Appendix

A Index Construction

A.1 Definitions & Data Sources

The realized stock return from holding security i between date t and $t-1$ equals:

$$r_{it} = \frac{P_{it} \times S_{it} + D_{it} - P_{i,t-1}}{P_{i,t-1}}, \tag{A1}$$

where S_t denotes the split factor associated with a capital operation with ex-right day t and D_t is the dividend per share with ex-dividend day t.[1] The value-weighted average realized rate of return from holding a portfolio of $i = 1 \cdots N$ stocks is:

$$r_{pt} = \sum_{i=1}^{N} w_{i,t-1} \times r_{it}, \tag{A2}$$

with weights defined by the previous day's price multiplied by the number of shares outstanding divided by market capitalization W_{t-1}:

$$w_{i,t-1} = \frac{p_{i,t-1} \times n_{i,t-1}}{W_{t-1}}. \tag{A3}$$

We construct an index from the time-series of portfolio returns:

$$I_t = \prod_{t=1}^{t} (1 + r_{pt}). \tag{A4}$$

The index reflects total stock returns, it includes dividends that are reinvested in the index, and it is value weighted.

We want to break up the total return index into its main components of dividends and capital gains. The standard solution is to subtract the dividend from Equation (A1), and treat the

[1] We do not split adjust the dividend per share, which reflects the old number of shares on the ex-right day of a capital operation. The dividend per share is affected by the capital operation, when the new shares have been issued and registered, which occurs several months later.

difference between the total return index and the resulting capital gains index as the dividend yield. This procedure is fine when we observe stock returns over the ex-dividend day, but this is frequently not the case. Instead, to make sure that we take into account the full effect of all dividends that influence the total return index, we construct a capital gains index by subtracting "accrued interest" from each return observation throughout the year:

$$r_{it}^{g} = \frac{P_{it} \times S_{it} + D_{it} - A_{it} - P_{i,t-1}}{P_{i,t-1}}, \tag{A5}$$

where we define accrued interest A_{it} as the next year's dividend (yet unknown to shareholders) divided by the number of business days in a year (daily data) or the number of months in a year (monthly data). The difference between the total return index that results from Equation (A1) and the capital gains index from Equation (A5) equals the dividend yield.

Finally, we are interested in estimating stock returns net of personal income tax. We assume that capital gains can be indefinitely deferred, while shareholders must pay annual income tax on dividends. We compute after-tax returns by subtracting a small amount of income tax from each return observation:

$$r_{it}^{\tau} = \frac{P_{it} \times S_{it} + D_{it} - A_{it} \times \tau_t - P_{i,t-1}}{P_{i,t-1}}, \tag{A6}$$

where τ_t is the personal tax rate on dividend income. By construction, we must have $r_{it} > r_{it}^{\tau} > r_{it}^{g}$.

The equations are standard, but they are not easily implemented given the restrictions of our data set. We need: *(i)* stock prices, *(ii)* dividends, *(iii)* split factors, *(iv)* number of shares, and *(v)* tax rates. The Official List contains stock prices as specified above, cash dividends, a marker for the ex-dividend day (from 1937), a marker for the ex-right day (from October 1919), and the number of shares outstanding (from 1959). The Company Law of 1910 requires that companies file detailed information about each capital change (par value, number of shares) with the Swedish Companies Registration Office. Two annals, Svenska Aktiebolag (1901–1977) and Aktieägarens Uppslagsbok (1928–1948), summarize those filings. We also collect information from annual reports (we have a complete collection), newspaper advertisements of rights offers, and in a few cases the primary

source documents from the National Archives of Sweden.[2] Tax rate tables are conveniently available from Söderberg (1996).

A.2 Prices

We define the daily price as the average transaction price of all reported transaction prices during the course of the day (see Table 1). We compute monthly stock returns, when there is a transaction price on the last business day of the month and there are adjacent prices from one month to the next. The motivation for focusing on transaction prices is that we want to measure the performance of liquid stocks that investors can buy and sell. Whatever happens to a stock's performance before or after it appears on the Official Quotation List is being ignored. The reason for using the average price instead of the opening auction price or the last recorded price of the day is that price information is scant, and we want to use everything we have. Ideally, we would like to measure daily returns from open to open or close to close, but this would come at the expense of deleting price information. In the modern portion of the data set, starting 1979, we base our calculations on the last transaction price of the day.

A.3 Dividends

Dividends are payable upon approval by shareholders, which means that dividends are paid after the annual general meeting. Shareholders can claim their dividends against the presentation of a coupon, which is attached to the stock ownership certificate (coupon sheet). From the early 1970s, stock ownership is electronic and dividends are paid directly into shareholders' accounts. Starting 1937, the Official Quotation List marks the ex-dividend day. Before 1937, we identify the ex-dividend day as the day of the annual general meeting, which is usually printed in the annual report. When the meeting date is missing from the annual report, we identify the ex-dividend day as a change in the coupon number on the Official Quotation List. Some companies make a second dividend payment later in the year. Semi-annual dividend payers choose a fixed date for the second

[2]There are many rights offers before 1912, but the offer terms are hard to come by. Therefore, one cannot compute split factors and stock returns in any meaningful way before 1912. For a few firms, we have collected newspapers advertisements of the rights offer terms, but the terms of most rights offers are missing.

payment such as December 1. In addition to dividends, some companies return capital to common stockholders,[3] and numerous companies redeem limited preferred stocks. Share repurchases are not allowed before March 2000.

