

The (implicit) cost of equity trading at the Oslo Stock Exchange. What does the data tell us?

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Abstract

We empirically investigate the costs of trading equity at the Oslo Stock Exchange in the period 1980–2008. We show the time series evolution of different measures of (implicit) trading costs: bid/ask spreads, the Roll (1984) measure and the Lesmond, Ogden, and Trzcinka (1999) estimate. We find a clear time variation in these measures, with estimated trading costs much lower in the late eighties and nineties than in the early nineties and just after 2000. The cost of trading has sunk in recent years, but not dramatically compared to earlier periods.

Introduction

The objective of this paper is to empirically investigate the cost of equity trading at the Oslo Stock Exchange, using data from 1980 to 2007. Conceptually this is a simple question to ask, but as a practical matter it is much harder to answer. The main problem is that the concept of *cost of equity trading* is not well defined, and there are many aspects of it.

Let us discuss a simple example. Suppose you want to buy 100 shares of StatoilHydro. Looking at current quotes you see the stock trading at NOK 137.80. You would therefore expect to pay NOK 13 780 to acquire this position, and give instructions to buy 100 shares to your broker. In the end you paid a total of NOK 13 950 to acquire the 100 shares. The *trading cost* of an equity position concerns such differences, differences in values before and after a trade.

In thinking about trading costs we usually distinguish the following concepts.¹

1. Direct costs of trading
2. Indirect costs of trading.
 - (a) Price impact
 - (b) Opportunity costs/Implementation shortfall

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¹This is one possible way of understanding transaction costs. An alternative, which is used in Baker (1996), is to distinguish 1) Direct transaction costs, 2) Bid-ask spread, 3) Market impact costs and 4) Delay and search costs. This categorization is often easier to intuitively understand, but the components are not mutually exclusive. For example, part of the market impact is usually covered by the bid/ask spread.

The direct costs of trading are the easy ones to measure. They are such items as processing costs from the exchange, broker fees, and the like. In the example, suppose you paid your broker NOK 100 to cover all such fees. This would translate into a (direct) trading cost relative to the initial value of $\frac{100}{13780} = 0.73\%$. But that does not explain the whole difference between the initial price and the final cost. The remainder is due to *price impact*, that prices move due to your order. Suppose that when your broker enters your order into the limit order book, the best ask (price at which a trader is willing to sell) is 138.50 and best bid (price at which trader is willing to buy) is 137.80. Your broker's choice now depend on your instructions. If you *really* want the shares, the broker can accept the current best price of 138.50. To do so the broker will submit a limit order to buy 100 shares at 138.50. This is the price impact in this case, the difference between the last trade (137.80) and the price improvement necessary (138.50) to make the trade immediately.

If you had been willing to take the risk of *not* getting the stock, your broker could have entered a buy order for 100 stocks at (say) 138.00. The problem is that doing so gives you a risk that the price will move in the “wrong” direction. Suppose the news ticks in that StatoilHydro has struck a large new oil find, just after you limit order to buy has been entered. The price could immediately move to (say) 150, and at the end of the trading day you are left without any StatoilHydro stocks. Such an outcome would be an example of opportunity costs, or implementation shortfall. Implementation shortfall is usually defined as a cost due to your portfolio differing from the desired one. It is usually very hard to estimate, and it is not something that can be estimated from public data, because it needs access to data about *desired* portfolios as opposed to actual portfolios.²

As is obvious from the above example, trading costs are nontrivial to define, which of course makes them even harder to estimate empirically. In this paper we will look at different empirical measures of *some* aspect of trading costs. Typically such cost measures are estimated using data on the whole record of trades (and quotes). In this paper we want to look at the evolution over time of trading costs at the Oslo Stock Exchange. Unfortunately we have only limited data available for use in this study, namely the daily record of (closing) prices recorded at the exchange. This makes it impossible for us to calculate the direct trading costs. We therefore concentrate on the implicit trading costs. Although we are missing out on an important part of the trading costs, typical results in the literature are that the implicit trading costs are actually larger than the explicit costs.³ Our limitation to daily data means that we will need to use “rough” measures of trading costs, but it will still be informative, and of course much better than the alternative of no estimates. With that qualification, we will look at three measures of (implicit) trading costs: The bid/ask spread, the Roll (1984) measure and the Lesmond et al.

