CHAPTER 1

# Data, Portfolios, and Performance: How We Test the Strategies

In this book, we demonstrate the performance of various strategies, which can require only a single input: historical prices. In this section, we will begin our journey to the world of price-based investing with a short description of how we both calculated and tested these strategies on real historical data. All the strategies have been implemented in a consistent and identical way so as to assure their comparability. Below, we describe three major aspects of our examinations: (1) the data we use, (2) the method we form the portfolios, and (3) the method we evaluate their performance.

## What Data We Use?

Today's financial markets know almost no borders. Sitting in his living room in Berlin an investor can access equity markets in London, New York, or even Tokyo with a single mouse-click. The world of investing has become more interconnected and accessible than ever before. As a result, we do not test our strategies in a single market, even if it's as large as the American market, but instead, we test them in a robust sample of 24 developed countries with extensive and well-established stock markets—that is, Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Hong Kong, Ireland, Israel, Italy, Japan, the Netherlands, New Zealand, Norway, Portugal, Singapore, Spain, Sweden, Switzerland, the UK, and the USA. These markets span across



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many continents and cultures and account for the majority of capitalization in global equity markets. We have based our computations on the price data sourced from FactSet. Naturally, our tests could be further extended to include the emerging or frontier markets, but our focus on the developed economies guarantees the strategies to be accessible to most of the developed-market investors.

As we have focused on the period from January 1995 to June 2017, our sample is fresh and timely, reflecting the recent changes and developments in financial markets. We also used older data, for instance, when forming a strategy for January 1995 requires data from the earlier periods as, for example, a momentum strategy which relies on past performance. At times, the return data for some or all of the countries is available for the shorter periods, in which case we use them. We calculate all of the strategies separately for individual countries.

We collected the initial data in local currencies as comparisons based on various currencies could be misleading (Liew and Vassalou 2000; Bali et al. 2013). This is especially reasonable for countries where inflation and risk-free rates are very high and differ significantly across the markets. As most studies adopt the dollar-denominated approach (Waszczuk 2014a), we also denominated all the data in US dollars to obtain comparable results on an international scale.[1] For consistency, whenever we needed to use the risk-free rate (e.g., to calculate excess returns), we used the benchmark returns on the US three-month Treasury bills. Throughout the book, we have used gross returns, that is, returns unadjusted for tax (whether income taxes or taxes on dividends), and rely on monthly returns, which is probably most prevalent among such studies, although most of the accounting data would change only quarterly.[2]

[1] This approach was used in numerous studies of the cross-section of stock returns. Examples include Liu et al. (2011), Bekaert et al. (2007), Brown et al. (2008), Rouwenhorst (1999), Barry et al. (2002), Griffin (2002), Bali and Cakici (2010), Chui et al. (2010), Hou et al. (2011), de Groot et al. (2012b), de Moor and Sercu (2013a, b), and Cakici et al. (2013).

[2] Waszczuk (2014a, b) indicates that the discrete-time asset pricing theory provides no information on the relevant interval of expected returns (Fama 1998). Thus, we choose monthly intervals, which are also the most widely used in similar studies. The reasons are twofold. On the one hand, it offers a sufficient number of observations to ensure power of the conducted tests. On the other hand, monthly intervals avoid excessive exposure to the micro-structure issues (de Moor and Sercu 2013a). Lower frequency could be adequate for the estimation of capital cost but not for asset pricing tests, for which shorter time intervals markedly improve their quality. In practice, it is used rather rarely, mainly when the research additionally encompasses macroeconomic data. The paper by Avramov and Chordia (2006),

Finally, being aware that not all stocks in equity market are tradable, for example, stocks of companies with extremely low liquidity and market capitalization would be very difficult to trade freely, we applied a series of various static and dynamic filters to the common stocks within our calculations at the beginning of each month when forming the investment portfolio. We took account of only companies with the total stock market capitalization exceeding $100 million and the average daily trailing six-month turnover beyond $100,000. As a very low price may also lead to practical difficulties with trading, due to a wide bid-ask spread, we discarded stocks with the trading price below $1.00 at the beginning of a given month.[3]

## Portfolios Structure

As in our study we have reviewed a lot of different strategies, to make them easily comparable, we investigated the strategies using portfolios designed in an identical fashion. To test various investment approaches, we applied the so-called one-way sorted portfolios by ranking all the stocks in our universe on a characteristic which in academia is called the "return-predictive variable" for it helps forecast future price changes. Naturally, for our purposes, we used price-based return-predictive variables. Having thus sorted the securities, we formed a long portfolio of stocks ranked with the highest predicted return and a short portfolio of securities with the lowest predicted returns.