Our approach to estimating dividend yield (Equation (A5)) rests on the notion of accrued interest, which is a function of shareholders' expectations of future dividends. In our calculations, we assume that shareholders have perfect foresight, i.e., we assume that the expected dividend per share equals the realization of the next dividend per share, we adjust for stock splits, stock dividends, and rights offers, which have a large quantitative effect on the dividend per share, but we ignore the relatively minor effects of special dividends. As long as shareholders' expectations are unbiased, estimation errors should cancel out by the law of large numbers.

A.4 Split Factors

A.4.1 Base Case

The price per share changes as a result of capital operations, which are abundant. The full data set contains 395 stock splits, 821 stocks dividends, and 1,055 rights offers. The number of event dates is less than the sum because many firms carry out multiple operations at the same time. The list of capital operations does not include new issues of stocks to target shareholders in acquisitions. Presumably, acquisition payments are at the full market price and do not change the market price per share. For the same reason, we also do not include redemptions of preferred stock in the list of capital operations.

Suppose there is one old share and that n additional shares result from a stock dividend or a stock split. The correction factor of a stock split or a stock dividend is equal to the new number of shares divided by the old number of shares:

$$S_t = \frac{1+n}{1}. \tag{A7}$$

[3]The balance entry of dividends is earned surplus, while return of capital is accomplished by writing down par value or reducing the number of shares outstanding through a reverse stock dividend. Return of capital is subject to court approval and debtholder consent.

The split factor can be greater than one or smaller than one (reversed).[4] In a rights offer of new shares below the market price, $P_{t-1} > P_o$, the expected ex-right price is:

$$E(P_t) = \frac{P_{t-1} \times 1 + P_o \times n}{1 + n}. \tag{A8}$$

and the split factor equals:

$$S_t = \frac{P_{t-1}}{E(P_t)} = \frac{P_{t-1} \times (1 + n)}{P_{t-1} + P_o \times n}. \tag{A9}$$

If the offer price exceeds the market price, $P_{t-1} < P_o$, the split factor is simply $S_t = 1$, which happens in 19 rights offers. In these cases, the rights offer fails (undersubscribed) or a guarantor picks up the residual.

The split factor of a rights offer is a function of the market price on the last day before the end of the rights offer period. When the company issues a new security that is not previously traded in the stock market, we do not know the value of the last cum-right price. In this case, we assume that the split factor equals the observed stock market response:

$$S_t = \frac{P_{t-1}}{P_t} \tag{A10}$$

This method implies that the rate of return over the ex-right day is zero. In the historical part of the data from 1912–1978, we impose this assumption on 20 rights offers of limited and participating preferred stocks, 10 stock dividends of limited preferred stocks, and 16 secondary distributions of which 14 distributions are equity carve-outs of subsidiary shares from a parent company. In the modern part of the data from 1979–2017, 154 distributions of securities are treated this way.

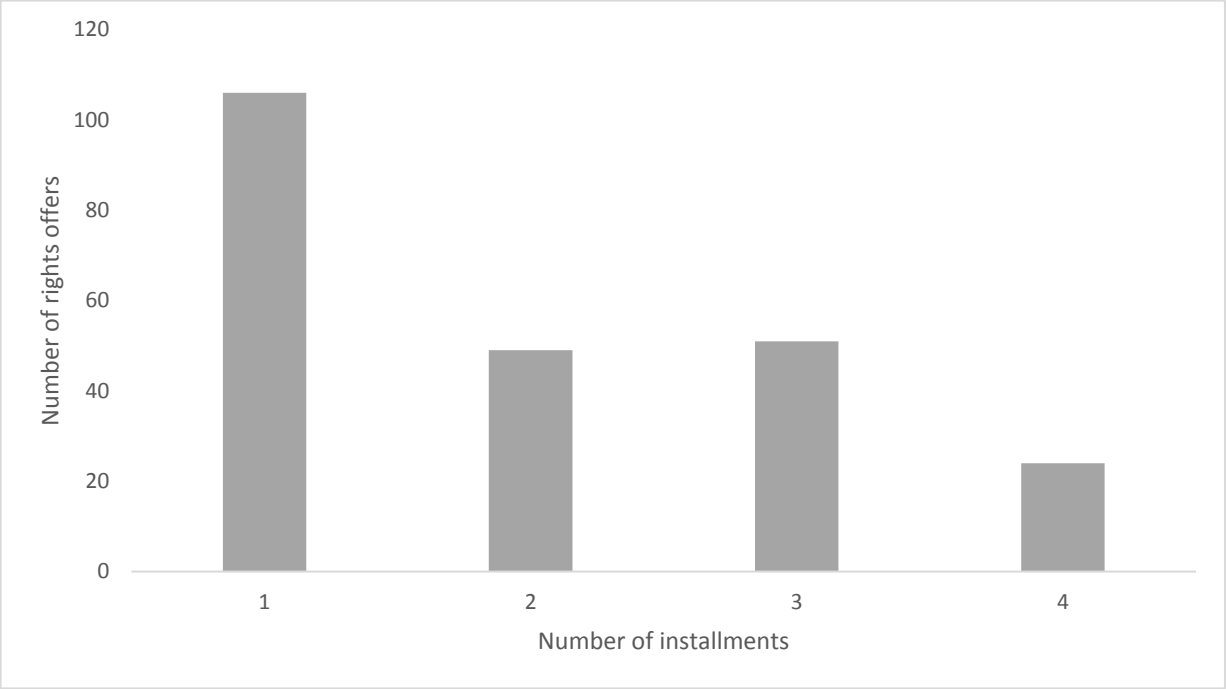
With the introduction of electronic share registry in the mid-1970s, shareholders on the record date have the right to either subscribe to the rights offer or trade their right during the rights offer period. The rights offer must remain open two weeks, and payment is due in one installment shortly after the end of the rights offer period. In our calculations, we ignore discounting between the record date and the payment date. The rights offer procedure and the calculation of split factors before the introduction of computers requires further explanation.

