalities (**1**) and (**2**) are satisfied. In the majority of cases, however, the inequalities are violated suggesting that there is a degree of segmentation between the ADR and underlying markets for these two stocks.

Why should stocks differ in the degree to which their underlying and ADR markets are consolidated? There are a number of reasons why ADRs and their underlying shares may not be perfect substitutes. For example, an investor who holds ADRs has to go through the depositary bank in order to exercise the voting rights that correspond to the underlying shares of the ADR. ADRs pay dividends in US dollars, a

(21) We would like to acknowledge the ADR Departments of Bank of New York and Morgan Guarantee Trust for supplying us with the information on cancellation fees, necessary for the calculation of the lower arbitrage limits.

fact which may make them relative unattractive to domestic investors. In some cases, dividends distributed to ADR holders are subject to a fee.(22) Differences in the extent of inter-market linkage between stocks may be related to the extent to which market-makers of particular underlying stocks have cost-free access to the short end of the ADR market and *vice versa*.

The extent to which the arbitrage inequalities are satisfied in the case of Reuters Holdings suggests that tax arbitage should equalise the quote midpoints of the two instruments as suggested by equations (**3**) and (**4**).(23) In contrast, given that the ADR and underlying markets of the other three stocks appear to be segmented, we would expect the ADRs of these stocks to trade at a premium over their corresponding underlying assets. The reason for this is that underlying shares are subject to stamp duty whereas their ADRs are not. In panels B1, B2, B3, B4 of Charts 3 and 4, we plot the sterling-equivalent quote midpoints for the ADR per share and the quote midpoints for the underlying share for each of the four companies in our sample. In Table E, we list the mean difference between the quote midpoint of the ADR per share and the quote midpoint of the underlying share for each of the four companies and we carry out tests of equality of means. The second column reports the mean difference relative to the average of the ADR and underlying mean midquotes.

As is strikingly apparent from Chart 4, the mean quote midpoint of the Reuters ADR is not significantly different from the mean quote midpoint of the Reuters underlying stock, supporting our hypothesis that extensive arbitrage between the Reuters ADR and its underlying share equalizes the quotes of the two instruments. In contrast, for three quarters of the observations the Rexam ADR per share midquote

(22) Dividend fees are more common for 'unsponsored' ADRs than 'sponsored' ones. Sponsored ADRs are created by the company whose shares they represent. The company usually pays most of the issuance and dividend fees charged under the deposit agreement. Unsponsored ADRs are 'market-driven' in the sense that they are created by investors without the company taking any action. Note that the four ADRs in our sample are sponsored. Moreover, investors holding the ADRs of these stocks do not have to pay dividend fees.

(23) Notice that if we add equation (**3**) to equation (**4**) we obtain: $P_a^{ADR} + P_b^{ADR} = P_a^{UND} + P_b^{UND}$. Clearly, if the two markets are linked, then at any point in time during the market overlap, the midquote of the underlying share will be equal to the midquote of its corresponding ADR per share.

Table E
ADR midquotes versus underlying midquotes

Company	Mean difference (£)	Relative difference	P-value
Burmah Castrol	0.0743	0.683%	0.0735
Rank Group	0.0565	1.318%	0.0003
Reuters Holdings	-0.0064	-0.087%	0.6537
Rexam PLC	0.0291	0.809%	0.1717

Data source: Reuters.

exceeds the Rexam underlying midquote. The mean difference between the Rexam ADR midquote and the underlying midquote, however, although positive, is not statistically significant. In contrast, the differences between the mean ADR midquotes of Burmah Castrol and Rank Group and the mean midquotes of their respective underlying shares are both positive and statistically significant at the 10% level.

5 Returns on ADRs versus returns on underlying shares

Our findings, so far, are consistent with the hypothesis that when the underlying and ADR markets for a particular stock are segmented, the ADR (the instrument which is not subject to stamp duty) trades at a premium over the underlying share (the instrument which is subject to stamp duty). The evidence, however, is based on a small sample of companies using data during the market overlap for 45 trading days. In order to complement the analysis of the preceding section we extend our sample of four companies to eleven companies. Given that a longer time series of synchronous quotes is not readily available, we use weekly returns data on ADRs and their underlying shares for the eleven companies in our extended sample.

Our criterion for company selection is continuous listing in both the UK and one of the three main US markets (NYSE, AMEX and NASDAQ) for as long a period as possible. Our final data set consists of continuously compounded underlying and ADR weekly returns corresponding to each of the eleven companies for the period 2 January 1987 to 12 July 1996. We adjust for the exchange rate component contained in ADR returns by computing adjusted series as:

$(1+R_t^{ADR}) \times (1+RX_t) - 1$, where R_t^{ADR} is the ADR dollar return and RX_t is the weekly continuously compounded return of the US dollar against the sterling.(24)

Assuming that during our sample period there was a degree of segmentation between the underlying and the ADR markets, we would expect the ADR per share price to exceed the underlying price.(25) Accordingly and under the assumption that investors expect approximately equal capital gains from holding the two instruments, the pre-stamp duty expected return on the underlying share would exceed the expected return on its corresponding ADR. To test this hypothesis we estimate the following model

$$
\begin{aligned}
R_t^{us} - R_t^{*as} &= c^s + u_t^s \qquad \text{where,} && (5)\\
u_t^s &= \varepsilon_t^s + \lambda^s \varepsilon_{t-1}^s, && (6)
\end{aligned}
$$

R_t^{us} and R_t^{*as} are the underlying and foreign-exchange adjusted ADR returns on stock s at the end of week t, respectively, and ε_t^s are white noise. We take into account the difference in closing times between the UK and US exchanges by modelling the disturbances u_t^s as a MA(1) process.(26) Table F reports the results of the estimation. In all cases, the point estimates, c^s, are positive but statistically insignificant. The average estimated difference is 0.033%, whereas the maximum and minimum differences are 0.060% and 0.020%, respectively.