²For an example of such an estimation and some discussion about implementation shortfall, see Næs and Ødegaard (2006). For more general discussion of trading costs see for example the summary article by Keim and Madhavan (1998), and the textbook discussions in Harris (2002) and Hasbrouck (2008).

³See for example the summary article by Keim and Madhavan (1998). Using data for institutional trading in the US in the period 1991-93, they find that for the stocks in the largest NYSE quintile, implicit costs were 0.17% and explicit costs were 0.13%. For the quintile of smallest stocks at the NYSE, they estimate implicit costs of 1.35% and explicit costs of 0.42%. This was for a sample of buyer-initiated trades.

(1999) measure. We calculate these various measures for all stocks on the exchange, aggregate them in the crosssection, and look at the time series of the resulting aggregates.⁴

In the rest of the paper we discuss each of the cost measures and show the estimates. We then compare the three cost measures, and finally look at some (crosssectional) determinants of trading costs.

1 Market place and data

The analysis of this paper concerns the Oslo Stock Exchange (OSE) in the period 1980–2007. Let us first comment on the functioning of the market place and our data. At the beginning of the period the OSE was organized as a periodic auction, where brokers indicated buy and sell interest, and transactions were coordinated by an auctioneer. This system was replaced with an electronic trading system in 1988. The character of the trading system has changed over time, but its main element is an electronic limit order book where brokers enter prices and quantities. In the first years since 1988 the brokers were present at the OSE, and trading was not necessarily done through the automatic system. In 1999 this system was replaced with a fully automated system, all trading had to be done through the computer, and as a result the brokers left the stock exchange. All trading is done through terminals which can be placed anywhere. The OSE has also introduced possibilities for electronic order submission by individual traders, often called “internet trading.” In all of these systems the exchange records end-of-day prices: last trades, and current best bids and asks at the end of the day. These prices are typically those disseminated to newspapers. Due to the changing nature of trading these data have slightly different interpretations depending on time period. Before 1988, the data is the bid, ask and trade prices recorded at the last auction that day. After 1988 the prices are the last bid and ask prices present in the order book, together with the price at which the last trade was consummated.

In the following we use data for all stocks on the OSE with the exception of a few illiquid and low priced stocks.⁵ The average crosssection contains 136 shares.

2 Measures of trading costs

Let us now look at the various empirical measures of trading cost.

2.1 The bid/ask spread

The bid/ask spread is the best known measure of trading costs, and from the earlier example it is easy to see why it is used in such a way. The bid/ask spread measures the price concession a

⁴It is here fitting to mention that much of the analysis that follows is also discussed in Næs, Skjeltorp, and Ødegaard (2008a), which looks at liquidity at the Oslo Stock Exchange. Liquidity is of course related to trading costs, but there are many more aspects than trading costs to it. In this paper we concentrate on the direct implications in terms of trading costs, and leave the more general aspects of liquidity to the other paper.

⁵We filter out stocks priced under NOK 10 and stocks traded less than 20 times a year. See Ødegaard (2007) for a description of these filter rules.

Table 1 Descriptive statistics for trading cost measures

Panel A: bid/ask spread

	Whole sample		1980–1989		1990–1999		2000–2007	
	mean	median	mean	median	mean	median	mean	median
(Kroner) bid/ask spread (NOK)	4.50	1.82	7.48	3.09	5.08	2.12	3.35	1.07
Relative bid/ask spread	0.040	0.026	0.041	0.027	0.047	0.031	0.037	0.020

Panel B: The Roll measure of trading costs

	Whole sample		1980–1989		1990–1999		2000–2007	
	mean	median	mean	median	mean	median	mean	median
Roll Measure	0.0264	0.0196	0.0267	0.0229	0.0268	0.0207	0.0252	0.0180

Panel C: The LOT measure of trading costs

	Whole sample		1980–1989		1990–1999		2000–2007	
	mean	median	mean	median	mean	median	mean	median
LOT	0.0581	0.0419	0.0578	0.0461	0.0605	0.0435	0.0482	0.0306

The table in Panel A shows the averages of spreads for the whole sample and for subperiods, both kroner spread and relative spread. Each month and for each stock, we calculate the monthly average across trading dates of the bid/ask spreads for that stock. The numbers in the tables are based on these monthly averages, treating each month/stock combination as an observation.