[4]The data set contains 28 reverse stock splits and three reverse stock dividends.

A.4.2 Rights Offers in the Past

Rights offers in the early part of our sample are complex. Three additional variables enter the calculations of the split factor: *(i)* stamp duty, *(ii)* interest, and *(iii)* future dividends. These complications arise from the fact that capital is scarce. Existing shareholders may not have sufficient liquidity to purchase new shares, and there may not be any outside shareholders who are willing to purchase the rights. To accommodate participation, subscribers are often allowed to pay for the new shares in multiple installments. Figure A1 displays the frequency distribution of the number of

Figure A1: Number of Installments 1912–1930



From 1912–1930, the payment for new shares issued through rights offers is often due in multiple installments. The figure plots the frequency of the number of installments per rights offer for 230 rights offers during this period. After 1930, the payment for all rights offers are due in one installment.

installments across rights offers from 1912–1930. The distribution is approximately equally divided between single and multiple installments with four installments being the highest. There are no

rights offers with more than one installment after 1930.[5] As we move forward in time, liquidity improves, the rights offer process shortens, and the formula for computing the split factor reduces to that of Equation (A9).

Stamp duty. A company must pay stamp duty in the amount of 1% of the offer price.[6] In some rights offers, the company pays the tax, while in other cases, the company requires that shareholders contribute with the funds to pay the tax. The effect of stamp duty is to raise how much shareholders pay for the new shares. Stamp duty enters the calculation of the split factor of 137 rights offers of which 90% take place from 1912-1920. The last observation where the company requests that shareholders pay stamp duty in addition to the offer price occurs in 1948.

Interest. A share of common stock consists of an ownership certificate and a coupon sheet. The rights offer specifies the initial coupon number of the new shares, which in most cases is either equal to the coupon number of the current income year or the coupon number that begins with the next income year.[7] Suppose that the new shares are assigned with the coupon number of the current income year. In this case, the issuing company requires that subscribers pay interest from the beginning of the current income year to the full payment of the new shares.[8] These interest charges imply that the new shares are fully paid from the beginning of the current income year in the sense of present value. Interest raises how much money subscribers must pay for the new shares in addition to the offer price and stamp duty. Accordingly, we add interest charges to the purchase price of 115 rights offers using the 30/360 convention and the interest rate stated in the rights offer. The last observation occurs in 1951. Suppose, instead, that new shares are assigned with

[5]The Company Law of 1910 states that new shares must be fully paid within one year of shareholders' approval of the rights offer, and management must register the shares with the Swedish Companies Registration Office within six months of the final payment. Shares cannot be issued and registered before they have been fully paid, and dividends cannot be distributed to the holders of new shares before they have been issued.

[6]There is also stamp duty in the amount of 1% of par in stock dividends. Naturally, the company pays this tax.

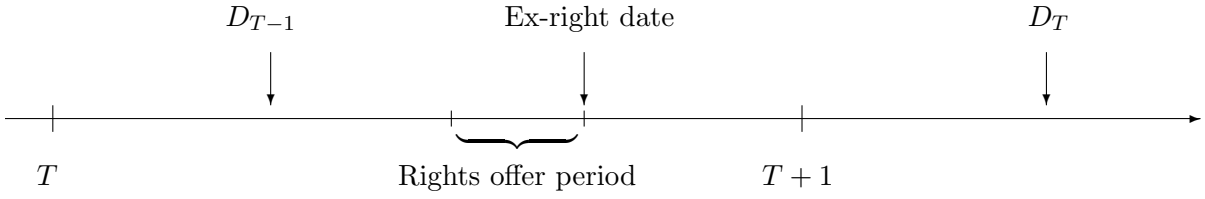
[7]Since dividends are paid annually, in the past, many companies numbered their coupons by calendar year (1912, 1913, etc.) This institutional observation suggests that regular dividends are significant in a stock market where liquidity is scarce. In three rights offers, the new shares entitle to corporate income from the middle of the current calendar year. The new shares of Kreuger & Toll receive 1/6 of the dividend for 1929 (November and December), and the new shares of Nordiska Kompaniet 1917 and Mexikanska Ericsson 1930 are entitled to 1/2 of the next dividend (July through December).

