PWL

Dimensional Equity Funds

Benjamin Felix MBA, CFA, CFP®, CIM®
Portfolio Manager,
Head of Research

Raymond Kerzérho CFA,
Senior Researcher, Head,
Shared Services Research

2022

This report was written by Benjamin Felix and Raymond Kerzérho of PWL Capital Inc. The ideas, opinions, and recommendations contained in this document are those of the author and do not necessarily represent the views of PWL Capital Inc.

For more information about this or other publications from PWL Capital, contact:
PWL Capital – Passmore, 265 Carling Avenue, 8th Floor, Ottawa, ON K1S 2E1
Tel 613-237-5544 • 1-800-230-5544 Fax 613-237-5949
ottawa@pwlcapital.com

Table of Contents

1. Introduction

PWL Capital (PWL) primarily uses funds from Dimensional Fund Advisors (Dimensional) to build our clients' investment portfolios. PWL's current position is that for the purpose of accessing multiple risk premiums in a systematic, cost- and tax-efficient manner for Canadian investors, Dimensional Canada's offering is unparalleled. The objective of this paper is to provide a broad overview of the theory and evidence behind the investment approach, and the specifics of how Dimensional implements investment products.

2. Background

To understand Dimensional's approach to investing it is necessary to take a brief tour through the evolution of asset pricing and portfolio theory over the past 70 years. The following theoretical and empirical studies include contributions from multiple economists who went on to receive the Nobel Prize in Economic Sciences for their work: Harry Markowitz and Bill Sharpe in 1990, Robert Merton in 1997, and Eugene Fama in 2013.

2.1 Modern Portfolio Theory (1952)

The story of Dimensional starts with portfolio theory. Markowitz (1952) developed a theory of portfolio selection on the basis that investors seek to minimize the variance in their portfolios for a given level of expected return, or, equivalently, they seek to maximize their expected return for a given level of variance. Mean-variance portfolio theory tells us there is an optimal combination of assets based on their expected returns and covariances that results in the highest possible portfolio expected return at each level of portfolio variance.

2.2 Capital Asset Pricing Model (1964)

Sharpe (1964) introduced the capital asset pricing model (CAPM) which turns Markowitz' theory into a testable prediction about the relationship between risk and expected return. The CAPM is an asset pricing model, meaning that it predicts the expected return of an asset based on its riskiness. In the CAPM, risk is proportional to an asset's covariance with the market portfolio, a measure known as its market beta. A stock that moves in lock step with the market has a beta of 1, while a stock that moves more than the market has a beta above 1, and less a beta below 1. Riskier (higher beta) stocks theoretically have higher expected returns. The CAPM assumes that all investors care about is the mean and variance of their portfolio and that they price assets based on the contribution of the asset to their portfolio. Under these assumptions, the market portfolio is the mean-variance optimal portfolio; the assets contained in the market are optimally priced to reflect their expected means and covariances such that their weight in the market portfolio is their mean-variance optimal weight. Investors will combine the market portfolio with a risk-free asset to tailor their portfolio to their risk and expected return requirement. To rely on a model like the CAPM, we need to trust market prices.

2.3 Efficient Capital Markets (1970)

Market efficiency, or the idea that market prices reflect all available information, comes from Fama (1970). In an efficient market, investors expect to earn returns commensurate with the risk that they take; the traditional investment activities of market timing and security selection are not expected to add value on average. From market efficiency and CAPM asset pricing stems the idea that investors should simply hold the market portfolio using low-cost index funds. Empirically, the CAPM is a failure (Fama and French, 2004). Whether this tells us that markets are inefficient or that the CAPM is a flawed asset pricing model is an impossible question to answer due to the joint hypothesis problem – any test of market efficiency is jointly a test of the model being used to price assets (Fama, 1991); we cannot know whether markets are inefficient or we have a bad asset pricing model. The failure of the CAPM should not be too much of a surprise given the model's restrictive assumptions. The CAPM assumes, among other things, that investors only care about the single period mean and variance of their portfolios. This seems like an unlikely description of long-term investors.

2.4 Intertemporal Capital Asset Pricing Model (1973)

Merton (1973) introduces the intertemporal capital asset pricing model (ICAPM) which considers a multi-period investor who, in addition to mean and variance, is concerned with the covariance of their portfolio returns with other things like their labor income, the prices of consumption goods, and the nature of future investment opportunities. The ICAPM does not tell us what exactly investors are concerned about, just that there are theoretical state variables that may affect how investors behave. A simple example is recession risk: investors are concerned with maximizing their expected return for each unit of variance, like a mean-variance investor, but they are willing to accept more variance or less expected return if their portfolio does not do poorly in recessions. Under the ICAPM, the market portfolio is no longer mean-variance optimal. The theoretical mean-variance optimal portfolio under the ICAPM is a combination of the market portfolio and the risky portfolios that represent sensitivity to unknown state variables that most investors are worried about. It is easy to dismiss an academic theory like the ICAPM based on its underlying assumptions, but Betermier, Calvet, and Sodini (2016) and Betermier, Calvet, Knüpferm, and Kvaerner (2021) document investor behavior that is remarkably similar to the predictions of the ICAPM.

2.5 Fama French Three-Factor Model (1993)

The failure of the CAPM took several forms. The CAPM predicts a linear relationship between market beta and expected returns, but empirically this relationship is weak as shown in Reinganum (1981) and Lakonishok and Shapiro (1986). Further challenges come from Banz (1981) who demonstrates that small capitalization stocks had higher average returns than larger stocks beyond what would be predicted by their market betas. Basu (1983) and Rosenberg, Reid, and Lanstein (1985), among others, find a positive relationship between relative price and average returns in the US, and Chan, Hamao, and Lakonishok (1991) find the same for Japanese stocks. In both cases the differences are unexplained by market beta. Rather than concluding that markets are inefficient due to the inability of the CAPM to price assets, Fama and French (1993) propose a multifactor asset pricing model in the spirit of the ICAPM. While it cannot be known for certain, Fama and French suspect that portfolios of small stocks and stocks with low prices may be sensitive to the unknown state variables that investors in ICAPM theory are worried about; they have higher returns because they are riskier.