The table in Panel B shows the averages of Roll measures for the whole sample and for subperiods. Each year and for each stock, we calculate the Roll measure using all trade dates in the year. The numbers in the table are based on these annual averages, treating each year/stock combination as an observation.

The table in Panel C shows averages of LOT measures for the whole sample and for subperiods. Each year and for each stock, we calculate the LOT measure using all trading dates in the year. The numbers in the table are based on these annual averages, treating each year/stock estimate as an observation.

trader will have to make when “crossing the spread.” In the earlier example the trader accepted the current ask price of 138.50 when the best bid was at 137.80. In this case the bid/ask spread is $138.50 - 137.80 = 0.70$. This 0.70 is then the price of crossing the spread. Very often we calculate the spread relative to the price, and find the *percentage spread*, or *relative spread*. The price we relate the spread to is typically the average of the current bid and ask price. In the given example, the relative spread is:

$$\text{Relative Spread} = \frac{0.70}{\frac{1}{2}(137.80 + 138.50)} = \frac{0.70}{138.15} = 0.005 = 0.5\%$$

But this spread measure, be it the kroner or percentage spread, is at best an incomplete measure of the cost of trading. It is important to understand its limitations. The first problem is that the bid/ask spread may understate the cost of a larger transaction. The current bid/ask spread is only valid for a given number of shares. In an electronic limit order book the best bids and asks are only valid for the number of shares at that tick in the book. In the more traditional dealer market, like the old system at NYSE, the bid and ask quotes are given by the market maker, and are only valid for a minimum number of shares, such as 100. If you want to trade larger quantities than these minimum numbers it is very likely that you will meet different prices, outside the current spread. This argument therefore says the current spread is a lower bound of the trading cost. On the other hand, there are arguments going in the opposite direction, saying that the true trading costs are *lower* than the observed spread. The intuition of this is best had by observing that traders in a market place usually arrive sequentially, and it is never sure whether the next trader is a buyer or a seller. As a result the actual trade prices tend to bounce back and forth between buy and sell quotes. If buyers and sellers are equally likely to arrive, this is used for a justification for the notion of the *half spread*, the notion that only half the time is it necessary to cross the spread, the actual trading cost is therefore only half of the spread. More generally, we introduce the notion of the *effective spread*, by assuming that there is some true equilibrium value for the stock, bracketed by the bid and ask prices. The effective spread is the difference between this true (of effective) price, and the trade price. This effective spread needs to be estimated from transaction data where all the trade prices are observed.⁶

With these qualifications we look at the actual estimates of (kroner) and (percentage) bid/ask spreads. In Panel A of table 1 we show averages and medians for these numbers for the whole period 1980–2007, and for three subperiods: 1980–1989, 1990–1999 and 2000–2007. For the median trade you have to pay a spread of NOK 1.82, or 2.6% of the trade value. This is a relatively high number. For comparison, using data for the Dow-Jones stocks at the NYSE for the whole period 1900–2000, Jones (2002) finds that the average relative spread was 0.64%, and even during the great depression in 1930, the average spread for the Dow Jones stocks was about 1.40%. Of course, the Dow Jones stocks were the largest stocks in the US, so the comparison may not be fully justified. If we limit the comparison to the largest quarter of

⁶For more complete discussion of these issues we refer to the textbook treatments in Harris (2002) and Hasbrouck (2008).

the stocks at the OSE, we find a median relative spread of 0.75%. However, if we look at the NYSE in the same period (1980–2007), average spreads were substantially lower than at the OSE, even for the largest stocks.