Although the estimated differences between the underlying and ADR one-week holding returns are insignificant, their consistently positive sign and their magnitude suggest that investors would hold ADRs for a longer period than they would hold underlying shares. In order to see whether this is the case, we compute 'break-even' periods, that is the

(24) For evidence on the foreign exchange effect on ADR returns see Park and Tavakkol (1994).

(25) Notice that in terms of the discussion in the previous section, this assumption is only justifiable to the extent that, on average, during our sample period, the ADRs and underlying assets of our sample stocks would not have been perceived as perfect substitutes.

(26) At the LSE market-makers are required to post quotes between from 0830 to 1630 GMT. Trading hours for the NYSE, NASDAQ and AMEX are 0930 to 1600 New York time. This implies that at the beginning of week $t+1$, the price of the underlying stock would adjust to incorporate the information released during Friday evening, which would have been already incorporated in the price of the ADR at the end of week t.

Table F
Mean differences between ADR and underlying returns

Company	Cross-listed in	Constant (c^s)	MA parameter (λ^s)
Barclays	NYSE	0.0005955	-0.52212
		(0.128)†	(0.000)
British Petroleum	NYSE	0.0002016	-0.68800
		(0.125)	(0.000)
British Telecommunications	NYSE	0.0003208	-0.45985
		(0.229)	(0.000)
Hanson	NYSE	0.000386	-0.53187
		(0.145)	(0.000)
National Westminster	NYSE	0.0003209	-0.56531
		(0.209)	(0.000)
Unilever	NYSE	0.000293	-0.29452
		(0.631)	-0.29452
Burmah Castrol	NASDAQ	0.0002548	-0.6368
		(0.168)	(0.000)
Rank Organisation	NASDAQ	0.0002247	-0.61931
		(0.378)	(0.000)
Reuters	NASDAQ	0.0002090	-0.77415
		(0.065)	(0.000)
Rexam	NASDAQ	0.0002417	-0.67963
		(0.408)	0.000
Courtaulds	AMEX	0.0005866	-0.52205
		(0.430)	(0.000)

† P-values are in parentheses.

Note: The table lists the results of estimating equations (**5**) and (**6**).

Data source: Datastream, Bank of England ONS database.

average period of time an investor would have to hold the underlying asset until he becomes indifferent between holding the underlying asset and holding its corresponding ADR.(27) If our hypothesis is correct we would expect average holding periods to exceed break even periods.

Table G
Comparison of average break-even periods with average holding periods

Company	Cross-listed in	Break-even (weeks)	Underlying (weeks)	ADR (weeks)
Barclays	NYSE	8.40	85.63	31.23
British Petroleum	NYSE	24.80	152.38	58.64
British Telecommunications	NYSE	15.59	152.60	46.68
Hanson	NYSE	12.95	97.10	18.53
National Westminster	NYSE	15.58	93.57	97.04
Unilever	NYSE	17.06	124.60	39.71
Burmah Castrol	NASDAQ	19.62	95.51	91.42
Rank Organisation	NASDAQ	22.25	74.57	45.67
Reuters	NASDAQ	23.92	100.77	80.85
Rexam	NASDAQ	20.69	75.95	53.74
Courtaulds	AMEX	8.52	77.67	n/a[1]

[1] We could not obtain the market capitalisation data for the Courtaulds ADRs.
Note: The first column reports the number of weeks an investor needs to hold the underlying asset in order to be indifferent between holding the underlying share and its corresponding ADR. The second and third columns report average holding periods for the underlying stocks and their corresponding ADRs.
Data sources: Datastream, FTSE International, the NYSE and NASDAQ.

In the third column of Table G, we report the calculated 'break-even periods' for each stock for the whole sample period.(28) In the fourth and fifth columns, we report the average holding periods for each stock based on 1995 data. Comparing the third and fourth columns of Table E, it is clear that the average holding periods of the underlying stocks exceed the average break even periods for all stocks in our sample. Given that the turnover generated in dealer markets is not comparable to the turnover of order-driven markets, we are only able to compare the average holding periods of the underlying stocks and

(27) The calculation for each stock s is: $\ln\left[(1+0.005)/(1+\widehat{c^s})\right]$.
(28) In testing for a difference in expected returns we are looking for a very small effect, eg $\ln\frac{P_t}{P_{t-1}}$ versus $\ln\frac{P_t}{P_{t-1-\varepsilon}}$ where $\varepsilon > 0$ is very small. Hence the lack of significance in not surprising.

their ADRs for the four stocks in our sample which are cross-listed on NASDAQ. In all cases, we find that the average holding period of the underlying shares exceeds the average holding period of their corresponding ADRs.(29) These findings are consistent with the view that stamp duty has a negative effect on turnover and suggest that investors take into consideration the level of the transaction tax when they decide how long to hold a particular asset [eg Jackson (1987)].