In order to calculate returns in a given month, typically called month *t*, we sorted the stocks within the sample at the end of the previous month (month *t*–1) according to the investigated characteristic, for example,

who investigated the Consumption CAPM, may serve as an example. Some of the methods and their description in this book are analogous and sourced from Zaremba and Shemer (2017).

[3] The filters applied in this book are similar to plenty of asset pricing studies on international equities. For instance, de Moor and Sercu (2013a, b) set the minimum market value at $100 million on the international sample and additionally limit the examinations to stocks with monthly trading volume larger than $100,000, identically as in this book. Brown et al. (2008) include only equities belonging to the intersection of top 50% market liquidity and top 50% market capitalization. van der Hart et al. (2005) set the lower boundary for the firm capitalization at $100 million for the last month of the study sample and Burghof and Prothmann (2011) use the limit of GBP20 million. Considering the price of the stock, most of the studies rely on the SEC definition, implying that penny stocks priced below $5 (Jegadeesh and Titman 2001; Gutierrez and Kelley 2008; Bhootra 2011).

short-run return and long-run return. Having ranked the markets by the investigated characteristics, we then determined the 20th and 80th percentile breakpoints for each measure. In other words, by focusing only on the 20% of the securities with the highest expected returns and the 20% of the stocks with the lowest predicted future returns, we consequently arrived at two quintile subgroups.[4]

Subsequently, we weighted the respective equities from portfolios. For simplicity, we used a straightforward weighting method—equal weighting, under which each of the best (or worst) stocks from the top (or bottom) quintiles of the ranking was assigned the same weight, that is, a fraction of the portfolio. In other words, we divided the portfolio into equal parts and bought the same amount of every stock. In practice, many methods are used, and all of them has some pros and cons.

*Equal Weighting* Among various methods, this is perhaps the simplest way of weighting portfolio components, giving identical weights to all securities. Importantly, we are likely to rebalance such portfolio frequently as stock prices rise and fall every month, changing thus the share in the portfolio. To hold equal stocks, the investor needs to rebalance it on a systematic basis. The more frequent the rebalancing, the more frequent the trading. Whereas the more trades we do, the higher rise the total transaction costs. As a result, a frequently rebalanced equal-weighted portfolio might finally prove costly for investors. In contrast, for portfolios constructed from one-way sorts, the cost drag may not significantly exceed other types of weightings, for example, the value weighting as the portfolio turnover comes not only from rebalancing but mostly from stocks entering and leaving the portfolio, which is common across all weighting schemes. To its advantage, this approach generates no overweight of any type of stocks making equally weighted portfolios exhibit decent exposure to small companies, which tend to yield high anomaly returns.

[4] The type of quantile portfolios highly depends on the number of available constituents, and it is a trade-off between the number of assets available and the grid resolution (Waszczuk 2014b). The most widely considered alternatives are quintiles, for example, Banz (1981) and Chan et al. (1998), and deciles, for example, Jegadeesh and Titman (1993, 2001) and Lakonishok et al. (1994). We decided that 78 diversified index portfolios are sufficient for the 20th and 80th breakpoints but insufficient for the 10th and 90th breakpoints. Among alternative approaches, Bauman et al. (1998) considered quartile grouping, Achour et al. (1998) worked with tertile portfolios, and Brav et al. (2000) used the 50% cut-off. In our case, due to a relatively small number of assets in the portfolios, we mostly rely on tertile portfolios.