Another interesting question when we look at the trading costs at the OSE is their evolution over time. In figures 1 and 2 we show the evolution over time of the two spread measures. For this comparison the most interesting is the relative spread, since this controls for the fact that prices also move around over time, both due to general movements of the market, and due to listings, delistings and stock splits. We therefore concentrate on the relative spread in figure 2. We observe a clear time variation in these numbers. Estimated trading costs were lowest in the late eighties, late nineties, and the current time period. There were periods with much higher transaction costs. An interesting observation, made in both Næs et al. (2008a) and Næs, Skjeltorp, and Ødegaard (2008b), is that these movements over time very much covary with the business cycle. Transaction costs in the stock market are high in downturns of the economy, and vice versa.

2.2 The Roll (1984) measure of trading cost

The Roll (1984) measure estimates trading costs as the effective spread implicit in the sequence of trades. If we posit the existence of a constant proportional effective spread s , Roll shows how one can back this out from the autocorrelation of successive price movements. The bouncing back and forth between bid and ask will be induced partly by the magnitude of the relative spread s , and Roll shows that this leads to a calculation as follows, where r_t is the stock return at time t :

$$Scov = cov(r_t, r_{t-1})$$

and estimate s as⁷

$$\hat{s} = \begin{cases} 2\sqrt{-Scov} & \text{if } Scov < 0 \\ \text{undefined} & \text{if } Scov > 0 \end{cases}$$

Panel B of table 1 shows averages of the Roll measure. We see that the numbers are relatively comparable to the earlier spread measures. In figure 3 we show the time series evolution of the Roll measure. We see the same pattern as for the spread, costs are low and high at roughly the same times.

2.3 The Lesmond et al. (1999) measure of trading costs

Typical estimates of actual transaction costs of trading are calculated from microstructure data on actual trades. The goal of Lesmond et al. (1999) (LOT) is to find a measure of transaction

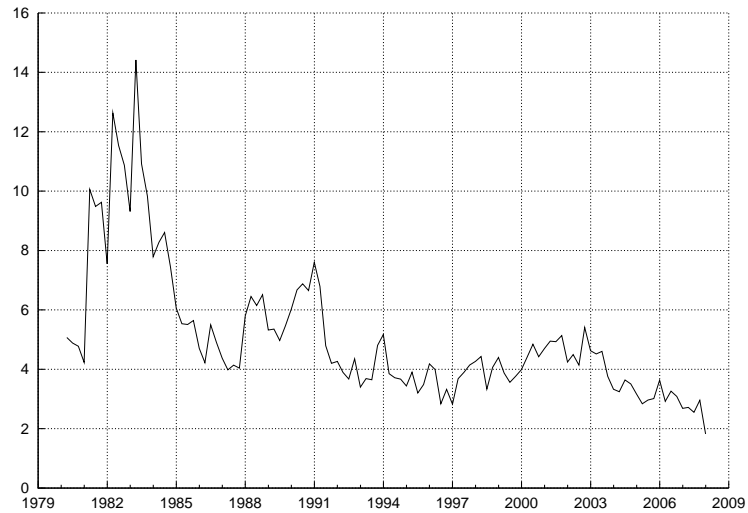
⁷The square root is only defined if $-Scov > 0$. Harris (1990) proposes to instead define

$$s = -2\sqrt{Scov} \text{ if } Scov > 0$$

but this would imply a negative trading cost, which is not economically meaningful. We therefore leave out these observations. A conceptually better way to do the estimation would be to use the Bayesian framework of the Gibbs sampler in Hasbrouck (2006), which would allow us to impose nonnegativity on the cost. Although we acknowledge that doing so would be preferable, we leave it for future work.