[8]From an accounting point of view, the offer price is split into capital and capital surplus, which are not available for future dividends, while interest is treated as earned surplus, which can be paid back as a dividend.

the coupon number of the next income year. In this case, the company pays interest to subscribers for payments that take place before the turn of the year, and the company charges interest for payments that occur after the turn of the year. The use of credit and debit interest implies that the new shares become fully paid from the beginning of the next income year in the sense of present value. Since the present value of future interest is zero, these interest payments have no effect on the calculation of the split factor.[9]

Dividends. Issuers of new shares do not interrupt the payment of dividends, which appear to be an essential source of liquidity for stock market participants. In fact, average payback time is three years, i.e., the average company returns the gross proceeds from the new issue in the form of dividends within three years.[10] Future dividends have a quantitative impact on the split factor that exceeds the effects of stamp duty and interest. To reduce notation, we suppress the operators for expectation and present value, and we do not state that the split factor must be greater than or equal to one. We also leave out stamp duty and interest from all equations.

Figure A2: Time Line of Rights Offer and Dividends



The figure displays the subscription period and the ex-right date of a rights offer between the payment of the dividend D_{T-1} that takes place immediately after the annual general meeting in year T, and the next dividend D_T, which is payable after the annual general meeting year $T+1$.

There are four cases that depend on the coupon number of the new shares and whether the ex-right day occurs before or after the annual general meeting of the current income year. Figure A2

[9] Some recent rights offers state a penalty interest for late payments. These charges have no implications for the calculations of split factors.

[10] Circulating cash in and out of the company is costly because, in addition to administrative costs, shareholders supply after-tax money (payments for new shares) in return for before-tax money (dividends).

illustrates the time line of a rights offer that takes place after the annual general meeting. The ex-right date is the last business day before the end of the subscription period (one day settlement).[11] At this time, there is no record date.

Case I: suppose that the coupon number of the new shares is $T+1$. Old shareholders are entitled to receive the next dividend, D_T, while new shareholders must wait another year before they will receive the dividend D_{T+1}. The expected ex-right price of the old shares is equal to:

$$E(P_t) = \frac{P_{t-1} \times 1 + P_o \times n - D_T}{1+n} + D_T. \tag{A11}$$

The second term on the right hand side is the (present value of the expected) dividend to be paid next year, and the first term is the (present value of the expected) ex-dividend price that will result after the next year's annual general meeting. The split factor associated with the ex-right day of the old shares equals:

$$S_t = \frac{P_{t-1} \times (1+n)}{P_{t-1} + (P_o + D_T) \times n}. \tag{A12}$$

The effect of the future dividend is equivalent to raising the offer price by the dividend amount. The dividend decreases the split factor, and the probability that the right ends up out of the money increases. If the new shares are fully paid and issued before the next annual general meeting, the Exchange may parallel list old and new shares, where old shares trade cum-dividend and new shares trade ex-dividend.[12] After the payment of the dividend D_T, old and new shares become equal. We implement Equation (A12) under the assumption that investors have perfect forecast of future dividends, and we ignore discounting. At this time, dividends are stable and easy to forecast, and the effect of discounting is negligible.

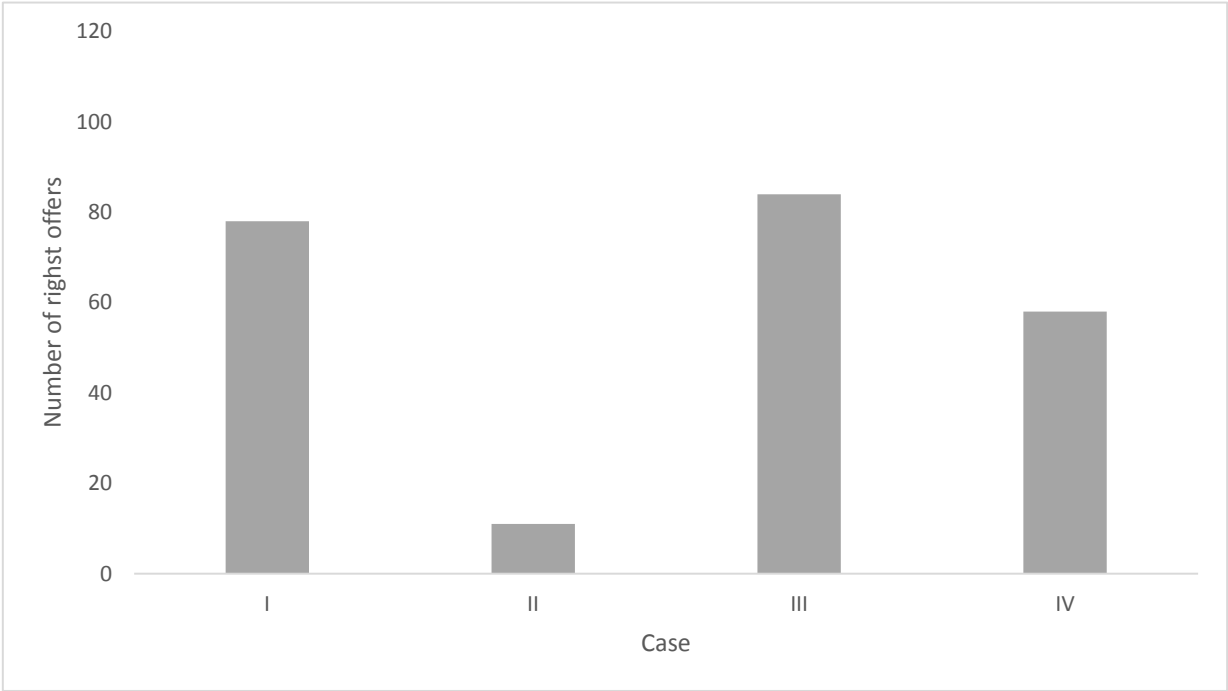
The other three cases follow immediately: **Case II:** if the first coupon number of the new shares is $T+1$ and the ex-right day occurs before the annual meeting of year T, new shareholders miss both dividend payments D_{T-1} and D_T, and the split factor must be adjusted for both dividends.

