Liquidity and Asset Pricing: Evidence on the Role of Investor Holding Period

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Keywords: Market microstructure, Liquidity, Holding period

JEL Codes: G10, G11, G12

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Abstract

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Introduction

Numerous empirical studies find that liquidity matters for asset returns. On the theoretical side, however, there is little agreement on what aspects of liquidity can generate large cross-sectional effects in asset returns. A number of theoretical models use the concept of *expected holding period* to link liquidity to asset prices.[1] So far, it has been hard to investigate these theories empirically. While some attempts have been made, they all suffer from lack of data on *actual holding periods*. Instead they rely on proxies of investor holding periods constructed from data on turnover. Even though a high-turnover stock necessarily has many of the stock's investors buying and selling the stock, it is by no means certain that *all* owners of the stock have short holding periods.[2] The core of this problem is that turnover is a characteristic of a stock, while holding period is a decision made by individual investors.

In the present paper, we analyze the relationship between holding periods, liquidity and asset prices using data on actual holding periods. The source of our contribution is access to the complete holdings for all investors at the Oslo Stock Exchange (OSE) over a 10-year period.[3] Our ability to measure holding periods from data on actual trading decisions at the level of individual investors, observed over a substantial period of time,

[1] Amihud and Mendelson (1986) is an early model where the expected holding period enters.

[2] The stock may have a group of very long holding period owners, but high turnover among the remaining investors.

[3] Current evidence on investor trading activity is largely based on small samples of investors, such as the the single broker customers of Barber and Odean (2000).

is quite exceptional. The only other papers which considers some of the same issues with similar data are Kyrolainen and Perttunen (2006), using data from Finland, and Dias and Ferreira (2005), using a sample of Portuguese investors. Both papers look at the holding period decisions of individual investors using datasets which are of shorter time periods, and, in the case of the Portuguese data, less complete, and neither of the papers attempts to move beyond the behaviour of individual investors to the wider implications of holding periods for the whole market.

In our work we look at three issues. First, we describe individual holding period decisions, and evaluate the determinants of these decisions. The typical holding period is found to be three quarters of a year, but the probabilities of liquidating an equity position, conditional on the length of time the ownership has lasted, show considerable time variation. Typical measures of liquidity, such as the bid/ask spread and turnover, are important determinants of individual holding period decisions. We also find clear differences in average holding periods across investor types.

Second, we ask to what degree typical proxies of holding period measure actual holding periods. We both compare actual holding period estimates to alternatives provided in the literature, and investigate the extent to which, in the cross-section of equities, holding periods and liquidity measures covary. Relative to existing evidence, holding periods seem shorter than previously thought. This is due to the fact that the distribution of actual holding periods is very skewed, at the same time as the distribution of turnover across stocks is skewed. Our estimate of the *median* holding period from turnover data is close to the *mean* actual holding period of around 2 years, a significantly higher number than the median actual holding period of 0.75 years. To investigate the consistency of holding period and liquidity measures, we construct a measure of average holding period at the stock level. As expected, the average holding period measure is positively related to spreads and negatively related to turnover. However, the correlations are surprisingly low.

Third, we investigate links between holding periods and asset prices. There are several theoretical arguments linking these. In the Amihud and Mendelson (1986) model there is an indirect link, where long term investors choose high spread stocks, and Amihud and Mendelson document a link between spreads and returns. Information based arguments, such as those in Yan and Zhang (2008), imply returns differences if long and short term investors are differently informed. To investigate these issues we therefore perform a number of cross-sectional asset pricing tests involving measures of actual holding periods. We find that while the average holding period measure is related to other measures of liquidity in the expected directions, it does a worse job in explaining the cross-section of stock returns than more standard measures of liquidity.

The paper is structured as follows. In Section 1 we briefly summarize the papers on holding periods, liquidity and asset pricing that are most relevant in our setting. Section 2 describes the market and the data set. In Section 3 we investigate the individual owners' holding period decisions. In Section 4 we look at how our actual holding periods compare to alternative proxies for holding periods suggested in the literature. We also relate holding periods to standard measures of liquidity. In Section 5 we compare the asset pricing implications of holding period measures and liquidity measures. Section 6 concludes.

1 Literature

The standard way of incorporating market frictions into asset pricing models is to assume that trading involves some *exogenous* trading cost (or illiquidity cost).[4] This implies that investors' expected holding period is crucial for the effect of illiquidity on required returns, i.e. the more often investors plan to trade, the more important are the trading costs. The importance of illiquidity costs therefore depends on the assumed structure of holding periods in a model. The simplest assumption possible is that the expected holding period is exogenous and identical for all investors. Assuming risk neutrality, these assumptions imply that the required return on assets is equal to the risk-free rate plus the per period percentage transaction cost, see Amihud et al. (2005).[5]

In the model of Amihud and Mendelson (1986), risk-neutral investors are assumed to have *different* exogenous holding periods and limited capital. These assumptions introduce a clientele effect into the solution whereby investors with long expected holding periods select stocks with high trading costs. The required return will then differ for different classes of investors, and the expected gross return becomes an increasing and concave function of the relative transaction cost. Amihud and Mendelson find empirical support for this hypothesis using spreads and stock returns from the NYSE over the 1961-80 period.[6]

[4]In fact, even the simple assumption that illiquidity reflects exogenous trading costs seriously complicates standard asset pricing models. This is because it precludes the existence of a pricing kernel that can price all securities. Explicit pricing rules can then only be derived under special assumptions, see Amihud, Mendelson, and Pedersen (2005).

[5]Risk neutrality implies that all assets are identical. Huang (2003) extends this analysis and studies the premium for liquidity risk assuming exogenous holding periods and risk-averse investors.

[6]Several other papers attempt to test the model using turnover as a proxy for holding period. Atkins and Dyl (1997) find evidence consistent with the spread-holding period relationship using the inverse of turnover as a proxy for the average holding period. Datar, Naik, and Radcliffe (1998) show that turnover is negatively related to stock returns in the cross-section, while Hu (1997) finds support for both an increasing and concave return-holding period relationship using data on returns and turnover from the Tokyo Stock Exchange. In the empirical test of their liquidity-adjusted CAPM, Acharya and Pedersen (2005) find a significant effect on prices from liquidity cost, also using turnover as proxy for

On the other hand, more realistic models with endogenous holding periods and risk-averse investors find that an exogenous liquidity cost has only miniscule effects on the level of asset returns. In a continuous-time model with exogenous asset prices, Constantinides (1986) shows that the optimal investment policy for risk-averse investors involves a trade-off between high trading costs from frequent portfolio rebalancing and utility costs from having a suboptimal asset allocation. While trading costs have a first-order effect on the demand for the asset, they only have a second-order effect on equilibrium asset returns. Vayanos (1998) extends this analysis to a general equilibrium model with endogenous holding periods. A calibration of his model gives a similar result; the effects of trading costs on equilibrium asset returns are small. Hence, we have the intriguing result that more realistic models assuming risk aversion and endogenous holding periods seem to do considerably worse in explaining empirical findings than less realistic models with risk neutrality and exogenous holding periods.

Huang (2003) notes that an important reason behind the discrepancy between theory and empirical findings regarding the effect of liquidity on asset prices is that asset pricing models in general cannot explain the observed high market trading volume. The strong dependence of liquidity premia on investor holding periods implies that theories that cannot account for observed high trading volume cannot explain observed liquidity premia either. In a model with *uncertain* exogenous holding periods, Huang shows that the premium for liquidity risk can be large if investors face liquidity shocks and are constrained from borrowing.[7]

Another and potentially related explanation is the restriction in asset pricing models that liquidity costs are exogenous. The market microstructure literature divides market frictions into asymmetric information costs and coordination costs (inventory risk and search problems), and shows that prices can diverge from long-term equilibrium values due to strategic trading behavior of investors. Thus, models that do not specify the ultimate source of trading cost differences cannot really explore how a full equilibrium will look like. For instance, it is not obvious that investors with long expected holding periods will select stocks with high trading costs since holding "long term" stocks reduces the value of the option to sell the stocks early.

While much of our analysis is inspired by models starting from the Amihud and Mendelson (1986) analysis, there are alternative formulations which may induce a link between holding periods and returns. In a recent paper, Yan and Zhang (2008) start with the premise of differently informed long term and short term investors, and show that this has implications for returns.

investors' average holding periods.

[7]Introducing additional motives for trade, Getmansky, Lo, and Makarov (2004) also find that the liquidity premium can be large when investors have high frequency trading needs.

Obviously, more knowledge about how and why expected holding periods differ among investors is highly valuable, and our paper significantly adds to our knowledge on this. There are two papers that are closely related to our analysis. Kyrolainen and Perttunen (2006) looks at a dataset of Finnish investors and Dias and Ferreira (2005) at a dataset of Portuguese investors. We expand on the analysis in these papers in a number of ways. First, while both these papers find some of the results we find on the behaviour of individual investors, neither of them go on to consider the wider implications of their findings for the cross-section of stock returns. Second, we have a more comprehensive sample of investors over a longer time period. Relative to the analysis of Kyrolainen and Perttunen (2006) we use a more correct method of analysis, based on duration analysis, which is also used in Dias and Ferreira (2005).

2 Market and data

The firms in the sample are listed on the Oslo Stock Exchange (OSE), which is a moderately sized exchange by international standards. In 1997 (about the midpoint of our sample), the 217 listed firms had an aggregate market capitalization which ranked the OSE twelfth among the 21 European stock exchanges for which comparable data are available. The number of companies on the exchange has increased from 141 in 1989 to 212 in 2003.[8]

This paper uses monthly data from the Norwegian equity market for the period 1992:12 to 2003:6. From the Norwegian Central Securities Registry (VPS) we have monthly observations of the equity holdings of the complete stock market. At each date we observe the number of stocks owned by every owner. Each owner has a unique identifier which allows us to follow the owners' holdings over time. For each owner the data include a sector code that allows us to distinguish between such types as mutual fund owners, financial owners (which include mutual funds), industrial (nonfinancial corporate) owners, private (individual) owners, state owners and foreign owners. In addition to this anonymous data set, we use public reports on individual owners' inside transactions to construct measures of insider ownership.[9] A third data source is the Oslo Stock Exchange Data Service (OBI). This source provides stock prices and accounting data. Finally, we use interest rate data from Norges Bank, the Central Bank of Norway.