6 Stamp duty effects on volatility

In this section, we turn to the effects of stamp duty on returns volatility.

Our main analysis, concerns the effects of stamp duty on volatility over relatively long horizons (daily, weekly and monthly volatility). It is also instructive, however, to investigate whether transaction taxes have any discernible effects on volatility using our data on ADR and underlying midquotes. Given that the foreign exchange component incorporated in ADRs could induce volatility unrelated to the transaction tax, valid comparisons have to be restricted to the companies for which we have synchronous quote and foreign exchange data. We therefore examine the variance of continuously compounded fifteen minute returns of our sample of four ADRs (which are not subject to stamp duty) *vis-à-vis* the variance of the continuously compounded fifteen minute returns of their underlying shares (which are subject to stamp duty). If the proponents of transaction taxes are right and such taxes are successful in reducing volatility, we would expect that the variance of the ADR return will be higher than the variance of their underlying stock return. Table H reports F-tests of equality of variance of the ADR with the variance of the underlying stock.

Clearly, for all four companies the ADR sample variance is significantly

(29) Dealer markets, such as the LSE, tend to report all transactions going through their members, whereas order-driven systems report transactions that occur through the centralised system. Moroever, the very nature of dealer markets leads to a greater volume of inter-dealer trades than those completed through an order-driven system. *Ceteris paribus*, however, we would expect the turnover of a dealer market to exceed that of an order-driven market. Since the average holding period of five out of the six UK ADRs that are listed on the NYSE is shorter than the average holding period of their underlying shares, we could loosely argue that this constitutes further evidence to the effect that transaction taxes lengthen holding periods.

Table H
Variance ratios of ADRs to their underlying shares

Company	Observations	Variance Ratio[1]	P-value
Burmah Castrol	132	0.6904	0.0174
Rank Group	156	0.5445	0.0000
Reuters	400	0.8377	0.0152
Rexam	72	0.5434	0.0058

[1] The volatility ratio is: $\dfrac{\widehat{\sigma^2}\left(\ln\frac{p_t^{ADR}}{p_{t-1}^{ADR}}\right)}{\widehat{\sigma^2}\left(\ln\frac{p_t^{UND}}{p_{t-1}^{UND}}\right)}$.

Data source: Reuters.

lower than the underlying sample variance, contradicting the hypothesis put forward by the proponents of the tax. These findings, however, suffer from two main shortcomings. First, the volatility ratio test assumes normality of returns, whereas the unconditional distribution of returns is known to have fatter tails than the normal distribution and to be characterised by time-dependent conditional volatility. Second, the findings are based on the comparison of the sample variances of two instruments with significantly different turnover characteristics. Since it is well documented that volatility and the change in log prices are positively correlated,(30) the lower volatility exhibited by the ADR returns may well be a result of the fact that, for three out of our four stocks, ADR turnover is dramatically smaller than underlying turnover (although this is not the case for Reuters Holdings, see Table C).

As mentioned above, financial data are known to exhibit time-varying conditional volatility, that is periods of low volatility being followed by periods of high volatility.(31) The GARCH model developed by Bollerslev (1986), as a natural extension to the ARCH class of models introduced by Engle (1982), has been used extensively to fit high frequency financial data. In what follows, we use univariate GARCH models to investigate stamp duty effects on UK equity volatility. Our approach is similar to that of Barr and Sellin (1996) who use Swedish data to test for such effects.(32)

(30) See Karpoff (1987) for a survey of the relation between trading volume and price variability.

(31) See Bollerslev, Chou and Kroner (1992) and Bollerslev, Engle and Nelson (1994) for a review of the literature on ARCH modelling in finance.

(32) Kupiec (1989) uses GARCH-M models to test for the effects of initial margin requirements on volatility.

The estimations are based on continuously compounded FTSE-All Share index returns of different frequencies covering similar periods, ie daily returns for the period between 2 January 1969 and 22 November 1996, weekly returns for the period between 8 January 1965 and 21 June 1996, and monthly returns for the period between January 1955 and December 1995. Whilst the daily and weekly data cover four stamp duty regimes, the monthly data cover five (see Section 2 for details).

Nonsynchronous trading in the stocks that constitute return indices is known to result in significant serial dependence in index returns [Scholes and Williams (1977) and Lo and MacKinlay (1990)]. In addition, prior to Big Bang, the FTSE-All Share index was computed using closing midquotes 'hand-collected' from individual jobbers resulting in further 'staleness' in prices. We allow for potential serial correlation by imposing an ARMA specification to model the level of the returns. In the estimation using the daily data, day of the week effects on the level of returns (ie pertaining to the ARMA specification) are removed by putting in dummy variables d_1, d_2, d_4, d_5, which equal one if the trading day is a Monday, Tuesday, Thursday and Friday, respectively, and equal zero otherwise. Finally, in our specification the transaction tax enters the standard GARCH model multiplicatively. This ensures the positivity of conditional volatility. The volatility specification takes the form:

$$\begin{aligned} y_t &= d_0 + \sum_{i=1}^{p} \phi_i y_{t-i} + \sum_{j=1}^{q} \theta_j \varepsilon_{t-j} + \eta_t, \\ h_t &= \exp(\gamma \tau_t) \times \left(\kappa + \sum_{i=1}^{gp} \alpha_i h_{t-i} + \sum_{j=1}^{gq} \delta_j \varepsilon_{t-j}^2 \right), \end{aligned} \qquad (\mathbf{7})$$

where y_t is the compounded returns series, d_0 is a constant, τ_t is the stamp duty rate, h_t is the conditional volatility of the innovations ε_t, $\varepsilon_t = \sqrt{h_t}\eta_t$ and η_t are normally distributed with zero mean and unitary variance. With the specification in (**7**), stamp duty is found to have positive effect on volatility if the point estimate of γ is greater than zero and *vice versa*. The advantage of this parameterisation is that stamp duty is allowed to have either positive or negative effects of unrestricted magnitude.(33)