[11] The rights offer must remain open four weeks from when the offer has been publicly advertised. The shareholder vote can be carried out before or after the end of the rights offer period (ex-post ratification).

[12] Separate listings of old and new shares takes place after some large rights offer by Ivar Kreuger's companies (Kreuger & Toll, Ericsson, Tändstickor, Mexikanska Ericsson). Dual listings of old and new shares are frequent before the Company Law of 1910 tightens the time line for new issues.

Case III: if the first coupon number is T and the annual general meeting takes place before the rights offer, new shareholders do not miss any dividends, and Equation (A9) applies. **Case IV:** if the first coupon number is T and the annual general meeting takes place after the ex-right day, new shareholders miss the payment of D_{T-1}, which enters the calculation of the split factor. Figure A3

Figure A3: Rights Offers and Dividends 1912-1930



The figure plots the number of rights offers divided into four cases. Case I: the new shares receive D_{T+1}, but the are excluded from the payment of D_T; Case II: the new shares receive D_{T+1}, but they are excluded from the payment of both D_{T-1} and D_T; Case III: the new shares receive D_T and they are not excluded from any dividends; Case IV: the new shares receive D_T, but they are excluded from receiving the payment of D_{T-1}.

plots the frequency distribution of the number of rights offers that fall into each of the four cases. The plot is based on rights offers from 1912–1930. The four cases are approximately equally common except for the one where new shareholders are excluded from receiving the payments of both D_{T-1} and D_T (ten observations). Dividend adjustments continue to matter in modern times, but the market standard becomes that of assigning the new shares with coupon number of the current income year D_T rather than the next income year D_{T+1}, i.e., the frequency distribution

shifts towards Cases III and IV to the right in Figure A3. As we enter the modern portion of the data (1979–2017), the dividend adjustment becomes rare (Case III only).

A.5 Number of Shares

The number of shares outstanding equals capital C_t divided by par value per share π_t:

$$n_t = \frac{C_t}{\pi_t}. \tag{A13}$$

Par value must be equal for all shares, and it cannot be less than 50 kronor per share.[13] This restriction is relaxed by the Company Law of 1975, and most companies split their stocks to lower par values.

Many companies have multiple classes of shares. Our principal solution is to pick the price of the most liquid class and treat the shares of all classes as perfect substitutes. This is an approximation. Numerous companies have multiple classes of common stocks that differ with respect to the number of voting rights per share and/or foreign ownership eligibility. For the most part, with some noticeable exceptions, prices are approximately equal. In the 1980s, the number of classes of shares issued by the same company is frequently three or four and, in one extreme case, as many as six. In preparation for joining the European Union in 1994, the Swedish Government removes the regulatory restriction on foreign ownership of Swedish companies, which reduces the number of classes of common stock to one or two per company. Some companies issue preferred stocks. Limited preferred stocks resemble junior debt and their prices do not approximate well for the prices of common stocks. However, the relative importance of limited preferred stocks decreases over time as the outstanding stock of preferred stocks does not increase with company growth. Other companies issue participating preferred stocks. Participating preferred stocks are priced close to common stocks and the approximation is good.[14]

Capital operations change the number of shares outstanding. We designate the ex-right day as the effective date when the number of shares changes as a result of a stock split, stock dividend,

[13] The Company Law of 1910 states the minimum par value per share. Courts can grant exception. Three insurance companies operate with two classes of common shares that have different par values.

[14] In addition to common and preferred stocks, three companies have deferred stocks outstanding.

rights offer, or the redemption of preferred stock. The motivation for this choice is that the market price reflects the new number of shares on the ex-right day even if the new shares will not be issued until later.[15] When a company issues new shares to the shareholders of another company, we choose the earliest of a known ex-right day, the date when the acquisition appears in the annual report, and the ex-right date of another capital operation that we know takes place later in the year.[16]

A.6 Tax Rates

Throughout most of the history of personal income taxation, dividends are taxed as ordinary income subject to a progressive tax table at the country level and a proportional tax at the county level. The tax reform of 1990 redefines dividends as capital income, which is subject to a 30% proportional tax rate at the country level and no taxes at the county level. Since income tax is progressive, the marginal tax rate depends on income. In our calculations, we retrieve the marginal tax rate of an income, which is equal to a constant multiple of GDP per capita, and then check how our results vary with the income multiple.