> If assets are priced rationally, our results suggest that stock risks are multidimensional. One dimension of risk is proxied by size, ME. Another dimension of risk is proxied by BE/ME , the ratio of the book value of common equity to its market value. (Fama and French, 1992)

If this is the case, investors can access higher expected returns if they are willing and able to bear the state variable sensitivities that most investors are worried about. Fama and French (1992) are not dogmatic as they give a nod to the possibility that the observed differences in average returns are due to market overreaction to the relative prospects of firms, as suggested by DeBondt and Thaler (1985). The Fama French Three-Factor model explains many of the anomalies that had been unexplained by the CAPM.

2.6 Fama French Five-Factor Model (2015)

Despite the relative order that Fama and French's Three-Factor model brought to the world of asset pricing, anomalies persist. Novy-Marx (2013) and Titman, Wei, and Xie (2004) show persistent anomalies unexplained by the Three-Factor model: profitability and investment. Controlling for market beta, size and relative price, firms with robust operating profitability tend to have higher average returns than firms with weak operating profitability, and firms with conservative asset growth tend to have higher average returns than firms with aggressive asset growth. Novy-Marx (2013) and Aharoni, Grundy, and Zeng (2013) document variables that proxy for expected earnings and investments, allowing them to be included in the Fama French Five-Factor asset pricing model (Fama and French, 2015). The Five-Factor model is an empirical model, meaning that its factors have been derived by observing the interactions between variables rather than through theoretical work, but it does have light theoretical connections.

The dividend discount model says that the theoretical value of a share of stock is the discounted value of expected dividends per share.

$$m_t = \sum_{\tau=1}^{\infty} E(d_{t+\tau})/(1+r)^{\tau} \qquad (1)$$

Equation 1 shows that the price m_t at time t is equal to the expected future dividends per share, $E(d_{t+\tau})$, discounted at the long-term average expected stock return r.

One of the problems with the dividend discount model is that not all firms pay dividends. Miller and Modigliani (1961) show that given investment policy, dividend policy is irrelevant to the valuation of shares. With dividend policy irrelevance, the value of expected dividends is equal to expected earnings minus expected investment. According to Miller and Modigliani (1961), the total market value of the firm's stock is given by Equation 2:

$$M_t = \sum_{\tau=1}^{\infty} E(Y_{t+\tau} - dB_{t+\tau})/(1+r)^{\tau} \qquad (2)$$

here $Y_{t+\tau}$ is the earnings and $dB_{t+\tau}$ is the expected change in book equity (asset growth). Scaling both sides of Equation 2 by the book value of equity, B_t, Equation 3 gives the theoretical valuation equation as presented by Fama and French (2015).

$$\frac{M_t}{B_t} = \frac{\sum_{\tau=1}^{\infty} E(Y_{t+\tau} - dB_{t+\tau})/(1+r)^{\tau}}{B_t} \qquad (3)$$

This theoretical valuation equation makes three statements about expected stock returns.

1. If we hold everything in Equation 3 constant except for the market value of the stock, M_t, and the expected stock return, r, then a lower ratio of M_t/B_t must imply a higher expected stock return. All else equal, a company with a lower price must have a higher discount rate. This is an expression of the relative price premium.
2. If we hold everything in Equation 3 constant except for expected future earnings, $Y_{t+\tau}$, and the expected stock return, r, then higher expected earnings must imply a higher expected stock return. All else equal, if two companies trade at the same price, the company with higher profits must have a higher discount rate. This is an expression of the profitability premium.
3. If we hold everything in Equation 3 constant except for the expected growth in book value of equity, $dB_{t+\tau}$, and the expected stock return, r, then higher expected asset growth must imply a lower expected stock return. All else equal, if two companies trade at the same price, the company with higher investment must have a lower discount rate. This is an expression of the investment premium.

The Five-Factor model suggests that in addition to the market risk premium, assets are priced based on company size, relative price, profitability, and asset growth (investment). The model can explain close to 95% of the differences in returns between diversified portfolios, and it is able to solve many of the anomalies left unexplained by the Three-Factor model. The other important takeaway from the valuation equation is that interactions between factors, if they exist, are important to portfolio construction. In other words, targeting one factor may imply not holding everything else in the equation constant. For example, if targeting profitability results in a growth (high relative price) tilt we would need to consider both profitability and relative price together. In the data, this is indeed the case. In Ken French's data as at February 2022, the portfolio of big companies with high operating profitability is about four times larger and three times more expensive than the portfolio of big companies with low operating profitability. These interactions are important in portfolio construction.

2.7 Choosing Factors

Today, there are hundreds of documented factors, or asset pricing anomalies, in published academic literature (Harvey, Liu, and Zhu, 2016), and many asset pricing models that attempt to find the right combination of factors to accurately reflect how the market prices assets. This intense academic competition has led to a horse race to find the "right" model. A potential challenge with comparing asset pricing models is that even in an efficient market, we only expect prices to reflect information to the point where the marginal benefits of acting on the information cease to exceed the marginal costs (Jensen, 1978). An asset pricing model that includes anomalies that cannot be traded is unlikely to be a model that contains useful information about differences in expected returns from the perspective of an investor. Detzel, Novy-Marx, and Velikov (2021) test multiple asset pricing models after accounting for transaction costs and find that the Fama French Five-Factor model outperforms competitor models that appear superior before transaction costs. Competing models that look good before costs but falter after costs tend to employ high turnover factors like momentum.

2.8 Theory in Practice

Investment theory began to show up in practice in the early 1970s at Wells Fargo where the first index fund was created by Mac McQuown (Wigglesworth, 2021). Soon after, The Vanguard Group was founded in 1975 and launched the Vanguard 500 fund, the first index fund available to retail investors, in 1976. Dimensional Fund Advisors was founded in 1981 on the basis of building a portfolio similar to an index fund that offered exposure to small capitalization companies. Dimensional's founder, David Booth, had identified that institutional investors were lacking in their small cap exposure. There were no small cap indexes, so Booth had free reign to design a strategy to capture small cap returns. Nobel prize winning economist Myron Scholes was an early director of the firm and was openly skeptical that small cap returns could be effectively captured after costs; he was interested in being part of what seemed like an interesting experiment. An index fund follows rigid rules for rebalancing which can be problematic in small capitalization stocks due to their higher transaction costs. Implementing a small company portfolio required a more flexible, but still rules-based, approach.