(33) Another way to model stamp duty effect is, as in Barr and Sellin (1996), to enter

In searching for the best specification, models of various orders for the ARMA(p,q) and GARCH(gp,gq) components are estimated. Among models satisfying standard statistical assumptions (ie independence and homoskedasticity), model selection is based on the Schwartz information criterion. For data of all frequencies, the GARCH(1,1) model is found to be sufficient to account for heteroskedasticity. As we can see from the second columns of Tables I, J and K, the results of the estimation suggest that stamp duty has a small but *positive* and statistically significant effect on daily and weekly conditional volatility and a negative but insignificant effect on monthly volatility. However, the inference is based on the assumption that the conditional density of returns is normal. The Bera-Jarque statistic reported in the bottom of the tables suggests that this is not the case. Although it has been shown that the unconditional distribution of ε_t in model (**7**) with conditional normal errors has fatter tails than the normal distribution [Bollerslev (1986)], this does not fully account for the leptokurtosis exhibited by most financial time series.

To allow for leptokurtosis, the same model selection procedure is reiterated assuming that $\varepsilon_t/\sqrt{h_t}$ are drawn from a t-distribution with ν degrees of freedom, where ν is a parameter to be estimated by maximum likelihood [see Hamilton (1994)]. The fourth columns of Tables I, J and K report the results. For all frequencies, the TGARCH(1,1) model fits the data better than the GARCH(1,1) model as indicated by the Schwartz information criterion. In all cases the inverse of the kurtosis parameter $1/\nu$ is statistically greater than 0 (normality corresponds to $1/\nu = 0$), implying that the t-distribution is a better approximation.(34) Using the TGARCH(1,1) model with the weekly and monthly data, the point estimates of γ are both small and positive but only statistically significant for the weekly returns. As for the daily returns, γ is postive, statistically significant and of the same order of magnitude as with the GARCH(1,1) model. The Portmanteau statistic ($Q_{85} = 108.8337$), however, indicates that the ARMA(9,0)-TGARCH(1,1) model does not account adequately for the serial correlation in the level of returns.

$\gamma\tau_t$ additively, i.e. $h_t = \gamma\tau_t + \kappa + \sum_{i=1}^{gp}\alpha_i h_{t-i} + \sum_{j=1}^{gq}\delta_j\varepsilon_{t-j}^2$. This, however, creates problems in the estimation where non-negativity may not be satisfied if $-\gamma\tau$ is too large.

(34) Testing the null hypothesis $H_0 : 1/\nu = 0$ with likelihood ratio test results in $\chi^2(1)$ statistics of 119.106, 99.867 and 52.99 for the daily, weekly and monthly returns respectively.

Table I
Daily Data (2 January 1969 - 22 November 1996): Full sample results

Model	GARCH(1,1)-ARMA (9,0)		TGARCH(1,1)-ARMA(9,0)	
κ	2.2216e-06	(-117.8290)†	2.4697e-06	(-90.5391)
α	0.8661	(13.7068)	0.8560	(12.0126)
δ	0.0959	(3.2781)	0.0890	(2.6886)
d_0	0.0009	(4.4540)	0.0008	(4.3207)
d_1	-0.0010	(-3.7073)	-0.0009	(-3.3190)
d_2	-7.0876e-05	(0.2502)	3.3884e-05	(0.1226)
d_4	-0.0007	(-2.5088)	-0.0006	(-2.1414)
d_5	-3.9791e-05	(-0.1391)	-4.9698e-05	(-0.1787)
ϕ_1	0.1808	(14.1995)	0.1808	(14.5219)
ϕ_2	-0.0390	(-0.302)	-0.0133	(-1.074)
ϕ_3	-0.0019	(-0.1410)	-0.0079	(-0.6225)
ϕ_4	0.0069	(0.5453)	0.0084	(0.6657)
ϕ_5	-0.0053	(-0.434)	-0.0033	(-0.2688)
ϕ_6	-0.0054	(-0.4425)	-0.0038	(-0.3165)
ϕ_7	-0.0275	(-2.1633)	-0.0267	(-2.1605)
ϕ_8	0.0309	(2.478)	0.0312	(2.5423)
ϕ_9	0.0377	(3.1623)	0.0354	(3.0089)
γ	0.0105	(3.6891)	0.0188	(4.3843)
$\exp(\gamma\bar{\tau})$	1.0124		1.0223	
ν	—	—	11.9250	(27.4455)
Q_{85}	106.1064	(0.0604)‡	108.8337	(0.04176)
Q^2_{85}	68.5756	(0.9031)	73.6852	(0.8045)
Bera-Jarque	104.1806	(2.3849e-23)	112.0774	(4.5993e-25)
AIC	-6.7093		-6.7427	
SC	-6.6918		-6.7243	
log likelihood	23711.904		23831.010	