Figure 1 Time series evolution of bid/ask Spread

Average



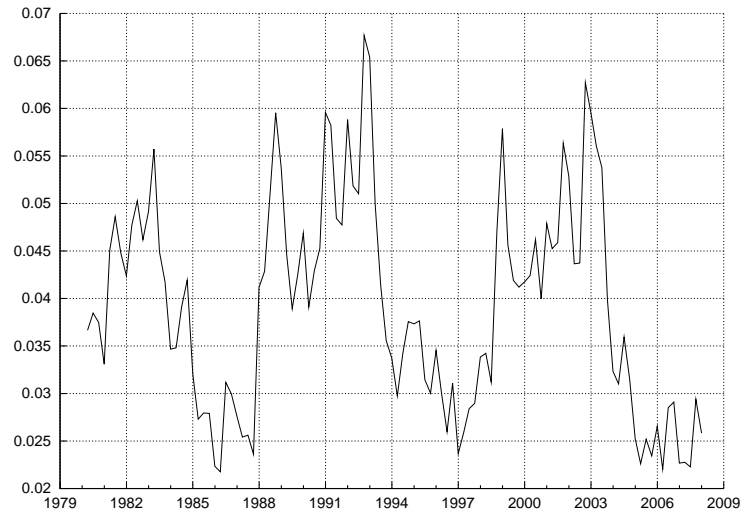
Median



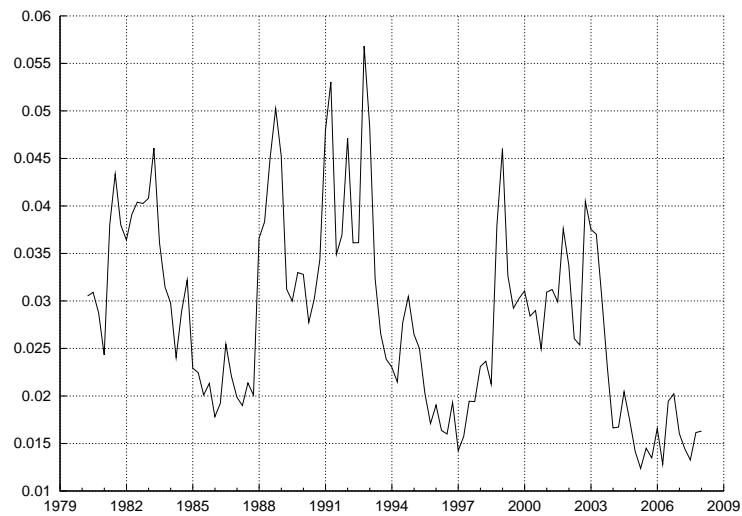
The figures show the average (top) and median (bottom) time series of the (kroner) bid/ask spread. For each stock we calculate the quarterly average bid/ask spread using all dates in a quarter. We then average these quarterly averages across stocks each quarter. The average on the top is trimmed by removing the most extreme observations on each side.