In the early days of stock market history, households own almost all shares directly. By 1950, the aggregate household ownership fraction has decreased to 70%, and today it is 15% (see Rydqvist, Spizman, and Strebulaev (2014)). Aggregate stock ownership gradually moves from households to corporations, institutions, and foreign investors. Corporations pay corporate tax, and foreign investors pay 15% withholding tax. In our calculations, we shall assume that only households pay income tax and that all other shareholders are exempt from income tax. Accordingly, we compute the weighted average of the household marginal tax rate and the zero marginal tax rate of all others:

$$\tau_t = \Omega_{ht} \times \tau_{ht}, \tag{A14}$$

where τ_{ht} is the marginal tax rate of our representative household at time t and Ω_{ht} is the aggregate ownership fraction of the household sector at time t.

[15] There are stock dividends and rights offers where we cannot identify the ex-right day because there are no prices. For these stocks, we choose the date when the capital operation appears in the annual report.

[16] Acquisitions are rights offers to target shareholders, who must accept the offer before the rights offer period ends.

B Thin Market Measurement

In this appendix, we delve into measurement issues that are mostly relevant for the historical portion of the data from 1912–1978. First, we explore whether stock market performance depends on which stocks we select for the stock market index. A large-cap index may perform differently from an all-inclusive index. Second, we want to know how our results change if we replace missing month-end-transaction prices with transaction prices from a few days back. A related issue is whether we can replace missing values with buy or sell limit orders, which are more abundant than transaction prices. The Affärsvärlden (AFGX) index is based on buy limit orders. Third and finally, we want to quantify the effect of not correcting stock prices for capital operations. The motivation is that split factors are difficult to construct and, in the case of rights offers, they require information that may not be available. The effect of omitted split factors is to some extent mitigated by the fact that adjacent transaction prices are often missing at the same time.

B.1 Stock Selection

We construct three stock portfolios that vary by liquidity. In particular, we select a stock into an index portfolio, if during the previous calendar year the stock's trading frequency passes a minimum threshold, which we set equal to 0% (all stocks included), 50% (mix of liquid and illiquid stocks), and 90% (mostly liquid stocks).[17] Once we have selected a stock into an index portfolio, it does not leave the index even if the stock's trading frequency drops below the cutoff. The motivation is to evaluate the performance of a rigid stock portfolio that does not change from one year to the next. All performance measures decrease by firm size or liquidity as captured by the selection rules 0/50/90, but the effect of stock selection is fairly small (Table B1). We think of the difference in average stock return as the effect of liquidity rather than risk because the difference in volatility across the three portfolios is negligible. The differences across the stock market portfolios is small because large capitalization stocks dominate the index calculations. The performance estimates of our three stock portfolios span that of previous index calculations for the Stockholm Stock Exchange

[17] We make an exception for 1912, when a stock is selected into an index portfolio in the beginning of the year based on the frequency of trading throughout the year.

Table B1: Stock Market Performance and Stock Selection 1912–1978

	Stock-selection rule			
	0%	50%	90%	AFGX
Average stock return (%)	6.43	6.25	6.03	6.34
Standard deviation (%)	14.91	15.37	16.29	—
Months with data (%)	33.2	61.6	75.2	—
#Observations	25,928	23,463	15,418	—

The table reports the geometric average stock market return conditional on the stock selection rule. AFGX is the stock market index of Affärsvärlden.

(AFGX).

B.2 Replacement Strategies

B.2.1 Search Back

We derive stock market performance from end-of-month transaction prices. If transaction prices are missing from either the last day of the month or the last day of the previous month, the observation is deleted from the index calculation. One alternative method is to replace missing end-of-month transaction prices with past transaction prices. Table B2 summarizes geometric average returns

Table B2: Stock Market Performance with Search Back 1912–1978

	Search back number of days					
	Zero	One	Two	Three	Four	Five
Average stock return (%)	6.43	6.78	6.98	7.03	7.05	7.10
Standard deviation (%)	14.91	14.08	13.82	13.65	13.55	13.44
Months with data (%)	33.2	42.0	46.5	49.2	51.1	52.6
#Observations	25,928	32,800	36,314	38,423	39,907	41,079

The table reports geometric average stock returns when we replace missing end-of-month transaction prices with past transaction prices. We search up to five days back.

when we search back up to five business days for a transaction price. Average stock returns increase monotonously from 6.43% without search back to 7.10% with five days search back because less liquid stocks are added to the index portfolio. Volatility decreases as we replace missing prices on the last day of the month with past prices. Sample size increases from about 26,000 months with data to above 40,000. The effect of increasing coverage from 33.2% to 52.6% is fairly small because the index calculation remains dominated by large-cap stocks. We conclude that search back makes a small difference to performance measurement.

B.2.2 Limit Orders

Many historical data bases with monthly or annual stock prices replace missing values with quotes. Dimson, Marsh, and Staunton (2016) construct a stock price index from 1899–1954 based on the midpoint between bid and ask at the end of each month. In their study of the New York Stock Exchange 1815–1925, Goetzman, Ibbotson, and Peng (2001) follow the same strategy and substitute in the average of bid and ask quotes, when transaction prices are missing. From the Brussels Stock Exchange 1833–2005, Annert, Buelens, Cuyvers, de Ceuster, DeLoof, and de Schepper (2011) collect end-of-month prices in order of preference: transaction prices, past prices, bid quotes, and ask quotes. Nyberg and Vaihekoski (2010) base their study of the Helsinki Stock Exchange 1912–1990 on monthly buy limit orders that do not represent trade, and previous return estimates from the Stockholm Stock Exchange 1901–2015 are for the most part based on non-traded limit orders (Frennberg and Hansson (1992) and Waldenström (2014)).