† Asymptotic t-statistics in parentheses.
‡ P-values in parentheses.
Note: $\exp(\gamma\bar{T})$: Effect of tax on $\hat{\sigma}_t^2$ evaluated at the mean of tax, Q_l: lth order Ljung-Box test statistics for $\hat{\epsilon}_t/\hat{\sigma}_t$, P-value in parenthesis below; Q_l^2: lth order Ljung-Box test statistics for $\hat{\epsilon}_t^2/\hat{\sigma}_t^2$, P-value in parenthesis below; AIC: Akaike information criterion ($-\frac{2}{T}\times$ log-likelihood $+\frac{2K}{T}$); SC: Schwartz information criterion ($-\frac{2}{T}\times$ log-likelihood $+\frac{K\ln T}{T}$); *Bera-Jarque*: Bera-Jarque normality test, P-value in parenthesis below; the number of observations is 7072.
Data source: Datastream.

Table J
Weekly Data (week ending 8 January 1965 - week ending 21 June 1996): Full sample results

Model	GARCH(1,1)-ARMA(2,1)		TGARCH(1,1)-ARMA(2,1)	
κ	1.8860e-05	(-39.0503)†	3.0726e-05	(-33.7430)
α	0.8452	(5.8425)	0.7928	(5.7269)
δ	0.1215	(1.7323)	0.1006	(1.4526)
d_0	0.0049	(5.4467)	0.0052	(5.9294)
ϕ_1	-0.6093	(-6.9733)	-0.6138	(-6.1617)
ϕ_2	0.1633	(5.8033)	0.1257	(4.5499)
θ_1	0.6842	(8.2145)	0.6456	(6.5573)
γ	0.0068	(1.0932)	0.0407	(2.5207)
$\exp(\gamma\bar{\tau})$	1.0079		1.0483	
ν	—	—	8.3049	(11.4070)
Q_{41}	47.7353	(0.2179)‡	52.2928	(0.1112)
Q^2_{41}	15.4617	(0.9999)	13.4553	(1.0000)
Bera-Jarque	60.3943	(0.0042)	89.2182	(4.2317e-20)
AIC	-4.7409		-4.8006	
SC	-4.7145		-4.7709	
log likelihood	3895.5218		3945.4554	

† Asymptotic t-statistics in parentheses.
‡ P-values in parentheses.
Note: $\exp(\gamma\bar{T})$: Effect of tax on $\hat{\sigma}_t^2$ evaluated at the mean of tax, Q_l: lth order Ljung-Box test statistics for $\hat{\epsilon}_t/\hat{\sigma}_t$, P-value in parenthesis below; Q_l^2: lth order Ljung-Box test statistics for $\hat{\epsilon}_t^2/\hat{\sigma}_t^2$, P-value in parenthesis below; AIC: Akaike information criterion ($-\frac{2}{T}\times$log-likelihood$+\frac{2K}{T}$); SC: Schwartz information criterion ($-\frac{2}{T}\times$ log-likelihood$+\frac{KlnT}{T}$); *Bera-Jarque*: Bera-Jarque normality test, P-value in parenthesis below; the number of observations are 1642.
Data source: Datastream.

The abnormally volatile period of the early 1970s and the October 1987 crash may be influential in determining the size and significance of the reported results. To see how the results are affected by periods of 'extreme volatility' we re-estimate the models after removing from each series observations exceeding the mean return by more than four times the standard deviation. These 'outliers' correspond mainly to the crash of October 1987 and the 'abnormally' volatile period of March 1974 and January 1975.

Table K
Monthly Data (January 1955 - December 1995): Full sample results

Model	GARCH(1,1)-ARMA(1,0)		TGARCH(1,1)-ARMA(1,0)	
κ	0.0004	(-18.2032)†	0.0007	(-13.6379)
α	0.7537	(4.1432)	0.5907	(2.6296)
δ	0.1320	(1.3510)	0.1276	(0.9027)
d_0	0.0066	(2.6259)	0.0092	(4.3411)
ϕ_1	0.0528	(0.8908)	0.0771	(1.6201)
γ	-0.0077	(-0.5106)	0.0400	(0.7246)
$\exp(\gamma\bar{\tau})$	0.9897			1.0549
ν	—	—	5.2232	(3.6986)
Q_{23}	26.7136	(0.2683)‡	28.4421	(0.1995)
Q^2_{23}	17.5989	(0.7789)	19.8937	(0.6483)
Bera-Jarque	25.0219	(3.6861e-06)	30.3643	(2.5497e-07)
AIC	-2.9709		-3.0750	
SC	-2.9195		-3.0151	
log likelihood	733.8761		760.3724	

† Asymptotic t-statistics in parentheses.

‡ P-values in parentheses.

Note: $\exp(\tau\bar{\gamma})$: Effect of tax on $\hat{\sigma}^2_t$ evaluated at the mean of tax, Q_l: lth order Ljung-Box test statistics for $\hat{\epsilon}_t/\hat{\sigma}_t$, P-value in parenthesis below; Q^2_l: lth order Ljung-Box test statistics for $\hat{\epsilon}^2_t/\hat{\sigma}^2_t$, P-value in parenthesis below; AIC: Akaike information criterion ($-\frac{2}{T}\times$log-likelihood$+\frac{2K}{T}$); SC: Schwartz information criterion ($-\frac{2}{T}\times$ log-likelihood$+\frac{KlnT}{T}$); *Bera-Jarque*: Bera-Jarque normality test, P-value in parenthesis below; the number of observations is 492.