[8]For some information about the structure of the Norwegian stock market we refer to Bøhren and Ødegaard (2000, 2001), and Næs, Skjeltorp, and Ødegaard (2008).

[9]For more details on this insider trading data see Eckbo and Smith (1998) and Bøhren and Ødegaard (2001).

3 What affects holding periods for individual investors?

In this section, we use duration analysis to describe actual holding periods and to study what variables might affect holding period decisions. By investigating whether the spread is an important determinant of investors' holding periods, we perform a *direct* test of the spread-holding period relationship in Amihud and Mendelson (1986).

3.1 Duration analysis

The econometric framework suited for analyzing questions about the length of time an investor chooses to keep his or her stake in a company, and what economic factors affect this decision, is duration (or survival) analysis. In duration analysis, one models the decision to terminate a relationship. In our setting, termination is the decision to liquidate an equity holding in a company.[10]

Duration analysis is the preferable method for analyzing holding period decisions because it is designed to alleviate the problem of censoring. In our setting, the censoring problem stems from the fact that we only observe investors for a limited period of time. Figure 1 illustrates the problem. Of the investors illustrated in the figure, it is only the holding period of investor A which will be measured correctly. The holding period of investor B will be *right censored*; all we see is that the investor was present at the last date and we do not know the final termination date. For investor C we correctly observe the terminal date, but we do not observe when the relationship is initiated, which is termed *left censoring*. Duration analysis involves the estimation of the probability distribution of the termination decision, taking the censoring problem into account.

This probability distribution of the termination decision can be characterized in a number of ways, for example by the *survival function*: the probability of surviving beyond a given date, or the *hazard function*: the probability of termination, conditional on having survived so far. The most common way of characterizing the probability distribution is through the hazard function. When we want to ask what factors affect duration, this is done by measuring a factor's *contribution* to the hazard function.

[10]In economics, duration models are used on e.g. labor market data to analyze determinants of the time spent unemployed, in which case the pertinent termination is movement between employment and unemployment, see Lancaster (1979) and Nickell (1979) for examples and Kiefer (1988) and van den Berg (2001) for surveys.

3.2 Estimated hazard and survival functions

We apply duration analysis to the holding periods of individual investors using monthly data for all investors at the OSE over the period 1992-2003.[11] To reduce noise, investors with less than five hundred shares are removed from the sample. Thus, we count as initiation the first time an investor is observed holding 500 or more shares, and termination when he or she reduces the stake to less than 500 shares.[12] This leaves about 1.4 million observations of investor-company durations.[13] In Table 1, we show mean and median holding periods for all owners and for owners grouped by investor type, i.e. financial, foreign, nonfinancial, individual and state investors. The numbers in the table illustrate some very interesting regularities in the data. For our purposes the most interesting number is the median, which is the holding period of the *typical investor*. Looking at all owners in the market, we find that the typical investor holds a position for 0.75 years. The median holding period varies significantly by type of investor, however. The most patient investors are private individuals, who hold their positions for 0.83 years, while the typical corporate investor, be it financial or nonfinancial, holds a position for only half a year. Note also that the mean holding periods are considerably higher than the median holding periods. Overall, the estimated mean holding period is close to 2 years, which is more than twice the length of the median holding period.[14] These findings clearly illustrate the skewed nature of the holding period distribution, where a few very long-term investors inflate the mean holding period. This feature of the data points to the need to use duration analysis to explicitly model the full distribution of holding periods, to which we now turn.

In Figure 2, we show the estimated survival- and hazard functions for the complete sample of investors. From the survival function, shown in the left panel of the figure, we can read the median holding period of 0.75 from the point where the survival function crosses the 0.5 line. Other interesting properties of holding periods are, however, better illustrated by the hazard function shown in the right panel of the figure.[15] If the proba-

[11] In survival analysis terms, our data set is a an example of spell data, where there is interval censoring since we only observe once every month, and there are some (identified) spells which may be left or right censored. While the interval censoring could be analyzed using discrete methods, we have for simplicity chosen to approximate the survival function as continuous.

[12] At the Oslo Stock Exchange, the typical minimal trading lot is 100 shares. Requiring five times the minimum lot size seems like a conservative lower limit on who is a "substantial" owner. Looking only at complete sellouts of stakes is of course a simple definition of termination. One could think of alternatives, such as a stake decrease by a given percentage.

[13] An investor can have several durations, both in the same and in other stocks.

[14] The estimate of 1.97 is adjusted for the censoring of data by extrapolation. Without censoring adjustment the estimate is 1.86.

[15] The hazard functions that follow are estimated using a Weibull probability distribution assumption. We have also looked at alternatives, such as a Cox specification. The results are robust to these alternative probability distributions.

bilities of liquidating an equity position, conditional on the length of time the ownership has lasted, are time independent, the hazard function will be flat. This is clearly not the case for our sample. Instead, we see a systematic time variation. The conditional probability of exit starts around 0.45, increasing to a maximum slightly above 0.5 around 1 year, and then decreases steadily, reaching 0.2 after 8 years, and keeps decreasing. The decreasing part of the curve after 1 year means that if an owner has held the stock for one year, he or she is less and less likely to terminate as time passes. The high probability of exit at the short horizon is the prime contributor to stock turnover. Over the same time period, the average annual stock turnover was about 60%.[16]

3.3 Determinants of the hazard function

Having described holding periods, we now turn to investigating what variables might affect the holding period decision. Duration analysis lets us ask this question by estimating the effect of a variable on the hazard function. In the standard specification of duration analysis, the hazard function is a constant function of the explanatory variables. We use time-varying explanatory variables such as firm size, stock volatility and spread in our analysis. To implement estimation we use the observed values of an explanatory variable at the time when a stake is first acquired as the input to the estimation. In economic terms this can be viewed as the holding period decision being based on observable variables when the initial stake is acquired.

By including spread as an explanatory variable, we perform a direct test of the spread-holding period relationship in Amihud and Mendelson (1986). Earlier empirical analysis, such as Atkins and Dyl (1997), tests this relationship using turnover as a proxy for holding period. Our paper improves on this analysis in two respects. First, we base the analysis on actual holding periods at the individual investor level. Second, we use the correct econometric framework for testing. The question of whether liquidity affects holding periods should be asked by testing whether the liquidity at the time when the stock position is entered into affects the hazard function for holding periods. In their analysis, Amihud and Mendelson use spread as their liquidity measure. In our analysis we consider both spread and turnover as liquidity measures.

In Amihud and Mendelson (1986), investors coming to the market have different expected holding periods. One rationale for this assumption could be that different groups

[16] It should be mentioned that there are some problems with the analysis at the very short end, induced by the fact that the minimum possible observation of holding period is one month. Since we only have monthly observations of holdings our minimal estimate of holding period is one month, found when we have only two consecutive observations of stock holdings. Cases where we only have one observation, with no observation of holdings for that owner either the month prior or the month after, are rounded down to a duration of zero. Zero durations are not used in the estimation.

of investors have distinctly different trading motives, for instance long-term pension saving versus short-term speculation. To account for these possibilities we consider investor type as an explanatory variable. Investor type is included in our analysis in two different ways. First, we use dummy variables for investor type in the estimation. However, since we are estimating a nonlinear relationship, dummy variables may not capture all the relevant information. We therefore also perform the analysis separately for the five different owner types.

It is also possible that an investor's planned holding period is influenced by the size of the investment. We therefore include investment amount as an explanatory variable. Since we only have monthly observations of holdings, we estimate the investment amount as the stock price at the end of the month multiplied by the number of shares. To avoid numerical difficulties we use the log of the investment.

In panel A of Table 2 we show the results from estimating the contributions to the hazard function of the investor-specific variables described above as well as two liquidity measures, relative spread (columns 2-3) and turnover (columns 4-5). The coefficients in the table measure contributions to the hazard function. Note here the interpretation of these coefficients: If a coefficient equals one, it does not contribute. A coefficient less than one lowers the conditional probability of exit, while a coefficient greater than one increases the probability of exit.

Let us first look at the estimated relationship between spread and holding period. As seen in the table, the coefficient is significantly below one. High spread decreases the probability of exit. We therefore confirm the posited relationship between spread and holding period. Stocks with high spreads tend to have owners with longer holding periods. Similarly, stocks which have recently experienced high turnover tend to have owners with shorter holding periods looking forward. The other explanatory variables in the regressions are all significant. The amount invested has a negative effect on the hazard function. This means that larger owners tend to have longer holding periods. The analysis also shows clear differences across investor types in average holding periods. Financial owners are the shortest term, while individual owners have the longest holding periods. Foreign and non-financial (corporate) owners have holding periods in between these two extremes.

In the estimation above, we only use investor-specific information and liquidity measures as explanatory variables. However, other properties of a stock may also be relevant for holding period decisions. To account for this, we add a few firm-specific variables to the analysis. Following Atkins and Dyl (1997), we include logs of stock volatility and firm size as possible determinants of holding period. In panel B of Table 2 we show the results when these two variables are added for two different analyzes of determinants of the hazard function, one using the spread as a liquidity measure, the other using turnover. In both specifications, volatility and firm size are significantly related to holding period. The holding periods tend to be shorter in firms with high volatility and large size. Note also that foreign ownership no longer is significant. This is probably because it is correlated with firm size. However, for our purposes the most important observation is that there is still a significant relation between liquidity and holding period. Ex ante liquidity affects realized holding periods.

