

The aggregate cost of equity underdiversification*

Internet Appendix

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1. Introduction

In this internet appendix, we provide additional information about the underlying individual Danish stocks that we use in the paper itself. We also provide the results from a number of robustness tests.

2. Stock Characteristics

We examine returns on all Danish stocks for which we have monthly stock market returns throughout the last twenty years. There are 91 stocks that fulfil this requirement. The sample period is April 1997 through April 2017. We list in Table A1 the names of the stocks, the average monthly returns (annualized), and the annualized standard deviations of monthly returns. The stocks are listed according to their average returns, in descending order. There is a wide dispersion in average returns. Two stocks (DSV and AMBU) have returned an impressive 22.4% per year on average for the last twenty years. This means that DKK 100 invested in one of these two stocks in April 1997 have turned into almost DKK 6,000 twenty years later. This appears from Figure A1 that shows the cumulative value of all 91 stocks throughout our sample period. At the bottom of the list, Torm has returned an average return of -22.8% per year. This means that DKK 100 invested in April 1997 had turned into a microscope DKK 0.56 in April 2017. So, if choosing one stock randomly in April 1997, one could have ended up with anywhere between DKK 0.56 and DKK 6,000 in 2017, or an average return anywhere between -22.8% and 22.4%.

There are 91 stocks in total. We want to compare the risk of a portfolio with $n = 1, 2, 3, \dots, 91$ stocks to the risk of a well-diversified benchmark. The benchmark we compare with is one where the investor in the first month of our sample (April 1997) invests an equal fraction in each of the 91 stocks, and keeps an equal fraction in each stock throughout the sample period. In other words, diversifying the investment across all stocks. The average annualised return to this market portfolio is 10.9% per year

and the annualised standard deviation is 15.5%. We highlight the return to this market portfolio (MP) in Table A1.

The 91 stocks listed in Table A1 are those stocks for which we have data throughout the last twenty years, as mentioned. This means that stocks that were available in 1997:4 but left the market due to mergers, acquisitions, bankruptcy etc. are not included. Similarly, those that enter the market after 1997:4 are not included either. Some of these stocks would lower the return to an investor who bought an equally-weighted portfolio of all available stocks in 1997:4 (for instance stocks that left the market due to bankruptcy) whereas others would have increased the return to an investor buying all stocks during the same period (for instance successful new entries after 1997:4). It turns out that the return on our market portfolio closely matches the return to the total Danish stock market, as measured by, e.g., MSCI Denmark. MSCI Denmark has returned 11.8% per year on average over the last twenty years. We consequently view our market portfolio as a reasonable representation of the return to a broad Danish stock market index over the last twenty years. In Section 3.4 in this Internet Appendix, we discuss consequences of assuming different market portfolios.

3. Robustness

3.1. Excluding investors holding mutual funds

26% of stock holders also hold mutual funds. Mutual funds are well-diversified per regulation. An investor who invests a small fraction directly in stocks but a large fraction in mutual funds would not be underdiversified, even if holding only, e.g., one stock directly. To make a perspective on this, we conduct the same calculations as those above for investors who do not hold mutual funds, i.e. investors who only hold stocks directly. We first stress that the major fraction of stock market investors do not hold mutual funds. 74% of stock holders do not hold mutual funds. These 737,782 stock holders, thus, do not gain stock market diversification via mutual funds. Conducting the same

calculations as above for the sample of stock holders who do not hold mutual funds, we find that the annual loss due to underdiversification is close to DKK 1.4bn. The total amount of stock holdings of these investors DKK 38bn. This implies that these investors in aggregate could improve their return by 3.7% per year, if shifting from underdiversified portfolios to well-diversified portfolios.

Calvet, Campbell, and Sodini (2007) show that the average loss of Swedish retail investors due to underdiversification is low when taking into account their savings in mutual funds. We show here that most Danish retail investors do not hold mutual funds. We also show that when focusing on this large majority of investors, the losses from underdiversification are still significant. This implies that a sensible conclusion based on the findings of Calvet, Campbell, and Sodini (2007) and those reported here is that they complement each other well: If many investors invest relatively large fractions in mutual funds, these investors end up holding portfolios with low idiosyncratic risks, even when they hold a low number of different individual stocks. On the other hand, if only few investors diversify via mutual funds, the aggregate costs of underdiversification can be sizeable. Most of our investors do not hold mutual funds.