The flexible systematic approach pioneered by Dimensional's first small cap portfolio is still in use today, giving Dimensional the benefits of low-cost broadly diversified indexing without the drawbacks related to the requirement to track an index. Given the long-term success of the strategies (detailed in the Appendix), the approach appears to have overcome the transaction costs challenge. Dimensional has been at the forefront of both uncovering and implementing the best ideas in financial economics research for more than 40 years.

3. The Dimensional Approach

Dimensional builds multifactor investment portfolios with a link to market capitalization weights. Dai, Saito, and Wang (2022) detail how maintaining a link with market weights reduces turnover and costs and limits extreme deviations from market weights. Unlike a market capitalization weighted index fund, Dimensional funds seek to increase exposure to multiple risk factors in the Five-Factor model. A simple way to think about the approach is that Dimensional starts with a market capitalization weighted portfolio and then systematically increases or decreases the weights of securities based on differences in expected returns. The portfolios are active in the sense that they do not blindly follow a market index, but they borrow many of the positive attributes that have made market-cap weighted broad market index funds appealing investments. While traditional active portfolio management proposes to select securities and time the market on the implicit assumption that market prices are wrong, Dimensional uses the information in market prices to gain insight into differences in expected returns. By overweighting higher expected return securities, Dimensional creates portfolios with a higher expected return than the market, a more reliable expected outcome due to multiple drivers of expected returns, broad diversification, low portfolio turnover, and low overall costs.

Dimensional's implementation of academic research in portfolios is more involved than simply buying more of the securities that represent the risk factors in the Five-Factor model. Unlike an index fund that rebalances quarterly or semi-annually, Dimensional adjusts the weights of securities in their portfolios on a daily basis. Security weights are determined by multiple criteria that can be broken down by horizon; long-term, short-term, and intra-day variables are considered. Long-term considerations are the security's exposure to company size, relative price, and profitability; short-term considerations are asset growth, momentum, and the cost to borrow the security; intra-day considerations are expected liquidity and transaction costs. Once securities are owned, Dimensional takes further steps to maximize shareholder value. These include securities lending revenue, stewardship (advocating for investors to enhance shareholder value through governance), and corporate actions (maximizing the value of corporate actions elections).

The remainder of this section will address the security weighting considerations and some of their interactions.

3.1 From Premium to Dimension

Beyond the academic debate on the "right" asset pricing model, Dimensional has evaluation criteria that are applied before attempting to implement research. From Lee (2013), a dimension of expected return must be sensible, persistent across time periods, pervasive across markets, robust to alternative specifications, and cost-effective to capture in well-diversified portfolios.

- Sensible: Must be a explained by a reasonable economic rationale.
- Persistent through time: Must work through very long periods of historical data.
- Pervasive across markets: Must work in multiple countries or regions.
- Robust to alternative specifications: Must work for a variety of definitions.
- Cost-effective to capture in well-diversified portfolios: Must generate a premium after accounting for costs.

In the case of Dimensional, all long-term factors under consideration are sensible with roots in the theoretical valuation equation, have been tested extensively out of sample through time periods and across geographic regions, are robust with numerous alternative specifications, and are cost effective to implement. The next section discusses the evidence for each premium and its implementation in detail.

3.2 Long-Term Considerations

Long-term considerations are related to long-term differences in expected returns spanning years or decades. In other words, portfolios need to maintain exposure to these factors for long periods of time to capture their expected return benefit while balancing trade-offs with short-term and intraday considerations.

3.2.1 Company Size

All else equal, Dimensional systematically overweights smaller companies and underweights larger ones. Small cap growth stocks with weak profitability and aggressive asset growth are entirely excluded from portfolios. Dimensional measures company size using the free float market capitalization of a stock. Free float is the total market capitalization of a stock, excluding stocks that are not available to the public such as those held by control shareholders, company executives and governments. The small cap universe of stocks is defined as all the stocks that cumulatively represent the bottom 10% of market capitalization. In strategies that are not constrained to the small cap universe, like the Core and Vector funds discussed later, lower size results in increased portfolio weights relative to the market across the market capitalization spectrum. Company size was the original empirical pricing anomaly but does not make an explicit appearance in the theoretical valuation equation. The standalone size premium originally identified by Banz (1981) has not been statistically different from zero since publication, including in replication studies of the original sample; the original finding was biased upwards due to the delisting bias documented by Shumway (1997).

However, when small cap growth low profitability and high asset growth are removed from the small cap universe (roughly 15% of the small cap universe) there is a statistically significant premium. As Asness, Frazzini, Israel, and Moskowitz (2018) somewhat comically explain, "size maters, if you control your junk."

If any skepticism about small caps remains, one of the other empirical realities must be considered: other premiums are stronger in small cap stocks. Blitz and Hanauer (2021) show empirically that there are powerful interaction effects between size and other factors, such as value. They show that academic factor portfolios, which consist of 50% large caps and 50% small caps, have significant alphas compared to factor portfolios constructed with 90% large caps and 10% small caps representing market capitalization weights. Fama and French (2015) suggest that size may help forecast returns implicitly by improving forecasts of profitability and investment or by capturing horizon effects in the term structure of expected returns. The conclusion on size is that the interaction between size and other known factors may be a sufficient reason for long-only investors to systematically overweight small stocks, even if the size characteristic itself is not rewarded with a premium.

3.2.2 Relative Price

Dimensional systematically overweights lower priced companies and underweights higher priced ones. Relative price is defined as the ratio of a stock's book equity to its market equity (price). When ranked from the lowest to highest price to book, low relative price ("value") stocks are those that cumulatively represent 30% of market capitalization with the lowest price to book, while high relative price ("growth") stocks are the stocks with the highest price to book cumulatively representing 30% of the market. Much has been written about whether scaling market equity by book equity this is the right metric to measure relative price given the increasing importance of intangible assets, which are not captured in book value, to modern businesses.