The dummy variables for investor type show significant differences across owner types; however, as noted above, simple dummy variables may not capture differences in the shape of the hazard function for the different owner types. We therefore redo the hazard function estimation for each of the five subsamples. Figure 3 and Table 3 show the results. There are some differences across owner types worth pointing out. The fact that financial and nonfinancial owners are relatively more impatient is seen by the higher values of the hazard function at the short end. Another interesting feature is the difference in the contribution of the investment amount across owner types. For individual owners, we find that the larger the initial investment the longer the holding period. For all the other owner types this relation is opposite. Larger investments tend to lead to shorter holding periods. This can be due to the importance of the investment in the portfolio of individual investors. While there are some differences across owner type, there are no differences in the relationship of most interest for our purposes. We see that ex ante liquidity is still an important determinant of future holding periods.

To conclude, there are two important results in this section that add to our knowledge of the link between holding periods and stock liquidity. First, we show that the conditional probability distribution of holding periods has a clear time variation. Most owners are short term; the typical owner keeps the position for three quarters of a year. But there is also a group of very long-term owners. In our sample, about 10% of the owners kept their positions for the whole sample period of ten years. Second, we show that stock liquidity, be it measured by spread or turnover, influences holding period decisions.

4 Proxies of holding periods

In this section we use our data on holding periods to shed light on the relationship between holding period and different measures of liquidity. First, we investigate whether the inverse of turnover is a good proxy for holding period as suggested by Atkins and Dyl (1997). We show that the proxy seriously overstates actual holding periods of individual investors. Second, we consider ranking of the cross-section of equities by measures of holding periods, and ask to what extent this ranking is related to rankings by standard liquidity measures. To perform such an analysis it is necessary to construct a measure that aggregates individual holding periods into a measure of holding periods at the stock level.

4.1 Estimating holding period from stock turnover

Atkins and Dyl (1997) use the inverse of annual turnover as an estimate of the average holding period of a firm's investors, i.e.

$$\text{Holding Period}_t = \frac{\text{Shares outstanding in year t}}{\text{No of shares traded in year t}}$$

and argue that this is a reasonable approximation of holding periods when investigating the relationship between transactions costs and investors' holding periods. As we shall see, however, the validity of this argument depends crucially on the distributional properties of actual holding periods.

Atkins and Dyl estimate average holding periods from a sample of US firms listed on NYSE and Nasdaq. Table 4 shows the results of the estimation and compare them with similar estimates for Norway. Estimating average holding period from turnover, we find an average across stocks of 3.33 years. However, as illustrated by the histogram in figure 4, the mean of this distribution is seriously pushed upward by a few very large estimates. The median of 1.96 is therefore a much better estimate of the typical holding period estimated from turnover. When we relate this result to the estimation of mean and median holding periods based on individual owners, we note the following. The estimate of the typical holding period based on turnover (1.97) hits the mean holding period for individual investors uncannily on the spot (1.96). The two estimates are therefore consistent with each other. However, from our data on actual holding periods, we know that this estimate of the mean holding period is seriously inflated by a few long-term investors. Put differently, the estimate based on turnover is not able to distinguish the more complex dynamics of holding periods we find from the data for individual investors, where we have a large group of short-term, impatient investors, and a smaller group of much longer term, patient investors. Thus, we cannot detect the typical holding period of 0.75 years using turnover data.

In the next section, we investigate to what degree data on individual owners' holding periods give additional, and different, information, than what we can find from turnover.

4.2 What is the relationship between actual holding periods and liquidity measures?

In this subsection, we shift focus from the holding period of individual owners to holding periods as an aggregate property of all the owners of a stock. The impetus for these analyzes comes from the empirical asset pricing evidence of a positive relationship between asset prices and microstructure measures of liquidity. If liquidity is an exogenous trading cost, as assumed in the theoretical asset pricing literature, then the link between liquidity and asset prices must be one of cost compensation. This cost compensation will vary with investors' expected holding period. We therefore want to investigate whether liquidity covaries with holding periods as such theories suggest. To investigate this we need a measure of average holding period at the stock level.

4.2.1 An index of average holding period at the stock level

To get a measure of holding period that we can relate to measures of stock liquidity, that are measured over short time intervals, we construct a holding period index. The measure is constructed as a "snapshot", where we take the owners at a given date, measure the holding period for each owner, and aggregate these individuals into one measure per stock. To lessen time series overlap, we truncate the measurement interval to one year at a time.[17]

Figure 5 illustrates our method for creating the index. At a given date t we use data for the holdings in the previous year. We take all owners with an equity stake at time t.[18] In the figure it means that we use owners 1, 3 and 4. Owner 2 has sold her stake 6 months earlier, and is not present in the company at date t. The holding period index for each owner is the holding period in fractions of a year. The index for the company is a weighted sum of the individual owners' indices. In the example in figure 5 the holding period index is

$$\texttt{hpi} = w_1 1 + w_3 \frac{7}{12} + w_4 \frac{3}{12},$$

where w_i is the weight for owner i. The weight for each individual can vary. If we want to put more weight on the large owners we use value weights where the fraction of the company held by each owner at time t is the weight. This index is termed `hpi(vw)`. If we are more interested in the typical owner we use equal weights $1/n$, where n is the number of owners in the sample at time t. This index is termed `hpi(ew)`.

[17] All holding periods above 1 are therefore truncated. One way to think about this is that we say any holding period more than one year is "long term," without distinguishing further. This is justified by the results on individual owners, where more than half of the owners had a holding period of less than two thirds of a year.

[18] To reduce noise we require that the number of shares is above a threshold of 500 shares.

We calculate holding period indices for each firm in the sample. We do it for both the equally weighted index `hpi(ew)` and the value weighted index `hpi(vw)`. Figure 6 shows the distribution of the two. Note the difference between the value weighted and equally weighted indices. That the value weighted index is more concentrated on the longer period must be caused by the larger owners tending to stay longer. This suggests a tendency that large owners have longer holding periods than small owners, a result we saw for individual owners in the determinants of the hazard function.

4.2.2 What determines the holding period indices?

A simple way of evaluating how the holding period index varies with other firm characteristics is by stratifying the sample of firms based on the characteristic we want to investigate, and calculate averages for each group. Panel A of table 5 implements this for a number of different firm characteristics: firm size, stock volatility, book-to-market (B/M) ratio, firm age, insider ownership and ownership concentration. The average holding periods seem higher for the smallest and largest quartiles of the firms. A similar pattern is true for volatility. The average holding period for value stocks (high B/M) seems to be longer than the average holding period for growth stocks. Firm age also seems important; the older the firm, the longer the average holding period. The last two variables, insider ownership and ownership concentration, show no obvious systematic patterns.

To test more formally the importance of the explanatory variables, we also run a multivariate regression for each of the two holding period indices. Panel B of table 5 shows the results for this estimation. Old firms and value stocks tend to have owners with longer average holding periods than young firms and growth stocks. Surprisingly, we find a negative coefficient on the firm size (though only significant for the equally weighted index). Thus, we find weak evidence that larger firms have shorter duration ownership than smaller firms. This finding is at odds with the evidence in Atkins and Dyl (1997) as well as with several suggested explanations for the opposite result that large firms should have long duration owners than smaller firms (including less risk, reduced divergence of investors' expectations, and less need for portfolio re-balancing due to more stable return distribution parameters). The two variables thought to be related to asymmetric information, stock volatility and insider ownership, do not seem to explain averages of holding periods for firms' owners. Finally, the size of the largest owner is important; the larger this owner, the longer the average holding period.

4.2.3 The relation between holding period index and other liquidity measures

To investigate the relationship between liquidity measures and holding period, we look at the covariability between these measures, and compare the properties of liquidity, such as the liquidity's determinants, to similar estimations for holding period indices.

We consider three different measures of liquidity: turnover, relative spread, and amortized spread. The turnover and relative spread are standard measures, and will not be discussed further. The amortized spread is particularly interesting for our purposes, as it attempts to measure an expected cost of trading equity that takes into account the holding period of a position. As such it can be viewed as an attempt to make trading costs across stocks comparable by looking at expected costs over a defined time interval, such as a year. The amortized spread measure was introduced in Chalmers and Kadlec (1998), and is roughly equal to the bid/ask spread multiplied by turnover.[19]

Panel A in table 6 shows stratified averages of holding period indices. We see that stocks with low turnover have longer holding period indices and that holding period is increasing in the spread. These observations are confirmed by the correlation coefficients in panel B of the table. All the coefficients have the expected signs. Note that in the cross-section, the correlation between turnover and the holding period indices is only around -0.5. This shows that turnover is an imperfect measure of holding period. Interestingly, the amortized spread has a very low correlation with the holding period indices. However, when we look at the quartiles of `hpi` there seems to be some systematic covariation between `hpi` and amortized spread.

To further investigate the links between the holding period indices and the liquidity measures we analyze the determinants of turnover and spreads in the same way as we did for the holding period indices. The results from this analysis are presented in tables 7 and 8, and should be compared to similar regressions for holding periods reported in table 5. As the tables show, the liquidity variables seem to have similar determinants as

[19] Chalmers and Kadlec (1998) used trading data to calculate the amortized spread for date T as

$$AS_T = \frac{\sum_{t=1}^{T} |P_t - M_t| V_t}{P_T \times SharesOut_T}$$

where AS_T is the amortized spread, P_t is a transaction price, M_t a midpoint price, V_t a trade quantity and $SharesOut$ is the number of shares outstanding. Observation T is the last observation of the day. Since we do not have transaction data, only closing data and volume, we approximate the daily amortized spread as

$$AS \approx \frac{P_T - M_T}{P_T} \frac{\sum_t V_t}{SharesOut_T} \approx \text{Relative bid/ask spread} \times \text{Turnover}$$

Multiplying this by 252 gives a daily estimate of the annualized amortized spread. We use averages of this measure over a time period in most of our analysis.

the holding period indices; firm size, B/M ratio, and the size of the largest owner are all significant determinants of both turnover and spread.