Data source: London Business School.

Table L
Daily Data (2 January 1969 - 22 November 1996): Excluding 'outliers'

Model	GARCH(1,1)-ARMA(9,0)		TGARCH(1,1)-ARMA(9,0)	
κ	1.9702e-06	(-114.7455)†	2.0067e-06	(-91.0940)
α	0.8716	(14.0191)	0.8773	(12.3390)
δ	0.07793	(2.3470)	0.0779	(2.4363)
d_0	0.0007	(3.7611)	0.0007	(3.7595)
d_1	-0.0008	(-2.9729)	-0.0008	(-2.9732)
d_2	1.5315e-05	(0.0412)	1.7652e-04	(0.0633)
d_4	-0.0006	(-1.9489)	-0.0006	(-1.9471)
d_5	1.1534e-05	(0.0412)	1.1733e-05	(0.0418)
ϕ_1	0.1815	(14.4340)	0.1816	(14.4480)
ϕ_2	-0.0004	(-0.0337)	-0.0007	(-0.0556)
ϕ_3	-0.0067	(-0.5269)	-0.0069	(-0.5412)
ϕ_4	0.0080	(0.6311)	0.0084	(0.6640)
ϕ_5	-0.0057	(-0.4446)	-0.0057	(-0.4495)
ϕ_6	-0.0003	(-0.0202)	-0.0007	(-0.0491)
ϕ_7	-0.0288	(-2.2970)	-0.0290	(-2.3040)
ϕ_8	0.0311	(2.5167)	0.0313	(2.5310)
ϕ_9	0.0379	(3.1557)	0.0380	(3.1757)
γ	0.0123	(3.9371)	0.0133	(4.8000)
$\exp(\gamma\bar{\tau})$	1.0145		1.0156	
ν	—	—	841.4400	(1.3955)
Q_{85}	101.1290	(0.1118)‡	101.068	(0.1300)
Q^2_{85}	86.6915	(0.4286)	87.0956	(0.4166)
Bera-Jarque	12.6619	(0.0019)	12.7027	(0.0017)
AIC	-6.7930		-6.7930	
SC	-6.7755		-6.7744	
log-likelihood	24007.3860		24008.0230	

† Asymptotic t-statistics in parentheses.
‡ P-values in parentheses.
Note: $\exp(\gamma\overline{T})$: Effect of tax on $\hat{\sigma}_t^2$ evaluated at the mean of tax, Q_l: lth order Ljung-Box test statistics for $\hat{\epsilon}_t/\hat{\sigma}_t$, P-value in parenthesis below; Q_l^2: lth order Ljung-Box test statistics for $\hat{\epsilon}_t^2/\hat{\sigma}_t^2$, P-value in parenthesis below; *AIC*: Akaike information criterion ($-\frac{2}{T} \times$ log-likelihood $+ \frac{2K}{T}$); *SC*: Schwartz information criterion ($-\frac{2}{T} \times$ log-likelihood $+ \frac{K\,lnT}{T}$); *Bera-Jarque*: Bera-Jarque normality test, P-value in parenthesis below; the number of observations is 7031 after removing 41 outliers which were more than four standard deviations away from the mean.
Data source: Datastream.

Tables L, M and N report the results of the estimation for both GARCH and TGARCH specifications. For weekly and monthly returns the TGARCH(1,1) model fits the data better than the GARCH(1,1) model. In these two cases the inverse of the kurtosis parameter is statistically greater than 0. For daily returns, however, with a $\chi^2(1)$ statistic of 1.396 , $1/\nu$ is statistically indistinguishable from 0. This implies that both distributional assumptions, normality as indicated by the Bera-Jarque and t-distribution as indicated by the likelihood ratio test, are inadequate. Using the TGARCH(1,1) model with weekly and monthly returns, the point estimates of γ are positive, statistically

Table M
Weekly Data (week ending 8 January 1965 - week ending 21 June 1996): Excluding 'outliers'

Model	GARCH(1,1)-ARMA(2,1)		TGARCH(1,1)-ARMA(2,1)	
κ	2.5332e-05	(-35.1390)†	2.073e-05	(-29.7356)
α	0.8343	(5.8661)	0.8387	(5.0467)
δ	0.0937	(1.3822)	0.0901	(1.1461)
d_0	0.0050	(5.5900)	0.0052	(5.7945)
ϕ_1	-0.6030	(-5.5193)	-0.6229	(-5.7116)
ϕ_2	0.1277	(4.5871)	0.1140	(4.0730)
θ_1	0.6433	(5.9716)	0.6490	(6.0150)
γ	0.0228	(2.2980)	0.0252	(2.0940)
$\exp(\gamma\bar{\tau})$	1.0268		1.0297	
ν	—	—	12.4600	(7.1480)
Q_{41}	43.0100	(0.3850)‡	44.4880	(0.3271)
Q^2_{41}	48.1250	(0.2070)	48.8128	(0.1878)
Bera-Jarque	11.0197	(0.0040)	11.6226	(0.0030)
AIC	-4.8314		-4.8415	
SC	-4.8051		-4.8119	
log-likelihood	3969.7547		3979.0300	