Arnott, Harvey, Kalesnik and Linnainmaa (2021) find that the book value fails to capture increasingly important internally developed intangible assets like patents, licenses, software, and brand reputation, and attribute the recently poor performance of value to this measurement deficiency. Under US generally accepted accounting principles (GAAP), externally acquired intangibles are reported on the balance sheet and accounted for when computing book equity, but internally developed intangibles are generally not capitalized on the balance sheet. To adjust for this, they capitalize research and development (R&D) and 30% of selling, general, and administrative (SG&A) expenditures and add them to the book value of firms, finding that this measure of value outperforms the traditional measure by a wide margin. Rizova and Saito (2021) scrutinize the finding and extend the sample to include the US market, developed ex US, and emerging markets. They confirm that adding estimated internally developed intangibles would have had a positive impact on the value premium over the long term and would have mitigated its underperformance in recent years. However, as previously mentioned, Dimensional looks at both value and profitability in building portfolios.

Measuring profitability also requires adjustments for R&D and SG&A since profitability is scaled by book equity – adjusting book equity and not profits would lead to incorrect results. With the adjustments, the profitability premium declines in the data. After the adjustments on both value and profitability, double sorts on value and profitability deliver similar results with and without adjustments for intangibles. They also find that the premium from the intangible-adjusted measure of value over the unadjusted measure is largely a sector effect. Controlling for sector differences largely eliminates premium differences in each of the three regions studied. They conclude that capitalizing estimates of internally developed intangibles does not yield consistently higher value and profitability premiums and adjusting for sector differences largely eliminates premium differences in each of the three regions.

Another common criticism of book value is that goodwill, the difference between the purchase price and the fair value of the net identifiable assets of the target firm in an acquisition, affects the usefulness of book value as a variable to scale price and profits. Dimensional's internal research has not found any reliable relationship between systematic goodwill adjustments and expected returns, as explained in discussion with Dimensional's co-CEO and CIO.

Regarding other metrics to scale price for measuring relative price, Lee and Rizova (2016) find that earnings-to-price, cash flow-to-price, sales-to-price or a blend of these metrics do not contain additional information about expected returns beyond that contained in book-to-market and profitability. Combining a cash flow metric with a balance sheet metric in a single measure inevitably leads to the measure picking up both elements of profitability and relative price. The other issue with measures other than book-to-market, as documented by Lee and Rizova (2016), is that they tend to increase portfolio turnover which, all else equal, reduces net expected returns. Furthermore, while combining valuation metrics often makes backtests look more compelling, Novy-Marx (2015) finds that the back-tested performance of strategies that use multiple metrics can appear to be "highly significant" even when the variables have no true relation to expected returns.

3.2.3 Profitability

All else equal, Dimensional systematically overweights more profitable companies and underweights less profitable companies. Profitability is measured by Dimensional as operating income before depreciation and amortization minus interest expense, scaled by book equity. Profitability has a strongly negative relationship with value, meaning that highly profitable companies tend to have high prices, and deep value companies tend to have low profitability. As explained in Novy-Marx (2014),

> Buying high quality assets without paying premium prices is just as much value investing as buying average quality assets at discount prices. Strategies that exploit the quality dimension of value can be profitable on their own, and accounting for both dimensions of value yields dramatic performance improvements over traditional value strategies (Novy-Marx, 2014).

Combining value and profitability together in portfolio construction further improves expected returns relative to targeting one or the other. Thinking through it logically, if two companies have the same relative price but one is more profitable than the other, the more profitable company must have a higher discount rate (expected return) baked into its price. Similar to book-to-price, there are debates within academic and practitioner literature over how to measure profitability.

Ball, Gerakos, Linnainmaa, and Nikolaev (2016) show that cash profitability (a measure that excludes accruals) outperforms measures of profitability that include accruals, and cash-based operating profitability subsumes accruals in predicting the cross section of average returns.

Dimensional uses operating profitability, which does not adjust for accruals. Rizova and Saito (2020) find that firms with high accruals also tend to be firms with high investment, explaining their lower average returns. Given that cash profitability subtracts accruals from operating profitability, companies with high cash profitability tend to be firms with lower accruals and lower investment. The higher average returns of firms with high cash profitability over firms with high operating profitability becomes unreliable after controlling for investment, and outside of the US the difference in average returns is unreliable without controlling for investment. Rizova and Saito (2020) conclude that cash profitability is an unreliable way to mitigate the negative effect of high investment firms; it is also less persistent than operating profitability as a proxy for future profitability resulting in higher turnover for cash profitability portfolios. Overall, using operating profitability as a proxy for future profitably combined with directly addressing high asset growth firms, rather than indirectly by removing accruals from operating profitability, results in more accurate targeting of the profitability premium.

The application of profitability is different across securities. Generally, higher expected return stocks sorted on size, relative price, and profitability are overweighted relative to market capitalization weights. In small caps the resulting turnover from an overweighting approach tends to increase turnover. Dimensional uses an exclusion approach for small growth low profitability, eliminating the lowest profitability firms within the small cap growth universe. For remaining small caps, profitability is considered in security weighting. As a point of interest, this exclusion is related to one of the problems with the Fama French Five-Factor model, as described in Fama and French (2015):

> The five-factor model's main problem is its failure to capture the low average returns on small stocks whose returns behave like those of firms that invest a lot despite low profitability. (Fama and French, 2015).

The profitability overweight across market caps was implemented in 2013 and the small growth low profitability exclusion was implemented in 2010.

3.3 Short-Term Considerations

Short-term considerations contain information about expected returns over months or days. Dimensional considers these variables to inform the timing of trades. For example, all else equal Dimensional will delay purchasing a security with negative price momentum, or delay selling a security with positive momentum. Momentum will not cause trading to happen but will inform delays in trading that would have happened otherwise.

3.3.1 Asset Growth

Dimensional approaches asset growth (investment) with an exclusion rather than an overweight due to the nature of the effect. Theoretically from the valuation equation, all else equal, lower investment firms should have higher expected returns than higher investment firms. Empirically, the dispersion in asset growth is much larger in small caps than it is in large caps. This is likely due to the fact that smaller companies have a smaller asset base to begin with. Rizova and Saito (2020) find in US, developed ex US, and emerging markets that the differences in returns between high and low asset growth firms within large caps are not statistically different from zero. This result makes sense given the low dispersion in asset growth across larger firms.