We also show, in table 9, results from adding liquidity variables to the series of explanatory variables used in the regressions presented in panel B of table 5. The liquidity variables are clearly significant determinants of the holding period indices, but most of the other variables are still significant.

5 The role of holding period for asset pricing

In this section we investigate the links between liquidity, holding period and asset returns. As was discussed briefly in the literature section, there are different possible reasons for holding periods to be linked to asset prices.

Amihud and Mendelson (1986) formalize the idea of a positive relationship between expected returns *net of trading costs* and the holding period. Two propositions are derived from their model. Proposition 1 states the spread-holding period relationship tested in subsection 3.3; assets with higher spreads should be allocated to portfolios with the same or longer expected holding periods. Proposition 2 states that observed asset returns should be an increasing and concave function of the relative spread. Jointly these two propositions imply that observed asset returns must also be an increasing and concave function of the expected holding period.[20] This relationship between holding period and asset returns is investigated by Datar et al. (1998), who find support for the joint proposition in Amihud and Mendelson (1986). However, they use turnover as a proxy for holding period, and as we have shown the correspondence between holding period and turnover is less than perfect.[21]

Yan and Zhang (2008) provide an alternative explanation for a link between holding period and asset prices. Their empirical analysis suggest that short-term institutions are better informed and exploit their informational advantage by active trading. These results suggest that there might be returns differences between the portfolios of long and short term investors due to differences in information.

In this section we ask whether asset prices in the cross section is related to holding period differences across stocks. In a sense our analysis is exploratory, we simply ask to what extent *holding periods*, as opposed to liquidity, matters for asset prices.

[20]Suppose that assets held by investors with a long expected holding period have the same or lower returns than assets held by investors with a short expected investment horizon. From Proposition 1, the assets held by the long term investors must have the highest spread. But then Proposition 2 cannot hold.

[21]The results in Datar et al. (1998) might instead be interpreted as supportive to Proposition 2 in the Amihud and Mendelson (1986) model with turnover as an alternative proxy for liquidity.

To investigate this, we perform various asset pricing investigations. First, we perform a simple analysis of the cross-section of stock returns based on portfolio sorting. All stocks are sorted into portfolios based on five criteria: turnover, relative bid/ask spread, amortized spread, and the two holding period indices `hpi(ew)` and `hpi(vw)`. The portfolio sorts are performed at year end. We then calculate portfolio returns for the next year before rebalancing the portfolios. We then calculate the averages of the excess returns for these five portfolio sorts and look for a systematic variation in excess returns. Table 10 shows the results from this analysis. For the portfolios sorted on the holding period indices, we find no clear pattern in excess returns. However, for all three liquidity measures we find a clear systematic variation: the better the liquidity of a portfolio, the lower its excess returns.

While the orderings in panel A in table 10 are indicative, they are not sufficient to conclude that the holding period measures do a worse job in the cross-section. They may merely reflect differences in risk. We therefore need to embed the question in a formal asset pricing analysis. There are numerous ways this type of analysis can be performed. We first do a simple correction for the three factor Fama and French (1995) model, by calculating returns in excess of the Fama French model. Averages of these excess returns are reported in panel B of table 10. While these numbers are more noisy than the returns in excess of the risk free rate, since the Fama French parameters are estimated, they still give the same impression as the results in panel A, the sorts using the holding period indices have less clear relationships with (Fama French) excess returns than the more standard liquidity measures.

As a different way of asking the same question, we ask whether we can use portfolios sorted by liquidity/holding period to construct a pricing factor that helps explain the cross-section of stock returns. The construction of this "liquidity factor" (`LIQ`) is done by a sort similar to the Carhart (1997) construction, where we at year-end sort the stocks based on the relevant liquidity/holding period measure, and take the difference in returns between the 30% top and 30% bottom stocks. This liquidity factor is then used as an explanatory variable in a joint estimation of the system

$$E[r] = \beta\lambda$$

$$\mathbf{r} = \mathbf{a} + \beta\mathbf{f}$$

where $\mathbf{f}$ is the vector of pricing factors, and λ (factor loadings) and β (betas) are jointly estimated. This is a well known formulation, see Cochrane (2005) for elucidation of the procedure. In our formulation, we use two elements in $\mathbf{f}$. One is the standard use of a market portfolio, where we use an equally weighted market portfolio for the Oslo Stock Exchange. The second is the constructed factor based on liquidity or holding period

(LIQ). For our purposes, the interesting question is whether different versions of the LIQ factor is priced in the cross-section, which is to test whether λ is significantly different from zero in an estimation on a set of test assets. As argued by Cochrane (2005), one should use a set of test assets with a decent cross-sectional variation. We therefore use a set of size-sorted portfolios.[22] Table 11 shows the complete results of the estimation where we apply the market factor and a LIQ factor constructed from relative spread to eight size-sorted portfolios.

We observe that both the market portfolio and the liquidity factor are significant determinants of the cross-section. The market risk premium is positive, as it should be. More importantly, for our purposes, is the fact that the liquidity risk premium is positive and significant. The importance of the liquidity factor is confirmed by the estimated betas for the size-portfolios on the liquidity factor. Many of these are significant. Hence, we find that a liquidity factor constructed from relative spread helps to explain the cross-section of returns of size-based portfolios.

We then repeat this exercise for four alternative measures of liquidity: turnover, amortized spread, hpi(ew) and hpi(vw). The results are summarized in table 12. For brevity, we only report estimates of β for the liquidity factor, and estimates of the factor premia λ. To facilitate comparison, we also include the estimation using the LIQ factor estimated using the relative spread.

For our purposes, the most interesting result in Table 12 is the fact that while the liquidity factors constructed from spread and amortized spread are very significant determinants of the cross-section, the factors constructed from holding periods are not significant. This investigation reinforces our earlier finding that the holding period indices do a worse job than more standard liquidity measures in asset pricing applications.[23]

6 Conclusion

We use a data set of the complete holdings of all investors in a stock market to look at expected holding periods for individual investors. We show how these decisions of individual investors sum up to a measure of average holding period at the stock level, and investigate the links between stock liquidity, holding periods, and asset returns.

We make a number of important contributions to the literature. First, we characterize

[22] Empirical evidence, in e.g. Næs et al. (2008), shows that firm size is a significant determinant of the cross-section of Norwegian stock returns.

[23] We have implemented various other asset pricing tests, such as a Fama and MacBeth (1973) formulation and a direct estimation of the components of the discount factor m, without the additional structure of the factor premia. We have also included the standard Fama French factors SMB and HML in the analysis. In all cases the holding period indices are less significant than the other liquidity measures, in particular the spread measures, although there are cases where neither of them are significant.

the distribution of holding periods using duration analysis. Using these methods we show that the median holding period is only 0.75 years. However, due to a very skewed distribution, the average holding period is close to 2 years. This number is also what would be estimated from (median) turnover. We also show that what is driving these results is a pattern of time variation in the conditional probability of selling the equity position. There is a high probability of exit the first year, and then steadily declining probability of exit once the stock has been held for a year. We also analyze the holding period decisions of individual investors and show that liquidity is an important determinant of holding periods for individual investors. Controlling for various investor specific and firm specific variables, we find that low liquidity (high bid/ask spread and/or low turnover) of a stock when the investor enters into a stock position, tends to result in a longer holding period.

A second contribution is related to the relationship between holding period and turnover. Current empirical literature on the links between holding periods and asset returns has used the inverse of turnover at the stock level as a proxy for expected holding periods for the individual investors of the stock (Atkins and Dyl, 1997). Based on the finding that the correlation coefficient between turnover and holding period indices constructed from data on actual holding periods lies around -0.5, we argue that turnover is only an imperfect measure of expected holding periods.

Our third contribution is to provide empirical evidence that the link between liquidity and asset prices is not explained by investors who want compensation for exogenous trading costs. Amihud and Mendelson (1986) suggest that the link between transaction costs (spreads) and returns works through investors' selection of stocks based on their expected holding periods. If this is the case, we should see that the average holding period in a stock is an important determinant of the cross section of stock returns. However, when we compare our measures of average holding period and more traditional measures of liquidity, such as spread and turnover, as determinants of the cross-section of stock returns, we find that the more traditional liquidity measures have much stronger links to asset returns.

While our results are still preliminary, there are some interesting avenues for further research. As discussed in the introduction, the Amihud and Mendelson model does not explain why there is a spread, just that different spreads can be sustainable when investors select stocks with different spreads based on their expected holding periods. A more complete model would also incorporate the cause of liquidity (spread) differences. A typical microstructure model would attribute these causes to information risk. We find that liquidity strongly affects holding periods. At the same time, we find little evidence of a link between holding periods and returns, and a strong link between returns and traditional microstructure liquidity variables. A possible explanation for these results is that the cause of the first effect is the Amihud and Mendelson intuition, investors reacting to spreads, while returns and microstructure liquidity are linked through the *cause* of spread differences. Trying to disentangle these effects seems a promising direction to go.