*Capitalization Weighting* Weighting on stock market capitalization, as an alternative to equal-weighting scheme, assigns bigger weights to stock market companies with large market values. As this approach concentrates in particular on large and liquid companies, it may result in lower trading costs (Novy-Marx and Velikov 2016; Zaremba and Nikorowski 2017), although the differences are moderate (Zaremba and Andreu Sánchez 2017), because a large part of the turnover stems from stocks entering and leaving the portfolio rather than from the rebalancing. To its disadvantage, capitalization weighting returns tend to appear the strongest in small caps and this type of portfolio formation underweights small caps diminishing the portfolio benefits from cross-sectional patterns.

*Liquidity Weighting* Liquidity weighting is a good candidate for an even more realistic approach to weighting portfolio constituents as it grants a higher share in the portfolio to the most liquid securities ranked by, for example, turnover; its unquestionable advantage is the low-trading cost: the investor concentrates on stocks that are highly liquid, which as a rule also display narrow bid-ask spreads. Unfortunately, such portfolios give also preference to the most efficient market segments, making the stocks less likely to display strong anomalous behavior.

*Factor Weighting* Following the factor-weighting approach, we weight the stocks neither according to their capitalization or liquidity but rather by their expected return proxied by an additional variable. For instance, when building a portfolio on the book-to-market ratio, you can weigh the components by the standardized book-to-market ratio; strictly speaking, the weights could be tied to either the raw variables (see, e.g., Zaremba and Umutlu 2018) or the ranking values (Asness et al. 2017).

This approach guarantees the portfolio share be closely linked to the expected performance. Unfortunately, the weights might also prove quite volatile, especially in the case of dynamic strategies, like momentum, leading to a high turnover and, in consequence, high trading costs.

*Enhanced Indexing and Other Methods* There are numerous other techniques of weighting the components of quantitatively managed portfolios. Some rely on sophisticated optimization algorithms while others are rule based (Narang 2013). One of the increasingly popular methods includes fundamental weighting based on weighting portfolio components on fundamental variables: for example, sales or the book-to-market ratio. This approach delivers decent returns at the level of both individual stocks and whole countries or indices.[5]

## Evaluation of the Strategies

To present the performance of various strategies, we have facilitated an array of statistical data: mean returns, volatilities, or skewness, using the following both simple and popular ratios to assess the returns and strategy risk.

*Sharpe Ratio* The Sharpe ratio originates from William Sharpe, a Nobel Prize laureate, who in his research entitled "Mutual Fund Performance" (Sharpe 1966) formulated the index, which was later named after him. Undoubtedly, the ratio is still the most popular investment performance measurement tool, which accounts for not only profit but also risk.

Under the most traditional definition, the Sharpe ratio measures the excess rate of return per unit of risk taken by the investor (Sharpe 1966). The ratio is calculated by dividing the excess return and the risk understood as the volatility (standard deviation) of these excess returns.[6] By excess return, we mean the difference between the return on the investigated portfolio and the return of the risk-free instrument.[7] Throughout

[5] For stocks, see, Arnott et al. (2005), Tamura and Shimizu (2005), Hsu and Campolo (2006), Walkshausl and Lobe (2010), and Zaremba and Miziołek (2017a). For comprehensive literature surveys, see Chow et al. (2011), Amenc et al. (2012), and Bolognesi and Pividori (2016); for country equity indices, see Estrada (2008), Yan and Zhao (2013), and Zaremba and Miziołek (2017b).

[6] In the literature, by default the term *volatility* means a yearly *standard deviation* of returns. Both terms are used in this book in the same meaning.

[7] In financial studies, we have two main methods of converting prices to returns: the arithmetic (simple) and logarithmic return approach. The latter is usually preferred for three basic reasons: (1) better arithmetical properties (including compounding over time), (2) return distributions that represent a larger degree of normality than arithmetic returns, and (3) reduced heteroscedasticity in logarithmic returns series (Waszczuk 2014b). This type of returns are not fully additive over assets, but the bias is rather small, especially for the short time intervals; so they are also used in the cross-sectional studies (e.g., Liew and Vassalou [2000], Diacogiannis and Kyriazis [2007]). In the calculations used in this book, for the sake

this book, it is represented by benchmark returns on the US three-month Treasury bills.