For small caps, Rizova and Saito (2020) find an economically large and statistically significant difference in returns between high and low asset growth firms in all three regions. This premium is driven primarily by small firms with high asset growth. The authors conclude that the investment premium is pervasive across markets and persistent over time. It is also pervasive across relative price and profitability segments as well as across sectors. Given that the asset growth premium is primarily driven by small firms in the top decile of asset growth, it is sensible to exclude them rather than attempt to apply over and under weights. The small high asset growth exclusion was implemented in 2019.

3.3.2 Momentum

While the five factors in the Fama French Five-Factor model fit nicely into a theoretical valuation framework, momentum continues to be an unexplained anomaly from the perspective of market efficiency. Jegadeesh and Titman (1993) document that strategies which buy stocks that have performed well in the past and sell stocks that have performed poorly in the past generate significant positive returns over 3 to 12-month holding periods. Carhartt (1997) adds momentum to the Fama French Three-Factor model to examine the performance of mutual fund managers. Fama and French (2018) add momentum to the Five Factor model and find that the Six-Factor model performs well (ignoring transaction costs) in comparative tests of asset pricing models.

Despite the lack of a theoretical risk-based explanation for momentum, there are theoretical explanations from behavioral finance. Empirically momentum is difficult to ignore in the data. Crill (2021) shows that the momentum premium decays rapidly and finds that despite the appealing data, live momentum funds struggle to capture the momentum premium, possibly due to the high turnover necessary to capture the premium. Since the momentum premium is short-term and high turnover, Dimensional implements it as a trading input by prioritizing buy and sell transactions based on momentum. Stocks with large relative underperformance tend to have negative excess returns in the next period, so Dimensional will delay buys of securities otherwise eligible for purchase; stocks with large relative outperformance tend to have positive excess returns in the next period, so Dimensional will delay sells of securities otherwise eligible for sale. This approach does not increase portfolio turnover in the way that targeting momentum would, but also ensures that Dimensional's clients are not consistently on the wrong side of momentum trades. Arnott, Kalesnick, Kose, and Wu (2017) come to a similar conclusion after investigating the struggles of live momentum strategies.

3.3.3 Securities Lending

Securities lending is when the owner of a security lends the asset to a borrower in return for compensation. These transactions are backed by collateral to protect the asset owner. Securities lending is a common activity within mutual funds and ETFs that allows unit holders to benefit from an additional source of revenue. Hendrix and Crabb (2020) find that stocks with high borrowing fees tend to underperform. There is high turnover among expensive-to-borrow stocks and many interactions to consider; expected returns, revenue from securities lending, portfolio diversification, and portfolio turnover need to be carefully balanced. To apply the information in borrowing costs, Dimensional delays the purchase of the most expensive-to-borrow small cap stocks. The expensive-to-borrow trading delay was implemented in 2013.

3.4 Intraday Considerations

In addition to longer-term considerations that inform decisions over years and shorter-term considerations that are useful over months or days, Dimensional also considers transaction costs, the minute-to-minute costs of implementing portfolios. Total transaction costs are a function of portfolio turnover multiplied by transaction costs. Turnover is minimized throughout the investment process, including in the design of portfolios, and the choice of variables used to weight securities. Transaction costs include implicit and explicit costs.

3.4.1 Implicit Transaction Costs

Ultimately, Dimensional needs to trade securities to implement portfolios. Trading between buyers and sellers on the stock market occurs through a price-time priority queue known as the limit order book. Buyers are ranked by price from the highest to lowest bid, and orders at the same price are prioritized by the time that the order was placed. Sellers are similarly ranked by their offer price (lowest to highest) and orders at the same price are ordered by time. The difference between the highest bid and lowest offer is known as the spread. If a trader requires immediacy, they will need to cross the spread, and may even need to pay higher prices as they work through the open orders to complete their trade. These price movements are known as implicit transaction costs. They are hard to measure and even harder for end investors to see as they are not typically reported. Based on the flexible design of Dimensional's portfolios they do not require immediacy when trading. In trading, price, time, and quantity are the most important considerations; optimizing for any two requires giving up the third. For example, a traditional active manager who deems a security to be undervalued will be willing to bid the price up a bit while filling their desired position, and a traditional index fund rebalancing their portfolio after the index they are tracking reconstitutes is required to quickly match the new index to minimize tracking error. In both cases the portfolio manager may impact prices as they act to quickly complete their trades. This can be even more problematic in small caps which will tend to have larger spreads. In Dimensional's case there will be several securities that bear the needed characteristics to rebalance the portfolio on any given day.

Being flexible in both the timing and quantity should reduce the cost of trading; the portfolio manager will trade the security with the most advantageous conditions. Liu and Wiley (2021) show that from 2017 through 2020 Dimensional's flexible approach to trading results in a 10.5 basis points advantage over market participants that demand immediacy. The advantage is larger in small caps and during times of high market volatility.

3.4.2 Explicit Transaction Costs

The other important aspect of trading is venue selection; there are many different exchanges that trades can be executed on. Different exchanges charge different fees and provide rebates to customers. Exchanges known as "maker-taker" exchanges charge fees for taking liquidity and offer rebates for providing liquidity whereas "inverted" exchanges charge fees for providing liquidity and offer rebates for taking liquidity. Given these options an investor who provides liquidity, like Dimensional due to their flexible trading, would likely choose maker-taker exchanges as their primary trading venue. However, Di Maggio, Liu, Rizova, and Wiley (2020) find that total trade costs, which consider fees, rebates, spreads, and market impact, are statistically indistinguishable across different venues. Based on this, Dimensional's trading algorithms account for both explicit and implicit costs when routing orders. Explicit transaction costs are reported in funds' Management Report of Fund Performance as a trading expense ration (TER). As an illustration of the explicit costs of Dimensional funds, the average TER for the five years ending 2021 for the Canadian Core Equity fund is 0.01%, for the Canadian Vector Equity fund it is 0.01%, and for the iShares Core S&P/TSX Capped Composite ETF it is 0.03%.