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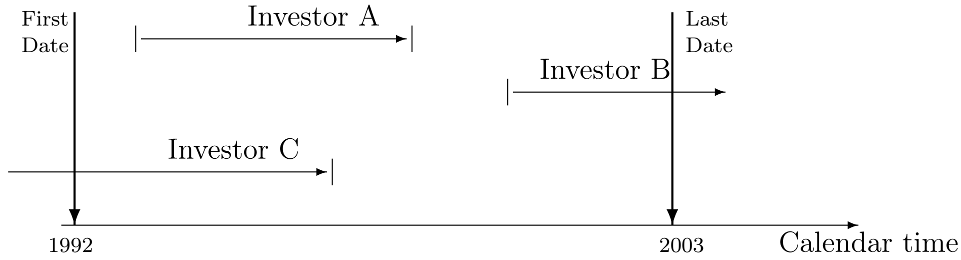
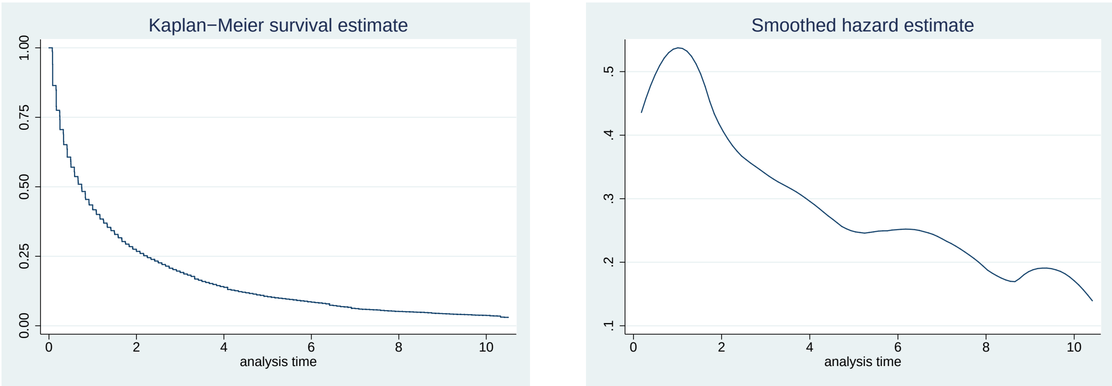


The figure illustrates some conceptual problems in our estimation of holding periods using monthly observations. In calendar time our sample starts in 1992:12 and ends in 2003:6. We illustrate the holding periods of 3 example investors, A, B and C. For investor A the holding period is contained within 1992–2003, and therefore estimated correctly. For investor B we correctly observe the initial date but as the investor keeps his stake until after the last date, all we know is that we observe the stake on the last date. The holding period of this owners is underestimated due to right censoring. For owner C we correctly observe the terminal date, but we do not observe the first date, only that this owner was present in the first date of the sample, in 1992:12. Hence the holding period is underestimated due to left censoring.

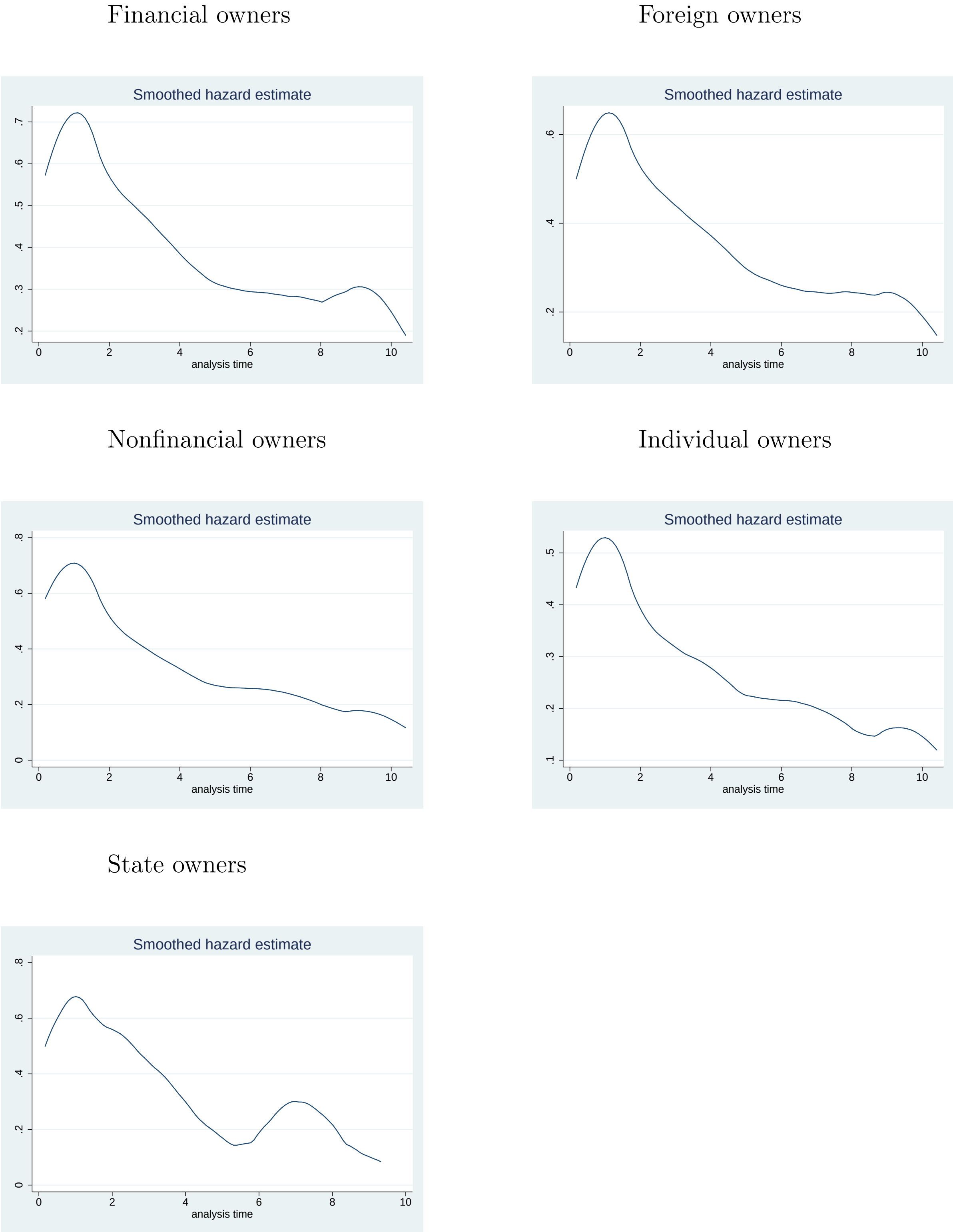
Figure 1: Illustrating the censoring problem

Survival function Hazard function



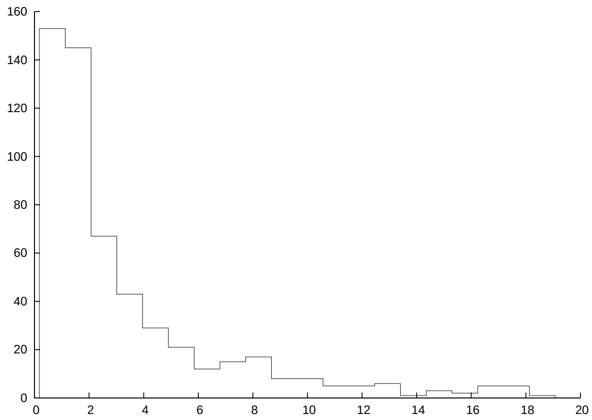
Estimated survival and hazard functions using all investor-company holding periods at the OSE in the period. The figure on the left is the estimated survival function. The figure on the right is the estimated hazard function. Analysis time in years. The analysis is based on 1,417,186 observations. The estimates are corrected for right censoring. The estimation uses a Weibull probability function. The analysis is performed using `Stata9`. The analysis uses monthly data from the Oslo Stock Exchange over the period 1992:12 to 2003:6.

Figure 2: Estimated hazard and survival functions



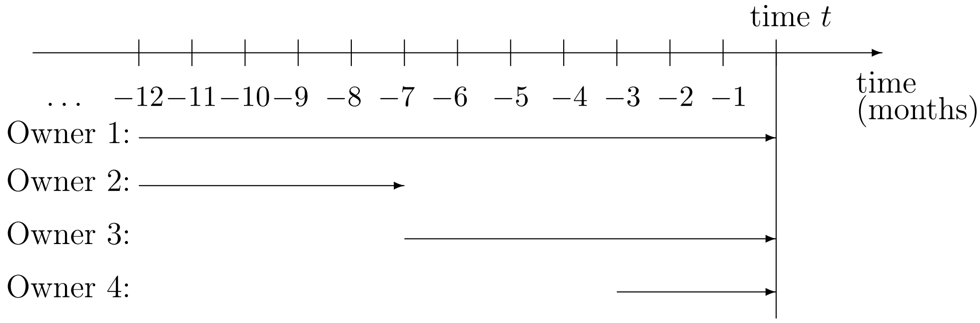
We show estimated hazard functions for separate estimations for the five owner types. The estimation uses a Weibull probability function. *Financial* owners: Mutual funds, banks and insurance companies. *Foreign* owners: Owners domiciled outside of Norway, both corporations and individuals. *Nonfinancial* owners: Industrial owners (corporations that are not financials). *Individual* owners: Private individuals/families. *State* owners: Public owners, including public pension funds. The analysis is performed using `Stata9`. The analysis uses monthly data from the Oslo Stock Exchange over the period 1992:12 to 2003:6.