The Sharpe ratio is a simple measure and could be expressed with the following formula:

$$SR = \frac{\bar{R}}{\sigma} \tag{1.1}$$

whereby $\bar{R}$ represents the mean excess return on the investigated portfolio over the examined period, and $\sigma$ is its standard deviation of excess returns. The ratio is usually presented on an annual basis, that is, with yearly excess returns.[8] Although our computations are based on monthly intervals, we also adopted an annualized version of the ratio by simply multiplying the monthly Sharpe ratio by the square root of 12.

While an unquestionable virtue of the Sharpe ratio is its simplicity, it performs poorly in the environment of negative excess returns. For this reason, we facilitated the Sharpe ratio with the so-called Jensen's alpha.

*Jensen's Alpha* The Jensen's alpha is a measure derived from the capital asset pricing model (CAPM, Sharpe 1964).[9] The CAPM is a simple model that was invented by the famous researcher—William Sharpe—for three main purposes: to explain the reasons for portfolio diversification, to create a framework for valuating assets in a risky environment, and to explain differences in the long-term returns of various assets.[10] The CAPM laid

of simplicity, we use arithmetic returns. For further discussion on the return calculation for financial studies, see Roll (1984) or Vaihekoski (2004).

[8] The Sharpe ratio was later frequently revised and modified by many authors, including its inventor; across this book, however, we rely on the simplest and most intuitive definition described by Sharpe (1966). For more examples of the modifications and revisions of the Sharpe ratio, see Sharpe (1994), Vinod and Morey (1999), Dowd (2000), Israelsen (2005), or Le Sourd (2007).

[9] The detailed characteristics of the Sharpe model were extensively presented in a number of financial textbooks, for example, Francis (1990), Elton and Gruber (1995), Campbell et al. (1997), Cochrane (2005), or Wilmott (2008).

[10] Treynor (1961, 1962), Lintner (1965a, b) and Mossin (1966) developed a similar model at the same time, so all four—including Sharpe (1964)—are now considered to be the fathers of the CAPM model. See also French (2003).

the foundation for many other methods of performance evaluation in investment portfolio management.

The fundamental assumption of the model states that volatility of a financial instrument can be broken down into two parts: a systematic and specific risk. The systematic risk stems from general changes in the market conditions and relates to the volatility of the market portfolio, whereas the specific risk relates to volatility which is, however, driven not by the market but by the internal situation in the company. In other words, losses ensuing a market crash are rather of a systematic nature while losses due to an employee strike belong to the specific risk category.

The CAPM model bears some vital implications for both portfolio construction and diversification. When building a portfolio, systematic risks of individual stock simply add up; however, specific risks, not being correlated, set each other off. Therefore, in a well-diversified portfolio, the influence of the specific risk is generally negligible, and in a well-functioning market, a rational investor may ignore the specific risk and concentrate solely on the systematic part. After all, would the investor even consider the specific risk if it could be easily diversified away at no cost?

This important implication of the CAPM model—stating that the investors should be only compensated for the systematic risk because the specific risk can be easily eliminated—is

$$R_{i,t} = \alpha_i + R_{f,t} + \beta_{rm,i} \cdot \left(R_{mt} - R_{f,t}\right) + \varepsilon_{i,t}, \tag{1.2}$$

where $R_{i,t}$, $R_{m,t}$, and $R_{f,t}$ are returns on the analyzed security or portfolio; $i$, the market portfolio and risk-free returns at time $t$; and $\alpha_i$ and $\beta_{rm,i}$ are regression parameters. $\beta_{rm,i}$ is the measure of the systematic risk which tells us how aggressively the stock reacts to the price changes in the broad market. Fundamentally, the CAPM formula implies that the excess returns on the investigated security or portfolio should increase linearly with the systematic risk measured with beta: the higher the risk, the higher the expected return.