Table B3: Stock Market Performance with Limit Orders 1912–1978

	Price	Buy side	Midpoint	Sell side
Average stock return (%)	6.43	7.37	6.23	6.00
Standard deviation (%)	14.91	14.57	13.87	14.23
Months with data (%)	33.2	50.1	34.1	43.5
#Observations	25,928	39,162	26,643	33,986

The table reports the geometric average stock market return that have been estimated from transaction prices, buy limit orders, the midpoint between buy and sell, and sell limit orders.

We want to compare stock returns from transaction prices with stock returns from buy limit orders, the midpoint between buy and sell, and sell limit orders. There is a clear pattern (Table B3). Stock returns from buy limit orders exceed those from sell limit orders with transaction prices and the midpoint between buy and sell falling between the two extremes. Buy limit orders are more frequent than transaction prices, which means that less liquid stocks are included in the return measurement of buy limit orders. Sell limit orders are also more frequent than transaction prices, but stock returns with sell limit orders are less than stock returns with transaction prices, so other factors than liquidity make a difference to the outcome. The difference between return measurement with transaction prices and the midpoint is not large. We conclude that replacing missing transaction prices with the midpoint does not add much.

After this initial investigation, we take a closer look at the statistical properties of limit orders. Table B4 reports summary statistics on the spread between between the best buy and the best sell

Table B4: Post-Auction Spread 1912–1978

	Number of ticks				
	Mean	Median	1 (%)	2 (%)	More (%)
Days with trade	3.65	2	34	25	40
Days without trade	10.64	7	6	10	85

The table reports the number of ticks that separate buy from sell limit orders at the end of the daily auction given that non-traded buy and sell limit orders exist and conditional on trade versus no trade, respectively.

limit order after all crossing limit orders and market orders have been cleared through the opening auction. We measure the spread as a multiple of the price tick, which from 1920–1978 is equal to:

$$\text{Tick} = \begin{cases} 0.50, & \text{if price} < 100, \\ 1, & \text{if } 100 \leq \text{price} < 1000, \\ 5, & \text{if } 1000 \leq \text{price}. \end{cases} \tag{B1}$$

The spread is much tighter on days with trade than it is on days without trade: the median spread

increases from two ticks on days with trade to seven ticks on days without trade, and the percent of spreads that exceed two ticks increases from 40% on days with trade to 85% on days without trade (rightmost column). We conclude that the statistical properties of limit orders are different on trading trading days versus non-trading days, which raises a concern of mixing transaction prices with the midpoint between buy and sell.

Next, we investigate the distribution of stock returns. For each stock and day with adjacent prices, we compute stock returns using transaction prices, buy limit orders, the midpoint between buy and sell, and sell limit orders, respectively. Table B5 reports the proportions of stock returns

Table B5: Distribution of Stock Returns

Direction	Normal dist.	Price	Buy side	Midpoint	Sell side
			A. Days with trade		
Positive (%)	38.2	41.6	37.8	42.1	35.2
Zero (%)	25.6	19.7	29.3	18.0	29.4
Negative (%)	36.2	38.8	32.9	39.9	35.4
#Observations		416,469	416,469	416,469	416,469
Days with data (%)		22.5	22.5	22.5	22.5
			B. Days without trade		
Positive (%)	38.2	—	26.0	32.8	22.5
Zero (%)	25.6	—	50.5	33.4	51.9
Negative (%)	36.2	—	23.6	33.8	25.7
#Observations			603,367	603,367	603,367
Days with data (%)			32.0	32.0	32.0

The table reports the observed percentages of prices and limit orders that move up, down, or stay the same. The left column shows the percent of the data that would move up, down, or stay the same under the normal distribution, mean 0.04%, standard deviation 1.5%, and rounding to the nearest tick of plus/minus 0.50 kronor.

that are positive, zero, and negative, respectively. We evaluate the observed proportions against the normal distribution under the assumption that prices are rounded to the nearest tick. On days with trade (Panel A), stock returns that are based on transaction prices are positive or negative more

often than the normal distribution,[18] while non-traded limit orders move up or down less frequently than the benchmark. Non-traded limit orders are stale. On days without trade (Panel B), buy and sell limit orders move up or down far less frequently than the normal distribution. Buy and sell limit orders do not move at all 50% of the time.

The behavior of limit orders on days without trade resembles that of posted prices in the market for residential real estate. A seller posts a price to attract the right level of buyer with whom the seller can negotiate the transaction price. The arrival of potential buyers is slow, and the seller has no incentive to revise the posted price from one day to another. The primary difference between the stock market under study and the residential real estate example is that both buyers and sellers of stocks post limit orders to attract a counterparty with whom negotiations can be carried out. We conclude from this brief analysis that the non-traded limit orders in thin markets may not represent competitive prices and could be poor substitutes for missing transaction prices.