Figure 3: Hazard functions estimated split by owner type



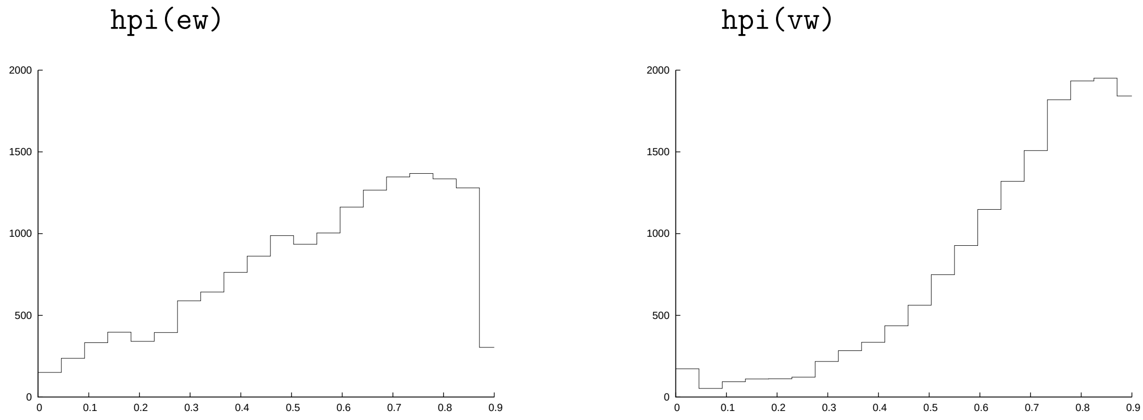
The histogram shows the distribution of estimates of the average holding period of investors. Holding period is estimated as one divided by annual turnover. The analysis uses monthly data from the Oslo Stock Exchange over the period 1992:12 to 2003:6.

Figure 4: Average holding periods estimated from turnover



The figure illustrates our method for creating a holding period index. We illustrate four example owners, 1–4. We look at all owners during the year, and calculate each owner's holding period in fractions of the year. For owner 1 the holding period is 1, for owner 2 it is 5/12, for owner 3 it is 7/12, and for owner 4 it is 3/12. A holding period index is calculated at time t. We only use the owners present at time t, and calculate the weighted average of holding periods for the individual owners as $\texttt{hpi} = w_1 1 + w_3 \frac{7}{12} + w_4 \frac{3}{12}$. We use two different weights. The first is equal weights. The resulting index is denoted `hpi(ew)`. The second is value weights: each owner receive weights based on the fraction of the company that owner holds at date t. The resulting index is denoted `hpi(vw)`.

Figure 5: Illustrating the method for creating a holding period index



Histograms of the holding period indices `hpi(ew)` and `hpi(vw)`. The indices are calculated for each company at year end. The variables `hpi(ew)` and `hpi(vw)` are averages of holding period length at the stock level calculated over a period of one year by taking all owners observed at the final date and taking the average holding period over the period for these owners. The index `hpi(ew)` is an equally weighted average and the index `hpi(vw)` is a value weighted average. . The analysis uses monthly data from the Oslo Stock Exchange over the period 1992:12 to 2003:6.

Figure 6: The distribution of holding period indices

Owner type	median	mean	no obs
All	0.75	1.97	1489365
State	0.75	1.79	5860
Foreign	0.67	1.61	156561
Financial	0.50	1.29	62357
Nonfinancial	0.50	1.45	204587
Individual	0.83	2.18	1055928

The table describes the estimated holding periods (survival times) for all investors and for the five different investor types state, financial, foreign, nonfinancial and individual. We show the median holding period and the mean holding period. The estimate of the mean is adjusted for right censoring by extrapolation, as described in the `Stata` manual. *Financial* owners: Mutual funds, banks and insurance companies. *Foreign* owners: Owners domiciled outside of Norway, both corporations and individuals. *Nonfinancial* owners: Industrial owners (corporations that are not financials). *Individual* owners: Private individuals/families. *State* owners: Public owners, including public pension funds. The analysis is performed using `Stata9`. The analysis uses monthly data from the Oslo Stock Exchange over the period 1992:12 to 2003:6.

Table 1: Descriptive statistics for estimated holding periods

Panel A: Investor-specific variables and liquidity

Variable	Haz. Ratio	pvalue	Haz. Ratio	pvalue
ln(Investment)	0.9773	(0.00)	0.9915	(0.00)
Financial	1.1770	(0.00)	1.1579	(0.00)
Foreign	0.9462	(0.00)	0.9362	(0.00)
Nonfinancial	1.0851	(0.00)	1.0741	(0.00)
Individual	0.7165	(0.00)	0.7114	(0.00)
Bid Ask Spread	0.5221	(0.00)		
Turnover			1.1952	(0.00)
n	1417186		1417186	

Panel B: Investor-specific variables, firm-specific variables, and liquidity

Variable	Haz. Ratio	pvalue		
ln(Investment)	0.9829	(0.00)	0.9887	(0.00)
Financial	1.1916	(0.00)	1.2069	(0.00)
Foreign	0.9932	(0.61)	0.9993	(0.95)
Nonfinancial	1.1157	(0.00)	1.1356	(0.00)
Individual	0.7551	(0.00)	0.7598	(0.00)
ln(Volatility)	1.4317	(0.00)	1.2192	(0.00)
ln(Firm Size)	1.0097	(0.00)	1.0411	(0.00)
Bid Ask spread	0.0034	(0.00)		
Turnover			1.2288	(0.00)
n	1038170			

The tables show the results for two separate analyzes of contributions to the hazard function illustrated in figure 2. The contribution to the hazard function is estimated using a Weibull probability specification. The coefficients for each variable have the following interpretation: A number less than one in numerical value lowers the probability of exit, inducing a *longer* holding period. A number greater than one induces a shorter holding period. In Panel A, the explanatory variables include investment size, owner type, and liquidity. In Panel B, we include volatility and firm size as explanatory variables in addition to investment size, owner type, and liquidity. Columns 2 and 3 show the results when we use the bid/ask spread as our measure of liquidity, while columns 4 and 5 show the results when we measure liquidity by turnover. *Investment*: The amount invested in that stock by the given owner, *Financial*: Dummy variable equal to one if the given owner is a financial corporation, *Foreign*: Dummy variable equal to one if the given owner is foreign, *Individual*: Dummy variable equal to one if the given owner is an individual (family) owner, *Nonfinancial*: Dummy variable equal to one if the given owner is a nonfinancial corporation, *Stock Volatility*: Volatility of the stock's returns, estimated using one year of returns, *Firm Size*: The value of the company's equity, *Bid/Ask spread*: Relative bid/ask spread $(P_a - P_b)/P_t$, averaged over a year and *Turnover*: Number of shares traded in the stock during one year divided by number of shares outstanding. The analysis is performed using `Stata9`. The analysis uses monthly data from the Oslo Stock Exchange over the period 1992:12 to 2003:6.

Table 2: Determinants of the hazard function

Panel A: Determinants of the hazard function using spread as liquidity measure

Investor type:	Financial		Foreign		Nonfinancial		Individual		State	
Variable	Hazard Ratio	p-value	Haz	pval	Haz	pval	Haz	pval	Haz	pvalu
ln(Investment)	1.0046	(0.09)	1.0511	(0.00)	1.0602	(0.00)	0.9494	(0.00)	1.0308	(0.00)
ln(Volatility)	1.1922	(0.00)	1.2009	(0.00)	1.2027	(0.00)	1.3476	(0.00)	1.0069	(0.87)
ln(Firm Size)	0.9567	(0.00)	1.0005	(0.86)	1.0170	(0.00)	1.0188	(0.00)	0.9429	(0.00)
Rel B/A spread	0.0050	(0.00)	0.1134	(0.00)	0.0141	(0.00)	0.0259	(0.00)	0.0001	(0.00)
n	48246		116750		154961		711225		4829	

Panel B: Determinants of the hazard function using turnover as liquidity measure

Investor type:	Financial		Foreign		Nonfinancial		Individual		State	
Variable	Haz. Ratio	pvalue	Haz	pval	Haz	pval	Haz	pval	Haz	pvalu
ln(Investment)	1.0041	(0.13)	1.0530	(0.00)	1.0605	(0.00)	0.9568	(0.00)	1.0241	(0.00)
ln(Volatility)	1.0595	(0.00)	1.1127	(0.00)	1.0816	(0.00)	1.1987	(0.00)	0.8294	(0.00)
ln(Firm Size)	0.9884	(0.00)	1.0132	(0.00)	1.0441	(0.00)	1.0352	(0.00)	0.9990	(0.93)
Turnover	1.1492	(0.00)	1.1363	(0.00)	1.1634	(0.00)	1.1593	(0.00)	1.2645	(0.00)
n	48244		116711		154944		711176		4829	

The tables show the results for five separate analyzes of contributions to the hazard functions illustrated in figure 3. The contribution to the hazard function is estimated using a Weibull probability specification. The coefficients for each variable have the following interpretation: A number less than one in numerical value lowers the probability of exit, inducing a *longer* holding period. A number greater than one induces a shorter holding period. The explanatory variables are investment size, volatility, firm size and liquidity. In Panel A we use the relative spread as the liquidity measure. In panel B we use turnover as the liquidity measure. *Investment*: The amount invested in that stock by the given owner. *Stock Volatility*: Volatility of the stock's returns, estimated using one year of returns. *Firm Size*: The value of the company's equity. *Bid/Ask spread*: Relative bid/ask spread $(P_a - P_b)/P_t$, averaged over a year. *Turnover*: Number of shares traded in the stock during one year divided by number of shares outstanding. *Financial* owners: Mutual funds, banks and insurance companies. *Foreign* owners: Owners domiciled outside of Norway, both corporations and individuals. *Nonfinancial* owners: Industrial owners (corporations that are not financials). *Individual* owners: Private individuals/families. *State* owners: Public owners, including public pension funds. The analysis is performed using `Stata9`. The analysis uses monthly data from the Oslo Stock Exchange over the period 1992:12 to 2003:6.

Table 3: Determinants of hazard function estimated separately for each investor type

	NYSE 1975-1989	Nasdaq 1983-1991	OSE 1992-2003
Average	6.99	4.01	3.33
Median	3.38	2.43	1.96

The table describes estimates of the average holding period of a stock's investors using the method of Atkins and Dyl (1997), where holding period is estimated as one divided by annual turnover, and compare it to data for the US, from Atkins and Dyl (1997).