† Asymptotic t-statistics in parentheses.
‡ P-values in parentheses.
Note: $\exp(\gamma\bar{T})$: Effect of tax on $\hat{\sigma}^2_t$ evaluated at the mean of tax, Q_l: lth order Ljung-Box test statistics for $\hat{\epsilon}_t/\hat{\sigma}_t$, P-value in parenthesis below; Q^2_l: lth order Ljung-Box test statistics for $\hat{\epsilon}^2_t/\hat{\sigma}^2_t$, P-value in parenthesis below; *AIC*: Akaike information criterion ($-\frac{2}{T}\times$log-likelihood$+\frac{2K}{T}$); *SC*: Schwartz information criterion ($-\frac{2}{T}\times$ log-likelihood $+\frac{KlnT}{T}$); *Bera-Jarque*: Bera-Jarque normality test, P-value in parenthesis below; the number of observations are 1634, after removing 8 outliers which were more than four standard deviations away from the mean.
Data source: Datastream.

significant for the weekly returns and of very similar magnitude to the point estimates obtained by estimating the models using the full sample.(35) Despite the violation of the distributional assumption for the daily data, the point estimates of γ obtained from the estimation of

(35) It is well known that the impact of news may have an asymmetric effect (otherwise knows as 'leverage effect') on the conditional volatility of returns. Several ways have been developed to allow for the asymmetries. Prevalent amongst them are the exponential GARCH (EGARCH) models of Nelson (1991) and the model by Glosten, Jagannathan and Runkle (GJR) (1989). We estimated both types of the model. In the case of the GJR model we could not obtain convergence. In the case of the EGARCH models, we could not find a parsimonious specification which accounted for the heteroscedasticity in daily returns. EGARCH models of order higher than (1,1), however, could fit the weekly and monthly data adequately. The effects of stamp duty on volatility thus obtained are similar to those obtained using the TGARCH(1,1) models.

Table N
Monthly Data (January 1955 - December 1995): Excluding 'outliers'

Model	GARCH(1,1)	ARMA(1,0)	TGARCH(1,1)	ARMA(1,0)
κ	0.0006	(-12.6490)†	0.0006	(-11.7590)
α	0.5819	(2.4640)	0.6041	(2.1770)
δ	0.1015	(0.6950)	0.1187	(0.6952)
d_0	0.0075	(3.2664)	0.0080	(4.0876)
ϕ_1	0.0538	(0.9835)	0.0611	(1.2100)
γ	0.0547	(1.1440)	0.0400	(0.7564)
$\exp(\gamma\bar{\tau})$	1.0759		1.0551	
ν	—	—	8.8848	(3.5766)
Q_{22}	26.1040	(0.2959)‡	25.3268	(0.3337)
Q^2_{22}	23.5790	(0.4274)	21.3170	(0.5618)
Bera-Jarque	7.5700	(0.0227)	9.0281	(0.0110)
AIC	-3.1248		-3.1406	
SC	-3.0734		-3.0807	
log-likelihood	776.4575		770.3714	

† Asymptotic t-statistics in parentheses.
‡ P-values in parentheses.
Note: $\exp(\tau\bar{\gamma})$: Effect of tax on $\hat{\sigma}^2_t$ evaluated at the mean of tax, Q_l: lth order Ljung-Box test statistics for $\hat{\epsilon}_t/\hat{\sigma}_t$, P-value in parenthesis below; Q^2_l: lth order Ljung-Box test statistics for $\hat{\epsilon}^2_t/\hat{\sigma}^2_t$, P-value in parenthesis below; AIC: Akaike information criterion ($-\frac{2}{T}\times$log-likelihood$+\frac{2K}{T}$); SC: Schwartz information criterion ($-\frac{2}{T}\times$ log-likelihood $+\frac{KlnT}{T}$); *Bera-Jarque*: Bera-Jarque normality test, P-value in parenthesis below; the number of observations is 488, after the removal of three outliers which were 4 standard deviations away from the mean.
Data source: London Business School.

GARCH(1,1) and TGARCH(1,1), respectively, are in line with those based on the weekly and monthly returns.

Since our data cover a rather long period of time, one concern may be that the estimates of γ may be picking up effects of structural changes. More specifically, different stamp duty regimes may coincide with different structural regimes where volatility may differ due to reasons other than stamp duty. To explore this possibility, the GARCH estimations are run again with the stamp duty specification excluded.

For the monthly and weekly returns only TGARCH(1,1) results are examined since TGARCH is found to be a better specification. Without the stamp duty specification, we find GARCH(1,1) and TGARCH(1,1) insufficient in accounting for heteroskedasticity for the daily return data. For the daily return data, the analysis is based on results from a TGARCH(2,1) model which is favoured by a test of GARCH(2,1) against TGARCH(2,1). Using the parameter estimates, the conditional volatility is computed and plotted in Chart 5. In the right panel of the chart we plot the conditional volatility which has been predicted using the full sample, whereas in the left panel we plot predicted conditional volatility using the sample which excludes the 'abnormally' volatile outliers. A striking feature of conditional volatility, revealed by these graphs, is that except for the period roughly between 1973-77 and the period corresponding to the October 1987 market break-down, there is not much variation in the pattern of conditional volatility across stamp duty regimes. Moreover, the period of relatively high volatility is unlikely to have been caused by a change in the rate of stamp duty as it starts before the change took place and does not last as long.(36)

The volatile period of the early 1970s falls partly in the regime of a high stamp duty rate equal to 2%. For the daily and weekly return data, there is only one regime with a 2% stamp duty rate which is also the highest. This explains why γ is found to be positive and statistically significant. In contrast, the monthly return data cover two stamp duty regimes with a 2% rate. The fact that there is no anomalous volatility in one of these high stamp duty regimes helps the model to identify the effects of stamp duty. It seems, therefore, that it is due to this additional piece of information in the monthly data that insignificant effects of stamp duty are found.