Finally, the $\alpha_i$ intercept measures the average abnormal return: the so-called Jensen's alpha. It is defined as the rate of return earned by the portfolio or a strategy in excess of the expected return from the CAPM model. The Eq. 1.3 could be easily rewritten to be used to evaluate past returns on a portfolio:

$$\alpha_i = \overline{R_i^E} - \beta_i \cdot \left(\overline{R_m^E}\right), \tag{1.3}$$

where $\alpha_i$ is the Jensen's alpha on the investigated portfolio, $\overline{R_i^E}$ is its mean excess return over the examined period, $\beta_i$ is the market beta, and $\overline{R_m^E}$ is the mean excess return on the market portfolio.[11] Throughout the book, we have used the capitalization-weighted return as the proxy for the market portfolio, which we calculated based on either gross or the risk-free rate, consequently represented by the US three-month T-bills.[12] Importantly, as far as a zero-investment portfolio is concerned, there is no need to subtract any risk-free rate.

The decisive rule for the Jensen's alpha states that when alpha from the CAPM model turns negative, it signals the investment in the analyzed strategy, or portfolio, to become unreasonable as a higher return at a comparable risk level could be achieved via investments in the risk-free asset and market portfolio.

*Statistical Significance* One important challenge in examining investment strategies is to distinguish when seemingly abnormal returns are truly abnormal and when it is pure coincidence. If a trader earned 10% annually for five consecutive years, how can we tell whether he has followed a superior investment strategy or he just got lucky? For this purpose, whenever we reported any mean returns or alphas, we simultaneously reported their

[11] For simplicity, in the book we use the Jensen's alpha in its most basic form. Nonetheless, this performance measure has been frequently updated and modified over time (Zaremba 2015). For example, Black (1972) suggested using a portfolio with a beta coefficient equal to zero instead of a risk-free return. Brennan (1970), on the other hand, constructed a model taking into account taxes. Elton and Gruber (1995) suggested using a total risk instead of a systematic one. Many papers also suggested putting additional attention to the way the profit was earned and how the alpha coefficient was decomposed in respect of its origin (e.g., Treynor and Mazuy 1966, McDonald 1973, Pogue et al. 1974, Merton 1981, Henriksson and Merton 1981, Henriksson 1984, Grinblatt and Titman 1989). Furthermore, a substantial body of research attempts to improve the measure of systematic risk. There are several basic strands in this line of studies. The first uses conditional betas taking different values for growing and declining markets (Ferson and Schadt 1996; Christopherson et al. 1999). The second approach incorporates other risk factors and macroeconomic variables (e.g., Ross 1976; Fama and French 1996; Carhart 1997; Amenc and Le Sourd 2003). Example of different types of systematic risk could be found in the models of Connor and Korajczyk (1986), based on the arbitrage pricing theory, the index model by Elton et al. (1993), or the management style analysis according to Sharpe (1992).

[12] In particular, we source the market factor returns from Kenneth R. French's website: http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html.

statistical significance which at least to some extent helps us statistically differentiate real return patterns from mere luck. When some mean return, or alpha, exceeds zero at the 5% level, it indicates a 5% risk of no real pattern in the returns, even though we have identified it in the historical data. In other words, the returns could turn positive only in our specific sample, and this result may not be replicated in another sample. Thus, this 5% threshold could also be interpreted as the probability of the returns plunging below zero when implementing this strategy to another sample.

The statistical significance test may be one sided, that is, informing us whether the returns are significantly higher than zero, or two sided, that is, informing us whether the returns depart from zero (either below or above).

Throughout this book, we presented the significance of both the mean and abnormal returns of the tested strategies[13] aiming to provide a better view on how compelling the performance of the strategies really is. If the abnormal returns remain significant at the level of 1% or 5%, we can be fairly sure that the strategy is no random return pattern. At 10%, the evidence is still firm, but less convincing. Once the significance plunges below 10%, the probability that the abnormal returns result from pure chance is considerable, thus it would be risky to assume it would continue in the future.[14]

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[13] All the regression parameters in this book were estimated using the OLS method. This approach has been employed, among many others, by Fama and French (2012). Furthermore, all the *t*-statistics were estimated using the bootstrap standard errors to avoid any distributional assumptions. Under our null hypothesis, all of the intercepts equal zero whereas the alternative hypothesis assumes the contrary. The bootstrap simulations are performed with the use of 10,000 random draws. All the statistical analyses are performed in R.

[14] Further details could be found in basically any statistical textbook, for example, Aczel (2012).

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