Table 4: Average holding periods estimated as in Atkins and Dyl (1997)

Panel A: Stratified quartiles

	hpi(ew)					hpi(vw)				
	All	1	2	3	4	All	1	2	3	4
Firm Size	0.580	0.629	0.558	0.543	0.595	0.674	0.685	0.658	0.674	0.697
Stock Volatility	0.570	0.630	0.548	0.522	0.579	0.682	0.714	0.667	0.664	0.684
BM Ratio	0.577	0.463	0.565	0.599	0.651	0.685	0.640	0.690	0.695	0.706
Firm listing age	0.579	0.477	0.554	0.610	0.642	0.672	0.616	0.657	0.680	0.717
Primary insider fraction	0.577	0.580	0.590	0.588	0.562	0.672	0.671	0.670	0.672	0.672
Largest owner	0.580	0.582	0.539	0.603	0.599	0.678	0.663	0.645	0.713	0.691

Panel B: Regression models

	hpi(ew)		hpi(vw)	
Variable	coeff	pvalue	coeff	pvalue
constant	0.767	(0.00)	0.548	(0.00)
ln(Firm Size)	-0.023	(0.00)	-0.000	(0.98)
Stock Volatility	0.579	(0.07)	0.414	(0.14)
BM Ratio	0.059	(0.00)	0.036	(0.00)
ln(Firm listing age)	0.102	(0.00)	0.038	(0.00)
Primary insider fraction	-0.122	(0.07)	0.056	(0.36)
Largest owner	0.112	(0.00)	0.130	(0.00)
n	1118		1118	
R^2	0.30		0.11	

The tables show how the holding period indices covary with firm characteristics. The top table (panel A) shows averages of holding period indices in stratified samples. For each line we group the stocks in the sample in four quartiles by the criterion listed on the left. We then calculate averages of holding period indices for each of the four groups. The quartiles are sorted in increasing value. So, for example, in the first line quartile 1 is the group with the smallest companies, and quartile 4 contains the largest firms. The bottom table (panel B) shows results of two independent regressions showing how the holding period indices listed at the top of each column are determined by the explanatory variables listed in the rows. The variables `hpi(ew)` and `hpi(vw)` are averages of holding period length at the stock level calculated over a period of one year by taking all owners observed at the final date and taking the average holding period over the period for these owners. The index `hpi(ew)` is an equally weighted average and the index `hpi(vw)` is a value weighted average. . *Firm Size*: The value of the company's equity. *Stock Volatility*: Volatility of the stock's returns, estimated using one year of returns. *B/M ratio*: Book/Market Ratio. *Listing age*: Number of years on the stock exchange. *Insider fraction*: Fraction of the company held by insiders. *Largest owner*: Fraction of the company owned by the firm's largest owner. The analysis uses monthly data from the Oslo Stock Exchange over the period 1992:12 to 2003:6.

Table 5: Determinants of holding period indices

Panel A: Stratified quartiles

	hpi(ew)					hpi(vw)				
	All	1	2	3	4	All	1	2	3	4
Annual Turnover	0.579	0.723	0.636	0.552	0.426	0.674	0.793	0.737	0.666	0.515
Annual Avg Rel BA Spread	0.576	0.515	0.550	0.573	0.690	0.671	0.642	0.649	0.672	0.735
Annual Amortized Spread	0.576	0.647	0.562	0.534	0.559	0.673	0.727	0.671	0.648	0.643

Panel B: Correlations between liquidity and holding periods

	Correlation		Rank Correlation	
	hpi(vw)	hpi(ew)	hpi(vw)	hpi(ew)
Annual Turnover	-0.509	-0.511	-0.478	-0.430
Annual Avg Rel BA Spread	0.207	0.380	0.185	0.268
Amortized Spread	-0.079	-0.010	-0.118	-0.068

The table in Panel A splits the sample into four quartiles based on the two liquidity measures and shows how the holding period indices vary. The table in Panel B shows Pearson's correlation coefficients and Kendall's rank correlation coefficients between holding period indices and liquidity measures. The variables `hpi(ew)` and `hpi(vw)` are averages of holding period length at the stock level calculated over a period of one year by taking all owners observed at the final date and taking the average holding period over the period for these owners. The index `hpi(ew)` is an equally weighted average and the index `hpi(vw)` is a value weighted average. *Turnover*: Number of shares traded in the stock during one year divided by number of shares outstanding. *Bid/Ask spread*: Relative bid/ask spread $(P_a - P_b)/P_t$, averaged over a year. *Amortized Spread*: The Chalmers and Kadlec (1998) definition of amortized spread, estimate of the annual cost of trading the stock. The analysis uses monthly data from the Oslo Stock Exchange over the period 1992:12 to 2003:6.

Table 6: The link between holding period indices and liquidity

Panel A: Turnover

	All	Quartiles of Annual Turnover			
		1	2	3	4
Firm Size	301	136	222	515	334
Stock Volatility	3.5	4.3	3.5	3.1	3.3
BM Ratio	1.02	1.13	1.56	0.72	0.70
Firm listing age	7.3	7.5	7.1	7.2	7.3
Primary insider fraction	1.8	2.1	1.8	1.8	1.7
Largest owner	26.9	32.8	28.9	23.1	23.2

Panel B: Relative bid/ask spread

	All	Quartiles of Annual Avg Rel BA Spread			
		1	2	3	4
Firm Size	873	1224	1030	695	537
Stock Volatility	3.5	2.4	2.9	4.0	5.9
BM Ratio	0.97	0.63	1.38	0.92	0.97
Firm listing age	7.9	9.1	7.9	6.9	7.9
Primary insider fraction	1.8	1.1	1.5	1.9	2.5
Largest owner	26.3	22.6	24.9	27.7	30.5

Panel C: Amortized spread

	All	Quartiles of Annual Amortized Spread			
		1	2	3	4
Firm Size	308	892	234	84	27
Stock Volatility	3.5	2.7	3.1	3.8	5.3
BM Ratio	0.99	0.68	0.79	1.48	0.99
Firm listing age	7.3	9.7	7.7	6.0	5.8
Primary insider fraction	1.9	1.5	1.8	2.3	1.8
Largest owner	26.6	32.2	25.4	23.1	25.5

The tables show how the liquidity variables covary with firm characteristics. Each table shows averages of liquidity in stratified samples. For each line we group the stocks in the sample in four quartiles by the criterion listed on the left. We then calculate averages of turnover, bid/ask spread and amortized spread for each of the four groups. The quartiles are sorted in increasing value. So for example in the first line quartile 1 is the group with the smallest companies, and quartile 4 contains the largest firms. *Turnover*: Number of shares traded in the stock during one year divided by number of shares outstanding. *Bid/Ask spread*: Relative bid/ask spread $(P_a - P_b)/P_t$, averaged over a year. *Firm Size*: The value of the company's equity. *Stock Volatility*: Volatility of the stock's returns, estimated using one year of returns. *B/M ratio*: Book/Market Ratio. *Insider fraction*: Fraction of the company held by insiders. *Listing age*: Number of years on the stock exchange. *Largest owner*: Fraction of the company owned by the firm's largest owner. The analysis uses monthly data from the Oslo Stock Exchange over the period 1992:12 to 2003:6.

Table 7: Determinants of liquidity measures - stratified quartiles

Variable	Annual Turnover coeff	Annual Turnover pvalue	Annual Avg Rel BA Spread coeff	Annual Avg Rel BA Spread pvalue	Amortized Spread coeff	Amortized Spread pvalue
constant	-0.166	(0.51)	0.200	(0.00)	0.032	(0.00)
ln(Firm Size)	0.052	(0.00)	-0.009	(0.00)	-0.001	(0.00)
Stock Volatility	-0.259	(0.72)	0.530	(0.00)	0.056	(0.00)
BM Ratio	-0.115	(0.00)	-0.001	(0.01)	0.000	(0.49)
ln(Firm listing age)	0.006	(0.69)	0.003	(0.00)	-0.000	(0.00)
Primary insider fraction	0.249	(0.23)	0.005	(0.42)	0.002	(0.20)
Largest owner	-0.869	(0.00)	0.024	(0.00)	-0.003	(0.00)
n	1639		1639		1639	
R^2	0.11		0.63		0.44	

The table shows results of three independent regressions demonstrating how the liquidity variables listed at the top of each column are determined by the explanatory variables listed in the rows. *Turnover*: Number of shares traded in the stock during one year divided by number of shares outstanding. *Bid/Ask spread*: Relative bid/ask spread $(P_a - P_b)/P_t$, averaged over a year. *Amortized Spread*: The Chalmers and Kadlec (1998) definition of amortized spread, estimate of the annual cost of trading the stock. *Firm Size*: The value of the company's equity. *Stock Volatility*: Volatility of the stock's returns, estimated using one year of returns. *B/M ratio*: Book/Market Ratio. *Insider fraction*: Fraction of the company held by insiders. *Listing age*: Number of years on the stock exchange. *Largest owner*: Fraction of the company owned by the firm's largest owner. The analysis uses monthly data from the Oslo Stock Exchange over the period 1992:12 to 2003:6.