4. Dimensional Canada Equity Investment Strategies

Dimensional Canada's equity fund offerings are categorized into two types: Core and Vector. Both are broadly diversified portfolios based on market capitalization weights with tilts toward higher expected return securities. Core portfolios include the full equity universe in each respective market while Vector portfolios exclude securities with the largest market caps and highest prices, and real estate investment trust securities. The tilt toward higher expected return securities is more extreme in the Vector strategy. In both portfolios small caps with low profitability and high relative price and small caps with high asset growth are excluded while stocks with smaller market caps, lower relative prices, and higher profitability are overweighted.

4.1 Integrated Equity Solutions

Both Core and Vector are considered integrated portfolios, meaning that they pursue size, value, and profitability premiums across all market capitalizations in a balanced manner in a single portfolio. To contrast, a combination approach would be a market capitalization weighted fund combined with a small cap value high profitability fund, or with individual small, value, and profitability funds. To achieve the desired factor exposures. Dai, Saito, and Watson (2021) find that holding aggregate portfolio characteristics and average returns roughly constant, an integrated portfolio will tend to have more even distributions of over and underweights relative to the market resulting less tracking error, lower turnover, and lower costs; it will more reliably capture premiums over time; and will have less turnover within small caps which tend to be the costliest securities to trade. The relatively low turnover of an integrated portfolio largely comes from internal migration of securities. Over a given period, several stocks will "migrate" from one category to another. For example, a small value stock may rise in price to the point where it bears the characteristics of a mid-cap growth company. As a result of this higher price, portfolio managers of a small cap value portfolio will eliminate the position as it no longer fits the mandate. In an integrated portfolio, mid cap growth stocks are still owned, though at a lower weight than the market capitalization. The portfolio manager may continue to hold the security, or at least will not need to eliminate the full position. As an illustration, the average turnover for the five years ending 2021 for the Canadian Core Equity fund is 10.22%, the Canadian Vector Equity fund turned over 15.61% of its holdings, and the iShares Core S&P/TSX Capped Composite ETF turned over 60.05%. Turnover does not have an explicit cost that can be measured like a TER, but the market impact of trading has an implicit cost.

4.2 Core Strategies

To construct Core funds, all eligible securities are sorted based on their size and relative price. This results in a grid of securities sorted by expected returns. These categories are ranked from the highest expected return to lowest expected return with an additional expected return multiplier applied for profitability. As a final step, a multiplier is assigned to each of the categories. The higher expected return categories will be assigned a multiplier that is above one, and lower expected return categories will be assigned a multiplier of less than one. For all categories, the portfolio weight will be rebased according to the multiplier times the free float market cap. As a result, higher expected return securities will be overweighted and lower expected return securities will be underweighted compared the market portfolio which by default assigns a multiplier of "one" to all categories. The Core methodology allows for a portfolio with a higher expected return than the market portfolio. The multipliers are only gradually increased as we move from lower to higher expected return categories, which reduces the need for active transactions in the portfolio. The portfolio is not required to hold all securities in each category; it must rather hold a highly representative subset of the securities. Finally, the Core methodology maintains a close connection with market prices which minimizes tracking error, turnover, and costs. In addition to the weighting scheme, several exclusions are implemented to further enhance expected returns. Small growth low profitability stocks and small high investment stocks are excluded from the portfolio. Regulated utilities and REITs are assigned neutral weights. Recent initial public offerings are excluded, and the stocks of bankrupt companies are not included in new purchases.

As an example, the relative over and underweights of the Canadian Core Equity Fund relative to the S&P/TSX Composite can be seen in Table 1.

Table 1 - Canadian Core Weight Multipliers Relative to S&P/TSX Composite as at March 31, 2022

Canadian Core Multipliers	Large and Mid Caps	Small Caps
Growth-Low Prof	0.39x	0.83x
Growth-High Prof	1.04x	2.13x
Value-Low Prof	0.78x	2.22x
Value-High Prof	1.27x	2.89x

Data source: Dimensional Fund Advisors

The weighted average characteristics of the Canadian Core Equity Fund can be seen in Table 2. Given the interactions between factors, it is notable that the Canadian Core Equity Fund has smaller size, lower relative price, and higher average profitability than the market index. A simple sort on value alone, as an example, would lead to lower average profitability than the market.

Table 2 - Canadian Core Equity Characteristics as at March 31, 2022

	Number of Companies	Average Market Cap (millions)	Aggregate Price-To-Book	Average Profitability
Canadian Core Equity Fund	407	$50,294	1.91	0.31
S&P/TSX Composite Index	239	$68,780	2.17	0.26

Data source: Dimensional Fund Advisors

4.3 Vector Strategies

Vector strategies are like core strategies, but they tilt more aggressively toward size, value, and profitability. While a Core fund will have exposure to most securities in the market, vector will have very little if any exposure to the lowest expected return large cap growth stocks and a much higher exposure to the highest expected return categories. As a result, Vector funds have higher expected returns and more tracking error relative to a total market index than a Core fund. Vector funds exclude REITs. Table 3 depicts the relative category multipliers for the Canadian Vector Equity Fund.

Table 3 - Canadian Vector Weight Multipliers Relative to S&P/TSX Composite as of 03/31/2022

Canadian Core Multipliers	Large and Mid Caps	Small Caps
Growth-Low Prof	0.28x	0.98x
Growth-High Prof	0.59x	2.75x
Value-Low Prof	0.99x	3.99x
Value-High Prof	1.48x	4.66x

Data source: Dimensional Fund Advisors

The weighted average characteristics of the Canadian Vector Equity Fund can be seen in Table 4. Compared to the Core fund we see smaller average size, a deeper value tilt, and slightly lower profitability – not a surprise given the deeper value tilt. Importantly, the average profitability of the holdings in the Vector fund still exceeds the market index.