Figure 2 Time series evolution of relative bid/ask spread

Average



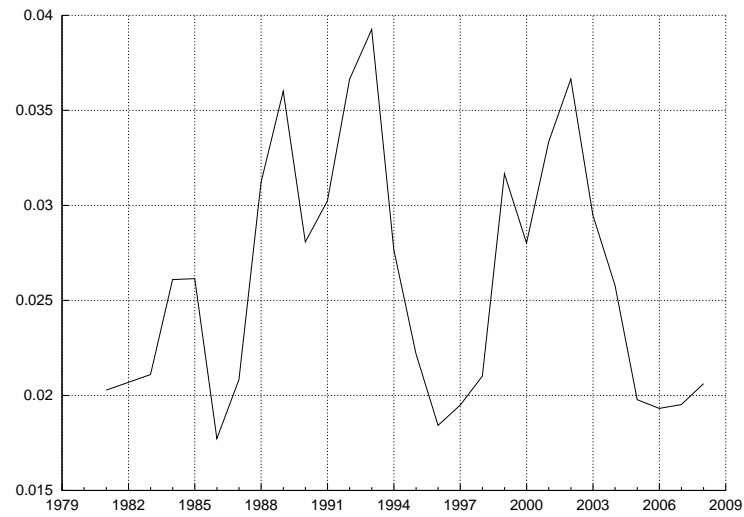
Median



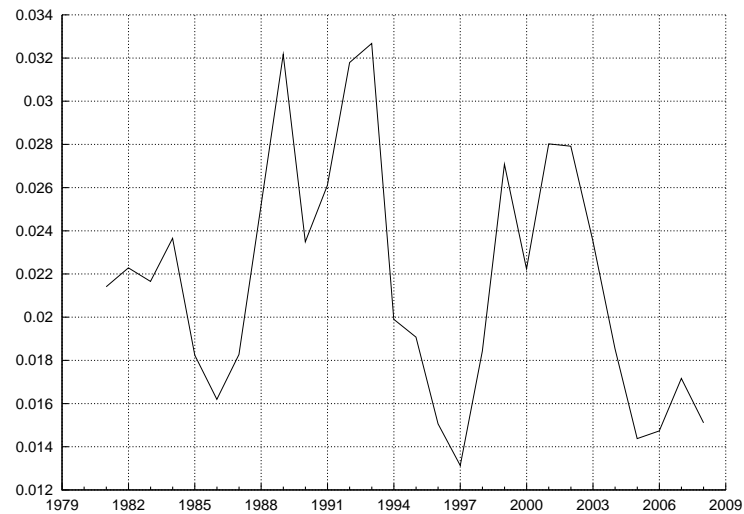
The figures show the average (top) and median (bottom) time series of the relative bid/ask spread. For each stock we calculate the quarterly average relative bid/ask spread using all trade dates in a quarter. We then average these quarterly averages across stocks. The average on the top is trimmed by removing the most extreme observations on each side at each date.

Figure 3 Time series evolution of Roll measure

Average



Median



The figures show the average (top) and median (bottom) time series of the Roll measure of transaction. For each stock we calculate the annual estimate of the Roll measure using all trade dates in the year. We then average these annual averages across stocks. The average on the top is trimmed by removing the most extreme observations on each side at each date.

costs that can be calculated using lower frequency data, such as daily returns. The idea of the model is to estimate a *threshold* where transaction costs are higher than the cost of *not* updating the price (by trading).

To understand the LOT measure, let us start by assuming there are, and suppose returns are generated according the usual “market model”

$$\tilde{R}_{jt} = a_j + b_j \tilde{R}_{mt} + \tilde{\varepsilon}_{jt}$$

where \tilde{R}_{jt} is the return on stock j at time t , \tilde{R}_{mt} is the corresponding return on the market portfolio, a_j and b_j are (stock specific) constants, and $\tilde{\varepsilon}_{jt}$ an error term.

For any change in the market return \tilde{R}_{mt} we should expect a corresponding change in the return \tilde{R}_{jt} of stock j . If we now posit a (constant) transaction cost we would only expect a change in \tilde{R}_{jt} when the change in R_{mt} is large enough to outweigh the transaction cost. Lesmond et al. (1999) propose a limited dependent variable model where observed returns \tilde{R}_{jt}^* are related to the “true” returns \tilde{R}_{jt} as follows

$$R_{jt}^* = \beta_j R_{mt} + \varepsilon_{jt}$$

where

$$\begin{aligned} R_{jt} &= R_{jt}^* - \alpha_{1j} & \text{if } R_{jt}^* < \alpha_{1j} \\ R_{jt} &= 0 & \text{if } \alpha_{2j} \geq R_{jt}^* \geq \alpha_{1j} \\ R_{jt} &= R_{jt}^* - \alpha_{2j} & \text{if } R_{jt}^* > \alpha_{2j} \end{aligned}$$

The transaction costs are represented by the constants α_{1j} and α_{2j} for each stock j . The LOT measure of trading costs are found by estimating the thresholds α_{1j} and α_{2j} . These are found by a maximum likelihood formulation by assuming Gaussian errors. From this one gets estimates $\hat{\alpha}_{1j}$ and $\hat{\alpha}_{2j}$. The difference