B.3 Split Factors

Detailed information about capital operations is difficult to collect for historical data sets. Computing split factors of rights offers is particularly demanding. Before the Official Quotation List of the Stockholm Stock Exchange puts a marker (from October 1919), identifying the ex-right day is a challenge by itself. In their study of the New York Stock Exchange 1915–1925, Goetzman, Ibbotson, and Peng (2001) state that they are unable to identify stock splits, but they do not offer any discussion of rights offers, which are abundant before 1925.[19] Annert, Buelens, Cuyvers, de Ceuster, DeLoof, and de Schepper (2011) state that they have corrected all stock returns for capital operations back to 1832 for the Brussels Stock Exchange, but the paper does not provide any detail of how the correction has been done or any explanation of what the capital operations are. Previous papers on historical Swedish data (Frennberg and Hansson (1992), and Waldenström (2014)) are silent about capital operations. In a study of Denmark 1922–1999, Nielsen and Risager (2001) say that they do not correct stock returns for rights offers before 1983. Quantifying the effect

[18] One would expect that stock returns, which are based on average daily stock prices move more than the benchmark because an average of multiple transaction prices from one day is likely to deviate by a small amount from the average of multiple transaction prices the next day.

[19] The financial section of the New York Times 1900–1925 reports on numerous cases of trading of rights.

of omitted split factors matters when we compare stock market performance from recent years with stock market performance from the past, if the effect of capital operations has been ignored.

Omitting a split factor results in an abnormal stock return of:

$$AR_t = \frac{1}{S_t} - 1. \tag{B2}$$

In our data, the average split factor is 1.120 (rights offers), 1.366 (stock dividends), and 4.717 (stock splits), respectively. These numbers predict one-day abnormal stock returns for a single stock of about –10%, –25%, and –80%, respectively. The effect on the stock market index is less because *(i)* the negative abnormal return for one stock gets averaged out across the stocks in the index portfolio, and *(ii)* for a large number of ex-right dates, we do not have adjacent prices that allow us to compute any stock return. To assess the attenuated effect on the index calculation, suppose that the average number of stocks in the index portfolio equals 30, the number of rights offers for which we can compute a stock return is 200, and the number of years is 67. Not correcting for the 200 rights offers, reduces the annual stock index return by:

$$E(AR) = 200 \times \left(\frac{1}{1.121} - 1\right) / (30 \times 67) = -1.07\%. \tag{B3}$$

Table B6: Stock Market Performance without Split Factors 1912–1978

		Stock return without correction for:		
	Corrected	Rights offers	Stock dividends	Stock splits
Stock return (%)	6.43	5.36	3.89	5.72
#Observations manipulated		201	217	36
#Observations not affected		245	285	47

The table reports geometric average annual stock returns in percent under three stock selection rules. The numbers to the left inside each parenthesis is the number of manipulated observations (rights offers, stock dividends, and stock splits), and the number to the right is the number of observations that are not manipulated because we do not observe prices on the ex-right day. In each experiment, we correct for all other capital operations (return of capital, equity carve-outs, secondary distributions, and issues of a new security.)

Omitted split factors reduce average stock returns by about one percentage point for rights offers, two and a half percentage points for stock dividends, and half a percentage point for stock splits (Table B6). The combined effect of omitted split factors equals the sum of these three numbers, about four percentage points, which is a large number. The effect of stock splits on portfolio returns is smaller than the other two capital operations because there are few stock splits. The frequency counts in the bottom two rows show that more than 50% of the capital operations are not affected by the omitted split factor because adjacent end-of-month transaction prices are missing.

We conclude that the effect of capital operations on the stock market index is large and cannot be ignored. The conclusion is somewhat surprising given that only a few hundred stock returns are affected in a sample of more than 25,000 observations. The quantitative effect of omitted split factors matters when we want to compare equity risk premia from the past with estimates from recent years.

References

Annert, Jan, Frans Buelens, Ludo Cuyvers, Marc de Ceuster, Marc DeLoof, and Ann de Schepper, 2011, Are Blue Chip Stock Market Indices Good Proxies for All-Share Market Indices? The Case of the Brussels Stock Exchange 1833–2005, *Financial History Review* 18, 277–308.

Dimson, Elroy, Paul Marsh, and Mike Staunton, 2016, Credit Suisse Global Investment Returns Sourcebook, Credit Suisse.

Frennberg, Per, and Björn Hansson, 1992, Computation of a Monthly Index for Swedish Stock Returns 1919–1989, *Scandinavian Economic History Review* 40, 3–27.

Goetzman, William N., Roger G. Ibbotson, and Liang Peng, 2001, A New Historical Database for the NYSE 1815 to 1925: Performance and Predictability, *Journal of Financial Markets* 4, 1–32.

Nielsen, Steen, and Ole Risager, 2001, Stock Returns and Bond Yields in Denmark 1922–1999, *Scandinavian Economic History Review* 49, 63–82.

Nyberg, Peter, and Mika Vaihekoski, 2010, A New Value-Weighted Total Return Index for the Finnish Stock Market, *Reserach in International Business and Finance* 24, 267–283.

Rydqvist, Kristian, Joshua Spizman, and Ilya Strebulaev, 2014, Government Policy and Ownership of Equity Securities, *Journal of Financial Economics* 111, 70–85.

Söderberg, Hans, 1996, *Inkomstskattens utveckling under 1900-talet.* (Skattebetalarnas Förening Stockholm, Sweden).

Waldenström, Daniel, 2014, Swedish Stock and Bond Returns, 1856–2012, IFN Working Paper No. 1027, Research Institute of Industrial Economics.