In short, visual examination of the predicted conditional volatility provides no evidence of a positive effect of stamp duty on conditional volatility. The visual examination also suggests that the positive effect of stamp duty on daily and weekly volatility based on the specification in (**7**) may be a result of a haphazard surge in volatility which coincided with the rise in the rate of stamp duty. We conclude therefore, that whilst there is no evidence of a positive effect of stamp duty on volatility, there is certainly no evidence of a negative effect either.

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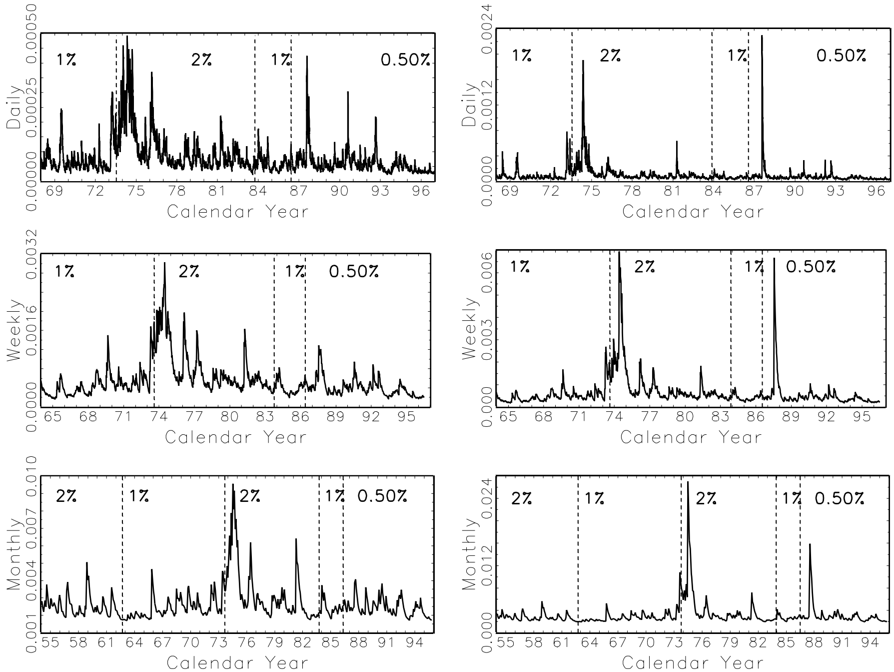
(36) Anderson and Breedon (1996) estimate monthly conditional volatility over the period 1945-1995 and find a pattern of volatility very similar to the one presented in the bottom left panel of Chart 5. They also note that the high volatility of the early 1970s may have been a result of a structural break in 1972, coinciding with the end of Bretton-Woods (subsequent tests, however, reject the hypothesis of a structural break).

Chart 5
Predicted conditional volatility



7 Conclusion

This paper has investigated the effects of stamp duty on the level and volatility of UK equity prices. The results obtained suggest that:

1 Announcements of changes in the rate of stamp duty have been followed by significant changes in the UK equity index.

2 Comparing synchronous ADR and underlying share quotes, for a sample of four stocks, we find that in the presence of market segmentation, the midpoint quotes of ADRs (which are not subject to stamp duty) are higher than the midpoint quotes of their underlying asset (which are subject to stamp duty). When the ADR and underlying markets are linked by extensive inter-market arbitrage, the midpoint quote of the ADR is economically and statistically indistinguishable from the midpoint quote of the underlying share.

3 If stamp duty is capitalised in prices, we would expect that the expected returns on ADRs would be lower than their pre-stamp duty expected returns on the underlying shares. Using an extended sample of companies, we find that expected pre-stamp duty returns on underlying assets are consistently higher than expected returns on their corresponding ADRs, *albeit* not at a statistically significant level. The magnitude of the estimated difference suggests that investors would hold underlying shares for a longer period than they would hold their corresponding ADRs in order to break even. We find evidence in support of this hypothesis. Overall, both the announcement effects analysis and the comparison of ADRs with their underlying shares suggest that stamp duty is capitalised in prices.

4 Contrary to the arguments put forward by proponents of transaction taxes, but also contrary to theoretical arguments suggesting that volatility is monotonically increasing in the rate of the STT, we find no evidence of a stamp duty effect on returns volatility.

Evidence on the effects of transaction taxes on the level and volatility of equity prices, using data from countries with a greater variability in their transaction tax rates, would add further empirical content to the long-standing debate on the effects of the Tobin tax. An interesting topic for further research would involve the extension of theoretical models of volume [for example Wang 1994, Blume *et al* 1994] to incorporate the effects of transaction taxes. Moreover, our understanding of the economic process by which transaction taxes affect asset prices and volatility would benefit greatly from more rigorous theoretical insights.

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