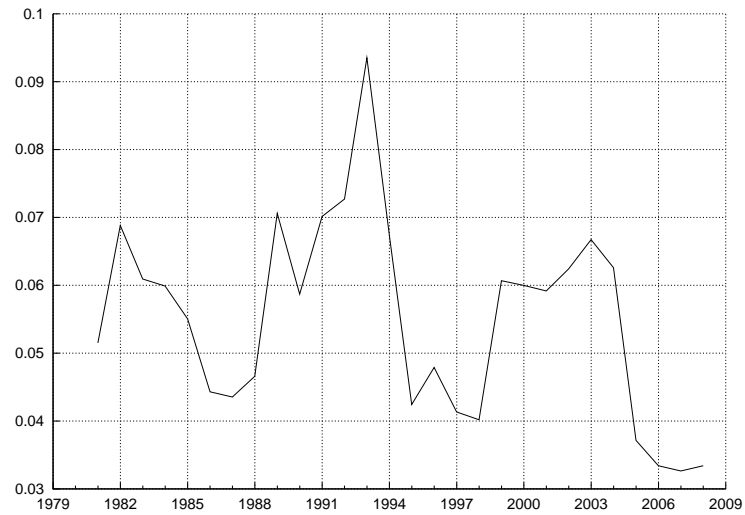
$$\widehat{LOT}_j = \hat{\alpha}_{2j} - \hat{\alpha}_{1j}$$

is the estimate of the round trip transaction cost for this stock.

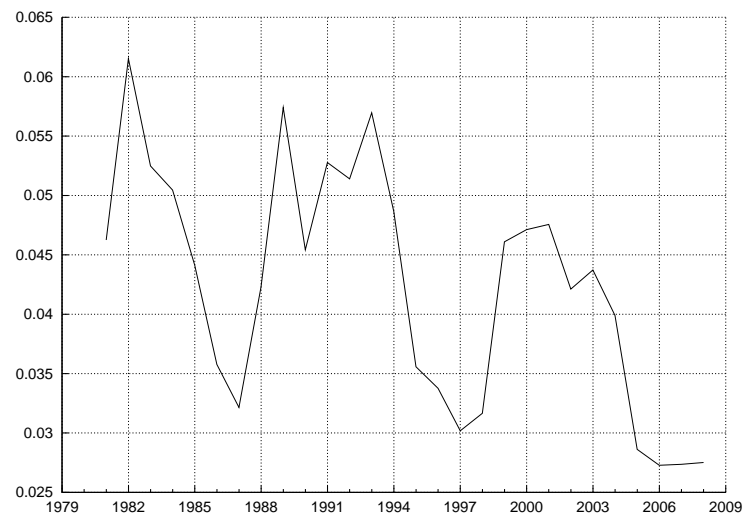
In Panel C of table 1 we show averages of estimated LOT measures. We see that the implicit transaction costs are much higher than both the relative bid/ask spreads and the Roll estimates. But, the most interesting observation is a comparison of the time series of this cost measure with the other two. Although they have been calculated using very different methods, and even different base data (spreads and returns), they very much agree on the time periods in which costs are low and when they are high. The same pattern of low costs in the late eighties and nineties and the current time, and high costs in the early eighties, nineties and just after 2000.

Figure 4 Time series evolution of the LOT measure

Average



Median



The figures show the average (top) and median (bottom) time series of the Lesmond et al. (1999) measure of transaction costs. For each stock we calculate the annual estimate of the Roll measure using all trade dates in the year. We then average these annual averages across stocks. The average on the top is trimmed by removing the most extreme observations on each side at each date.

3 Determinants of trading costs

In this section we investigate the determinants of trading costs. A stylized fact observed in many stock markets is that trading costs vary with the size (in terms of market capitalization) of the firm. The biggest firms have the lowest trading costs. We first illustrate this by showing the time series evolution of the different cost measures for portfolios sorted on size.

3.1 Illustrating size differences

A simple way to illustrate the effect of size on cost measures is to first sort into portfolios based on size, and then plot the time series of resulting estimates. This is done in figure 5, where we show the time series evolution of our three trading cost measures for size quartile portfolios. We sort the firms on the OSE into four portfolios based on market capitalization,⁸ and for each of the portfolios calculate the cost measures. For each of the three cost measures there is a clear relationship between firm size and trading costs. The lowest trading costs are found for the largest firms on the exchange.

3.2 Estimating determinants of trading costs

Let us finally consider a more formal way of investigating what factors affect trading costs. We regress the three cost measures on three factors which may be important determinants of trading costs: firm size, stock price, and stock volatility. In table 2 we show the results of three such regressions. Regarding firm size, the regressions confirms the picture of figure 5: Trading costs are decreasing in firm size, the larger the firm, the lower the trading costs of its equity. If we look at the other significant coefficients, we find that trading costs are increasing in stock price and in stock volatility.