Table 8: Determinants of liquidity measures – regressions

	hpi(ew)		hpi(vw)		hpi(ew)		hpi(vw)		hpi(ew)		hpi(vw)	
Variable	coeff	pvalue	coeff	pvalue	coeff	pvalue	coeff	pvalue	coeff	pvalue	coeff	pvalue
constant	0.722	(0.00)	0.512	(0.00)	-0.127	(0.20)	0.058	(0.55)	0.998	(0.00)	0.752	(0.00)
ln(Firm Size)	-0.013	(0.00)	0.008	(0.02)	0.021	(0.00)	0.024	(0.00)	-0.033	(0.00)	-0.008	(0.07)
Stock Volatility	0.688	(0.01)	0.502	(0.04)	-2.765	(0.00)	-1.423	(0.00)	0.882	(0.01)	0.678	(0.02)
BM Ratio	0.036	(0.00)	0.017	(0.00)	0.063	(0.00)	0.038	(0.00)	0.059	(0.00)	0.036	(0.00)
ln(Firm listing age)	0.097	(0.00)	0.034	(0.00)	0.079	(0.00)	0.025	(0.00)	0.099	(0.00)	0.035	(0.00)
Primary insider fraction	-0.100	(0.08)	0.074	(0.17)	-0.125	(0.04)	0.054	(0.35)	-0.117	(0.08)	0.060	(0.32)
Largest owner	-0.042	(0.13)	0.003	(0.90)	-0.012	(0.69)	0.062	(0.03)	0.094	(0.00)	0.115	(0.00)
Annual Turnover	-0.153	(0.00)	-0.126	(0.00)								
Annual Avg Rel BA Spread					4.774	(0.00)	2.620	(0.00)				
Amortized Spread									-6.784	(0.00)	-5.976	(0.00)
n	1118		1118		1118		1118		1118		1118	
R^2	0.50		0.32		0.46		0.18		0.31		0.12	

The table shows results of four independent regressions showing how the holding period indices listed at the top of each column are determined by the explanatory variables listed in the rows. The variables hpi(ew) and hpi(vw) are averages of holding period length at the stock level calculated over a period of one year by taking all owners observed at the final date and taking the average holding period over the period for these owners. The index hpi(ew) is an equally weighted average and the index hpi(vw) is a value weighted average. *Firm Size*: The value of the company's equity. *Stock Volatility*: Volatility of the stock's returns, estimated using one year of returns. *B/M ratio*: Book/Market Ratio. *Insider fraction*: Fraction of the company held by insiders. *Listing age*: Number of years on the stock exchange. *Largest owner*: Fraction of the company owned by the firm's largest owner. *Turnover*: Number of shares traded in the stock during one year divided by number of shares outstanding. *Bid/Ask spread*: Relative bid/ask spread $(P_a - P_b)/P_t$, averaged over a year. *Amortized Spread*: The Chalmers and Kadlec (1998) definition of amortized spread, estimate of the annual cost of trading the stock. The analysis uses monthly data from the Oslo Stock Exchange over the period 1992:12 to 2003:6.

Table 9: Adding liquidity measures as determinants of holding period indices

Panel A: Excess returns

	hpi(ew)	hpi(vw)	Turnover	Spread	Amortized Spread
1	1.31	1.21	2.13	0.86	1.13
2	1.30	1.88	1.34	1.20	1.07
3	1.25	1.05	1.36	1.80	1.53
4	1.48	0.89	1.42	1.45	0.94
5	1.36	0.96	1.73	1.44	1.40
6	0.82	1.29	1.98	1.30	1.45
7	0.75	1.09	1.57	1.61	1.36
8	1.30	1.18	1.55	1.35	1.89
9	1.16	0.65	1.24	2.69	2.41
10	0.70	1.18	1.57	2.16	2.67

Panel B: Returns in excess of the Fama French three factor model

	hpi(ew)	hpi(vw)	Turnover	Spread	Amortized Spread
1	0.76	-0.37	0.64	0.01	-0.03
2	-0.75	1.31	-0.44	-0.14	-0.10
3	0.28	-0.42	0.04	-0.15	0.16
4	0.05	-0.37	0.21	-0.32	-0.35
5	0.23	0.06	0.30	-0.35	-0.07
6	-0.25	0.04	0.24	-0.55	-0.34
7	-0.25	0.00	-0.25	-0.30	-0.42
8	0.40	0.17	-0.35	-0.24	-0.07
9	0.27	-0.38	-0.00	1.02	0.12
10	-0.11	0.44	-0.58	0.47	0.52

We here perform a number of cross-sectional investigations of asset prices. We show excess returns of 10 portfolios sorted by either a holding period index (`hpi`) or a liquidity measure. For each stock we calculate the `hpi` indices and the three liquidity measures annual turnover, average relative bid/ask spread and amortized spread. We then use these numbers to group the stocks into 10 portfolios. This portfolio grouping is done at yearend. We then calculate returns of these portfolios for the next year. The top table (panel A) describes the excess returns of these 10 portfolios, i.e. returns in excess of the risk-free interest rate. The bottom table (panel B) describes the returns in excess of the Fama French three factor model of these 10 portfolios. This is estimated as follows. For each stock we use five years of historical data to estimate the parameters b_m, b_{HML} and b_{SMB} in the Fama French model

$$r_{it} - r_{ft} = b_{m,i}(r_{mt} - r_{ft}) + b_{HML,i}HML_t + b_{SMB,i}SMB_t + \varepsilon_{it}$$

We then use the estimated parameters to find the realized excess return the next month. Moving forward, parameters are continuously reestimated using five years of data. The variables `hpi(ew)` and `hpi(vw)` are averages of holding period length at the stock level calculated over a period of one year by taking all owners observed at the final date and taking the average holding period over the period for these owners. The index `hpi(ew)` is an equally weighted average and the index `hpi(vw)` is a value weighted average. *Turnover*: Number of shares traded in the stock during one year divided by number of shares outstanding. *Bid/Ask spread*: Relative bid/ask spread $(P_a - P_b)/P_t$, averaged over a year. *Amortized Spread*: The Chalmers and Kadlec (1998) definition of amortized spread, estimate of the annual cost of trading the stock. The analysis uses monthly data from the Oslo Stock Exchange over the period 1992:12 to 2003:6.

Table 10: Cross-sectional investigations of asset prices

	a		r_m		spread	
1	0.0066	(0.25)	0.8557	(0.00)	0.5261	(0.00)
2	0.0024	(0.62)	0.7867	(0.00)	0.1386	(0.04)
3	0.0013	(0.79)	0.9873	(0.00)	0.0168	(0.84)
4	0.0030	(0.63)	1.1870	(0.00)	0.1553	(0.12)
5	0.0002	(0.96)	0.9364	(0.00)	-0.0731	(0.26)
6	0.0001	(0.98)	1.0675	(0.00)	-0.0953	(0.20)
7	-0.0045	(0.43)	0.9692	(0.00)	-0.5160	(0.00)
8	-0.0037	(0.59)	0.9145	(0.00)	-0.4365	(0.00)
$\lambda_1(r_m)$	0.0152	0.00				
λ_2(spread)	0.0144	0.00				

The table shows the result for estimating the system

$$E[r] = \beta\lambda$$
$$\mathbf{r} = \mathbf{a} + \beta\mathbf{f}$$

where the relative spread has been used to generate the "liquidity factor" (`LIQ`). *Bid/Ask spread*: Relative bid/ask spread $(P_a - P_b)/P_t$, averaged over a year. The analysis uses monthly data from the Oslo Stock Exchange over the period 1994:1 to 2007:12.

Table 11: GMM estimation of factor portfolios

	spread		turnover		am spread		hpi(ew)		hpi(vw)	
1	0.527	(0.00)	-0.335	(0.07)	0.433	(0.00)	0.132	(0.02)	0.007	(0.90)
2	0.139	(0.04)	-0.061	(0.58)	0.083	(0.25)	-0.003	(0.95)	0.002	(0.86)
3	0.017	(0.84)	0.014	(0.91)	-0.007	(0.93)	-0.052	(0.19)	0.002	(0.84)
4	0.156	(0.12)	-0.092	(0.55)	0.164	(0.05)	0.027	(0.49)	0.004	(0.88)
5	-0.073	(0.26)	0.056	(0.51)	-0.074	(0.28)	-0.061	(0.05)	0.001	(0.96)
6	-0.095	(0.20)	0.060	(0.58)	-0.056	(0.41)	-0.068	(0.11)	0.001	(0.95)
7	-0.516	(0.00)	0.331	(0.00)	-0.400	(0.00)	-0.189	(0.00)	-0.003	(0.94)
8	-0.436	(0.00)	0.255	(0.10)	-0.328	(0.00)	-0.166	(0.02)	-0.003	(0.95)
$\lambda(m)$	0.015	(0.00)	0.015	(0.00)	0.015	(0.00)	0.018	(0.00)	0.012	(0.70)
λ(spread)	0.014	(0.00)								
λ(turnover)			-0.025	(0.04)						
λ(am spread)					0.031	(0.00)				
λ(hpi(ew))							0.044	(0.07)		
λ(hpi(vw))									2.026	(0.91)

The table summarizes five different estimations of the system

$$E[r] = \beta\lambda$$

$$\mathbf{r} = \mathbf{a} + \beta\mathbf{f}$$

The system is estimated using GMM. We use two factors, a market factor, er_m, which is the excess return on an equally weighted market index, and a liquidity factor `LIQ`, constructed from portfolios sorted by various liquidity factors. We only report the betas for the liquidity factor, not the alphas and betas against the market. The variables `hpi(ew)` and `hpi(vw)` are averages of holding period length at the stock level calculated over a period of one year by taking all owners observed at the final date and taking the average holding period over the period for these owners. The index `hpi(ew)` is an equally weighted average and the index `hpi(vw)` is a value weighted average. *Turnover*: Number of shares traded in the stock during one year divided by number of shares outstanding. *Bid/Ask spread*: Relative bid/ask spread $(P_a - P_b)/P_t$, averaged over a year. *Amortized Spread*: The Chalmers and Kadlec (1998) definition of amortized spread, estimate of the annual cost of trading the stock. The analysis uses monthly data from the Oslo Stock Exchange over the period 1994:1 to 2007:12.

Table 12: GMM estimation of factor portfolios