Table 4 - Canadian Vector Equity Characteristics as at March 31, 2022

	Number of Companies	Average Market Cap (millions)	Aggregate Price-To-Book	Average Profitability
Canadian Vector Equity Fun	349	$39,840	1.69	0.28
S&P/TSX Composite Index	239	$68,780	2.17	0.26

Data source: Dimensional Fund Advisors

4.4 International Considerations

Dimensional Canada's International equity funds consist of both international developed and emerging markets securities with an approximately two-thirds developed and one-third emerging markets allocation at the time of writing. To be considered for inclusion in portfolios, international markets are evaluated on foreign investor restrictions, financial accounting and reporting practices, financial markets settlement system, market and exchange regulations, and market liquidity and costs. Foreign securities may be accessed through local listings or depository receipts/ foreign listings. As a brief case study, at the time that the Russian equity market closed in 2022 resulting in total losses for investors, Dimensional was significantly underweight Russia in their emerging markets strategies. This had been the case since 2014 when, based on the previously outlined criteria, Dimensional deemed the market to be unfavorable.

5. Expected Returns

The structure of Dimensional's equity funds provide more exposure to higher expected return securities than the market cap weighted index. While this sounds compelling, it is not free. Dimensional charges higher fees than a capitalization weighted index fund. To estimate the expected returns of Dimensional's equity strategies we use the Fama French Five-Factor model to estimate the factor loadings of live funds. Following Felix, Kerzerho, and Warwick (2022), we find an expected return in excess of the market of 0.35% net of fees for the Dimensional Global Equity Portfolio which combines Core and Vector funds.

5.1 Expected Returns Methodology Summary

Felix, Kerzerho, and Warwick (2022) use multifactor regression to estimate the funds' exposure to factor premiums and apply expected premiums to these loadings to estimate expected excess returns. They use live fund data gross of fees and withholding taxes and add fees back in later; fees and withholding taxes will always result in negative alphas. This approach demonstrates a "clean" alpha. Core and Vector funds both have economically meaningful and statistically significant factor loadings, with Vector having stronger loadings than Core. The funds have statistically insignificant alphas which is what we would expect for funds that are pursuing factor risk premiums and not taking active bets. Most alphas, while not statistically different from zero, are negative. This is not surprising given that we are examining live funds with real implementation costs.

In all cases we see that most of the variation in the funds' returns is explained by the model (R^2 above 0.99). Felix, Kerzerho, and Warwick (2022) assume that all factor loadings with t statistics below 2 are 0, multiply all non-zero loadings by the expected factor premium, and subtract the fund management expense ratio (MER). It should be noted that factor loadings are noisy estimates of sensitivity to each premium, and differences in loadings across funds may not represent true differences in expected returns between funds. Additionally, due to limited data, some loadings have t stats below 2 despite the fund targeting a premium; with more data we may expect these t stats to rise above 2, changing our expected return estimate.

5.2 Historical and Expected Factor Premiums

Felix, Kerzerho, and Warwick (2022) observe the world factor premiums for the period 7/1992 – 5/2022, considered out of sample with respect to Fama and French's research, and apply a shrinkage factor of 0.7, or a 30% reduction in the historical premiums, to estimate expected premiums. The methodology for the shrinkage factor is detailed in Felix, Kerzerho, and Warwick (2022). Using both out of sample data and an additional shrinkage factor offers a conservative estimate.

Table 5 - World Premiums 7/1992 - 5/2022

	SMB	HML	RMW	CMA
Historical Premiums	0.36%	3.07%	3.91%	2.65%
Expected Premiums (Shrinkage factor = 0.7)	0.25%	2.15%	2.74%	1.86%

Source: PWL Capital; Data source: Ken French

5.3 Dimensional Core and Vector Expected Returns

To develop a rough estimate of expected excess returns of Dimensional funds over capitalization weighted indexes we apply the previously described methodology to each fund. This estimate indicates how much better off we expect to be in the long-run, net of fees, for owning Dimensional funds rather than traditional total market index funds.

Table 6 - Estimated Expected Returns for Dimensional Funds

	Expected Gross Premium	Fund MER	Net Expected Premium
Canadian Core	0.37%	0.25%	0.12%
Canadian Vector	0.52%	0.35%	0.17%
U.S. Core	0.50%	0.24%	0.26%
U.S. Vector	0.87%	0.35%	0.52%
International Core	1.05%	0.41%	0.64%
International Vector	1.39%	0.55%	0.84%
Global Portfolio*	0.69%	0.34%	0.35%

Data source: Dimensional Returns Web, Ken French Data Library; Source: PWL Research

*Global portfolio consists of 34% Canadian equity, 41% US equity, and 25% International equity with a split of two-thirds Core andone-third Vector

A global portfolio representative of the model portfolios used in PWL client accounts (excluding a REIT, fund which is included in the model portfolios) has an excess expected return of 0.35% annualized after fees over a market capitalization weighted index. Relative to a comparable portfolio of market capitalization weighted index funds, like, the Vanguard All-Equity ETF Portfolio VEQT with an MER of 0.24%, the Dimensional global portfolio has an excess expected return of 0.59%.

These figures are substantial, and theoretical. To answer the question of whether Dimensional can capture expected premiums in live funds we include in the Appendix the historical performance of Dimensional's US domiciled equity funds with 20 or more years of history relative to comparable Vanguard funds, both of which have decades of performance data available for comparison. Comparing funds to funds rather than funds to indexes is useful because indexes are not directly investable, they are not live products, and they do not reflect fees, costs, and withholding taxes. Over the available history since their inception, Dimensional has proven an ability to effectively capture risk premiums after costs. Across most fund categories for their available histories the realized premiums over market weighted index funds have exceeded our estimated expected premium.

5.4 Factor Correlations

Positive expected returns independent of the market expected return are compelling on their own, but one of the strongest arguments for pursuing multiple sources of expected return is that premiums may be positive at different times. Pursuing multiple premiums improves the reliability of long-term investment outcomes. This is observable through correlations across premiums in each region.