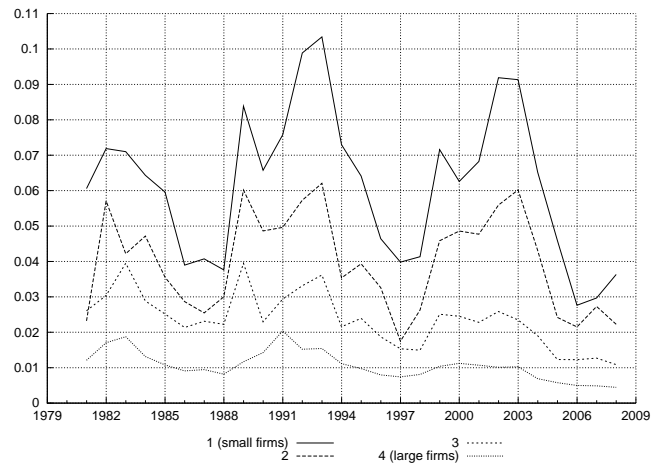
Table 2 Determinants of trading costs

Variable	Relative bid/ask spread		LOT measure		Roll measure	
	coeff	pvalue	coeff	pvalue	coeff	pvalue
constant	0.115	(0.00)	0.059	(0.00)	0.057	(0.00)
ln(Firm Size)	-0.006	(0.00)	-0.005	(0.00)	-0.002	(0.00)
ln(Stock price)	0.002	(0.00)	0.005	(0.00)	-0.000	(0.56)
Stock Volatility	0.681	(0.00)	1.950	(0.00)	0.618	(0.00)
n	3775		3781		2336	
R^2	0.54		0.78		0.43	

The table contains three different regressions, where each column shows the result of a separate regression where the dependent variable is listed at the top of the column, and the explanatory variables are listed on the left.

⁸Portfolios are recalculated annually using the end-of-year market capitalizations

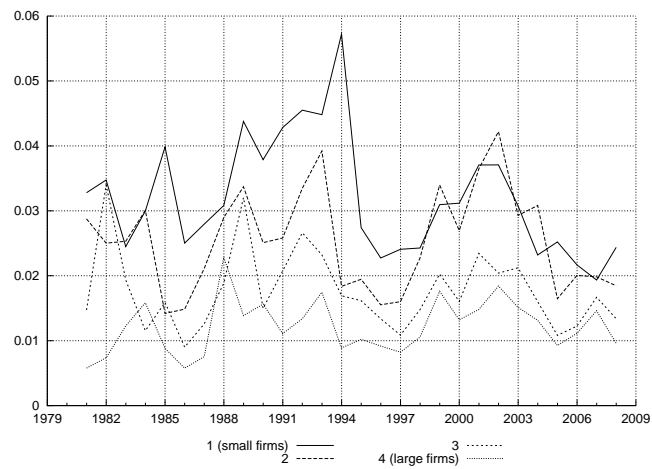
Figure 5 Time series evolution of cost measures – size sorted portfolios
BA spread



LOT



Roll



Medians for four size sorted portfolios for each of the three cost measures: Relative B/A spread,

4 Conclusion

In this paper we have empirically estimated components of the (implicit) cost of trading equity at the Oslo Stock Exchange in the period 1980–2007. We observe that the institutional environment has changed in the period, moving from period auctions to fully automated, continuous trading. We calculate three different measures of trading costs in the period, the bid/ask spread, the Roll measure and the Lesmond et al. (1999) measure. Since the measures are calculated using different data, they should differ in their sensitivity to changes in the institutional framework. Reassuringly, we observe that the three different measures to a large extent agree with each other. We find, not surprisingly, that costs at the OSE are high compared to the NYSE. We also find time variation in the costs. Costs were low in the late eighties and late nineties. Although currently estimated costs are lower than these two periods, current costs are not *that* much lower than the case in these two earlier periods. We also observe a business cycle variation in equity trading costs. Costs tend to be low in good times and high in bad times. We also find that costs vary with the value of the underlying asset, stock price and volatility.

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