3.2. Asset pricing implications of portfolio shifts

When calculating the aggregate loss, we implicitly assume that the expected risk premium remains at 5% when investors replace their current underdiversified portfolios with a levered market portfolio. There are four main reason why this is a reasonable assumption. First, it is the standard assumption in the CAPM. In the CAPM, investors can move up and down the capital market line (assuming no borrowing and lending constraints), given the expected risk premium. Our investors have substantial savings outside stocks, i.e. can easily replace some of their cash or bond holdings with stock holdings. Second, the marginal investor determines the market risk premium. Given that Denmark is a small economy with open capital markets, this marginal investor is the marginal world investor. Our calculations deal with Danish retail investors. Third, and related to the previous point, the market

value of listed Danish stocks is app. DKK 1,300bn (\approx USD 200bn) in 2012. Danish retail investors thus hold only app. $75/1,300 = 6\%$ of all listed Danish equity. This means that Danish retail investors constitute a relatively small fraction of total investments in the Danish stock market. Finally, if capital is elastic, such that firms issue more capital when demand for capital increases, the expected risk premium remains constant no matter the degree of leverage of the market portfolio (as in the CAPM).

3.3. Heterogeneity across individuals' performance

Conditioned on the number of stocks in investors' portfolios, we implicitly assume that all investors are identical. In other words, we assume that all investors holding, e.g., one stock would benefit from shifting from undiversified to diversified portfolios. It is outside the scope of this paper to examine in detail the performance of each individual's portfolio. Related literature gives us some hints regarding heterogeneity among investors, however. Goetzmann & Kumar (2008) find results supporting our assumption that individual investors with better diversified portfolios perform better. Examining around 60,000 individual investors at a large U.S. discount brokerage during the 1991-1996 period, they report for example that (p. 457): "*On an annual basis, the most diversified investor group earns a 2.04% higher return than the least diversified investor group.*" Using the same data, but a different method, Ivkovic et al. (2008) find that there is no difference in performance between the average investor with a concentrated portfolio and the average investor with a diversified portfolio. When analyzing a small subset (less than 10%) of investors with high wealth allocated to the stock market (above USD 100,000), they find that investors holding concentrated portfolios outperform investors holding diversified portfolios.

3.4. Market portfolios

Our calculations of the aggregate costs of diversification are based on the assumption that the equal-weighted portfolio of our 91 individual stocks represents an efficient market portfolio. Other portfolios might represent a "market portfolio", however.

For instance, when we use the equal-weighted portfolio of the 91 stocks in Table A1, we implicitly assume that Danish investors diversify across Danish stocks only. There are other broad “market portfolios” based on Danish stocks, however, such as the MSCI Denmark or the FTSE Denmark market portfolios. If one instead assumes that Danish investors invest internationally, an international portfolio would be a better candidate for the market portfolio. This could for instance be a European portfolio (e.g., the MSCI Europe, the STOXX 600, or the STOXX 50) or a global portfolio (e.g., MSCI World, the MSCI AC World, or the FTSE All World). In this section, we discuss the consequences for our main estimates if using these other market-portfolio candidates.

What matters for our estimates of the aggregate cost of diversification, as explained in Figure 6, is the standard deviation of the assumed market portfolio. Table A2 shows annualized standard deviations from the equal-weighted portfolio of the 91 stocks that we use in our benchmark calculations, together with other relevant candidates for market portfolios of Danish investors. All standard deviations are based on monthly returns in Danish kroner from April 1997 through April 2017.

Table A2 presents calculations of the aggregate loss from diversification if using different broad market portfolios. We find that other broad Danish market portfolios have a higher standard deviation than the equal-weighted average of the 91 stocks from Table A1, and consequently a smaller aggregate loss from underdiversification than in our baseline calculations. On the other hand, and perhaps theoretically more correct, if one assumes that Danes can invest internationally (which they of course can), the true market-portfolio would be an international portfolio. The standard deviations of the global portfolios are close to the standard deviations of the equal-weighted portfolios, implying that the aggregate loss is close to, but slightly lower, than our benchmark results. No matter the exact choice of market-portfolio, however, the conclusion is that the aggregate loss is substantial and close to three percent.

References

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Goetzmann, W. N. and A. Kumar, 2008. Equity portfolio diversification, *Review of Finance* 12, 433–463.

Ivkovic, Z., C. Sialm, and S. Weisbenner, 2008. Portfolio concentration and the performance of individual investors, *Journal of Financial and Quantitative Analysis* 43, 613–655.

Table A1. List of stocks.

The table shows the list of stocks included in the analysis, together with average monthly returns (annualized) and annualized standard deviation of monthly returns. *MP* is the market portfolio.

Name	Return	STD	Name	Return	STD
DSV	22.4%	32.1%	TIVOLI	6.4%	17.1%
AMBU	22.4%	33.2%	INVSTSSL.LUXOR	6.4%	46.0%
GABRIEL HOLDING	19.3%	26.9%	GYLDENDAL 'A'	6.1%	41.3%
COLOPLAST	19.0%	21.3%	FLSMIDTH & CO.	6.0%	37.2%
RINGKJOBING LANDBOI	18.8%	23.3%	RIAS	5.8%	23.7%
DMPKBT.NORDEN	18.5%	41.9%	HVIDBJERG BANK	5.6%	35.4%
NOVO NORDISK	18.5%	26.4%	BRODRENE HARTMANN	5.6%	26.7%
DFDS	17.5%	33.5%	GYLDENDAL 'B'	5.4%	26.9%
TOPDANMARK	16.9%	24.5%	CARLSBERG 'B'	5.4%	28.5%
BRD KLEE	16.4%	35.1%	CARLSBERG 'A'	5.1%	27.3%
KOBENHAVNS LUFTHAV	16.1%	26.7%	SOLAR	5.1%	155.4%
AKTKT.SCHOUW & CO.	15.6%	35.7%	DANTAX RADIO	4.2%	27.0%
NKT	15.3%	48.6%	ARKIL HOLDING	4.0%	27.9%
WILLIAM DEMANT	14.4%	29.9%	FLUGGER	3.9%	26.7%
GRONLANDSBANKEN	14.4%	24.6%	SKJERN BANK	3.7%	29.2%
ROYAL UNIBREW	14.1%	43.6%	SALLING BANK	3.6%	26.1%
SYDBANK	13.5%	28.8%	SANTA FE GROUP	3.5%	35.8%
UNITED INTL.ENTS.	13.2%	32.4%	TOTALBANKEN	3.3%	47.8%
JEUDAN	12.3%	17.5%	ALM BRAND	3.0%	33.1%
SPAR NORD BANK	11.5%	25.3%	MONBERG & THORSEN	2.4%	37.2%
JYSKE BANK	11.1%	29.1%	MIGATRONIC	1.9%	30.7%
DANSKE BANK	10.9%	30.9%	HARBOES BRYGGERI	1.8%	25.5%
ROBLON	10.8%	26.9%	SKAKO	1.3%	37.6%
GN STORE NORD	10.8%	43.6%	GREENTECH ENERGY SY	1.2%	63.9%
MP	10.9%	15.5%	IC GROUP	-1.4%	46.2%
LOLLANDS BANK	10.4%	26.5%	SCANDINAVIAN BRAKE S	-1.7%	44.9%
TDC	9.8%	29.2%	BANG & OLUFSEN	-1.8%	47.2%
DJURSLANDS BANK	9.7%	19.6%	H&H INTERNATIONAL	-2.2%	43.3%
NORDJYSKE BANK	9.2%	21.5%	NORTH MEDIA	-3.0%	47.7%
ROCKWOOL	9.2%	32.2%	VESTJYSK BANK	-4.0%	41.4%
KREDITBANKEN	9.0%	18.2%	NEWCAP HOLDING	-6.1%	78.3%
ALK-ABELLO	9.0%	33.1%	TK DEVELOPMENT	-6.2%	51.9%
ROCKWOOL	8.9%	31.7%	PARK STREET NORDICO	-6.4%	56.5%
PER AARSLEFF	8.7%	29.5%	GLUNZ & JENSEN HOLD	-6.6%	42.9%
MONS BANK	8.6%	20.4%	NTR HOLDING	-6.9%	31.1%
NORDFYNS BANK	8.3%	22.3%	SANISTAL	-7.7%	32.1%
HOJGAARD HOLDING 'A'	8.1%	32.7%	INTERMAIL	-8.8%	37.7%
HOJGAARD HOLDING 'B'	7.9%	31.7%	DALHOFF LAR.& HORNE	-9.3%	46.8%
A P MOLLER - MAERSK 'B'	7.6%	32.8%	OSTJYDSK BANK	-12.2%	46.9%
A P MOLLER - MAERSK 'A'	7.4%	32.2%	SILKEBORG IFS	-12.8%	49.6%
EGETAEPPEP	7.0%	27.0%	BRONDBY IF	-12.8%	55.8%
SP GROUP	6.7%	43.5%	BIOPORTO	-14.0%	70.3%
LAN & SPAR BANK	6.7%	12.1%	ARHUS ELITE	-14.9%	117.5%
FE BORDING	6.6%	28.0%	CEMAT	-17.1%	74.8%
ANDERSEN & MARTINI	6.5%	33.1%	NEUROSEARCH	-18.6%	69.9%
			VICTORIA PROPERTIES	-18.7%	64.1%
			TORM	-22.8%	62.8%

Table A2. Aggregate loss with different choices of market portfolio

The table statistic includes all Danish stockholders in 2012. STD is annualized standard deviation and *Aggregate loss* is the estimated annual loss in DKK millions due to underdiversification based on different proxies of the “market portfolio”.

Portfolio	STD	Aggregate loss
Equally-weighted portfolio of 91 stocks	15.5%	3.1%
FTSE Danish market	18.6%	1.8%
MSCI Denmark	19.3%	1.5%
MSCI Europe	17.0%	2.4%
STOXX EUROPE 600	16.6%	2.6%
STOXX EUROPE 50	16.5%	2.6%
MSCI WORLD	16.0%	2.9%
MSCI AC WORLD	16.2%	2.8%
FTSE ALL WORLD	16.3%	2.7%

Figure A1. Cumulative returns of 91 Danish stocks. 1997:1-2017:1

The figure shows the development in cumulative returns for 91 Danish stocks.