Table 7 - Canadian Factor Premium Correlations - 07/1992 – 03/2022

	CAN MKT- RF	CAN SMB	CAN HML	CAN RMW	CAN CMA
CAN MKT- RF	1				
CAN SMB	0.20	1			
CAN HML	-0.23	0.00	1		
CAN RMW	-0.19	-0.34	0.17	1	
CAN CMA	-0.30	-0.15	0.62	0.21	1

Data Sources: Ken French Data Library, Dimensional Returns Web

Table 8 - US Factor Premium Correlations - 07/1992 – 03/2022

	US MKT- RF	US SMB	US HML	US RMW	US CMA
US MKT- RF	1				
US SMB	0.23	1			
US HML	-0.11	-0.03	1		
US RMW	-0.37	-0.46	0.37	1	
US CMA	-0.34	-0.03	0.63	0.25	1

Data Sources: Ken French Data Library, Dimensional Returns Web

Table 10 - All Country ex-North America Factor Premium Correlations - 07/1992 – 03/2022

	AC ex-NAMKT- RF	AC ex-NA SMB	AC ex-NA HML	AC ex-NA RMW	AC ex-NA CMA
AC ex-NA MKT- RF	1				
AC ex-NA SMB	-0.10	1			
AC ex-NA HML	0.04	0.04	1		
AC ex-NA RMW	-0.33	-0.08	-0.45	1	
AC ex-NA CMA	-0.30	0.08	0.59	-0.35	1

Data Sources: Ken French Data Library, Dimensional Returns Web

Low or negative correlations are particularly interesting over long horizons where the market risk premium has failed to deliver. A recent example of the market going through a prolonged period of underperformance is US stocks for the 10-year period ending July 2009. Over that time period the US stock market represented by the CRSP 1-10 index lost an annualized 0.19% while the Fama/French US Small Value Research Index returned an annualized 9.51%, the Fama/French US Value Research Index returned an annualized 3.78%, the Fama/French US High Profitability Research Index returned an annualized 2.09%, and one-month US Treasury Bills returned an annualized 2.95%.

This is far from an isolated incident. There were 111 (mostly overlapping) 10-year periods ending between July 1973 and June 2020 where the US market premium was negative. Over those same 111 periods where the market premium was negative, SMB, HML, and CMA were all positive, while RMW was negative in 53 of the 111 periods.

The single worst time to retire in the US stock market data was December 1968. From then until January 1984, the US market gained an annualized 7.26%, but trailed one-month US Treasury Bills which returned an annualized 7.63% and approximately matching inflation which ran at an annualized 7.22%. Over the same time period, the Fama/French US Small Value Research Index returned 15.80% annualized, and the Fama/French US Value Research Index returned 13.46% annualized.

A more extreme example is Japan from July 1990 through December 2021. Over the full period the Japanese stock market measured by the Fama/French Japan Market Index delivered an annualized return of 2.61%, barely surpassing one-month US Treasury Bills which returned 2.48%. The Fama/French Japan High Profitability Index delivered similar performance at an annualized 2.64%. Meanwhile, the Dimensional Japan Small Cap Value Index and the Fama/French Japan Value Index delivered annualized returns of 5.10% and 7.46% respectively.

Conclusion

Based on the theoretical underpinnings and empirical support for Dimensional's approach, combined with Dimensional's careful implementation and long-term track record of success, we believe that their products are the best solution for most of our clients. While the future is always uncertain, we believe that it is reasonable to expect the increased exposure to common risk factors in Dimensional's funds to more than offset their fees and costs, and that exposure to multiple sources of expected return increases the reliability of long-term outcomes for our clients.

Appendix: Dimensional's Long-Run Performance as at March 2022

Name	Start Date	Return	Std Dev
DFA US Micro Cap I	1/1982	11.81	19.72
Vanguard 500 Index Investor	1/1982	11.93	15.01
Vanguard Small Cap Index Inv	1/1982	10.28	19.79
DFA Continental Small Company I	7/1990	7.61	18.51
Vanguard European Stock Index Investor	7/1990	6.66	17.45
DFA US Small Cap I	4/1992	10.67	19.30
Vanguard 500 Index Investor	4/1992	10.45	14.48
Vanguard Small Cap Index Inv	4/1992	10.41	18.66
DFA Asia Pacific Small Company I	2/1993	7.87	23.58
Vanguard Pacific Stock Index Investor	2/1993	4.13	17.34
DFA US Large Cap Value I	8/1998	8.14	18.33
Vanguard 500 Index Investor	8/1998	7.53	15.45
Vanguard Value Index I	8/1998	7.40	15.64
DFA US Small Cap Value I	1/2000	10.28	21.38
Vanguard 500 Index Investor	1/2000	6.63	15.15
Vanguard Small Cap Value Index I	1/2000	9.91	19.16
DFA International Value I	5/1996	5.66	18.56
Vanguard Total Intl Stock Index Inv	5/1996	4.66	16.96
Vanguard International Value Inv	5/1996	5.25	17.24

Data Sources: Dimensional Returns Web, Vanguard

Appendix (Continued): Dimensional's Long-Run Performance

Name	Start Date	Return	Std Dev
DFA Emerging Markets I	6/1994	6.46	21.33
Vanguard Emerging Mkts Stock Idx Inv	6/1994	5.62	22.29
DFA International Small Cap Value I	5/1996	6.85	17.86
Vanguard Total Intl Stock Index Inv	5/1996	4.66	16.96
Vanguard International Value Inv	5/1996	5.25	17.24
DFA International Value III	5/1996	5.84	18.57
Vanguard Total Intl Stock Index Inv	5/1996	4.66	16.96
Vanguard International Value Inv	5/1996	5.25	17.24
DFA US Large Cap Value III	8/1998	8.28	18.33
Vanguard 500 Index Investor	8/1998	7.53	15.45
Vanguard Value Index I	8/1998	7.40	15.64
DFA Emerging Markets II	9/1997	7.14	21.78
Vanguard Emerging Mkts Stock Idx Inv	9/1997	5.91	22.77
DFA Emerging Markets Small Cap I	4/1998	10.47	22.68
Vanguard Emerging Mkts Stock Idx Inv	4/1998	6.71	22.50
DFA Emerging Markets Value I	5/1998	9.53	24.49
Vanguard Emerging Mkts Stock Idx Inv	5/1998	6.78	22.54
DFA US Large Company I	10/1999	7.76	15.04
Vanguard 500 Index Investor	10/1999	7.68	15.05

Data Sources: Dimensional Returns Web, Vanguard

The Authors

Benjamin Felix MBA, CFA, CFP®, CIM®
Portfolio Manager,
Head of Research

Benjamin Felix is the Head of Research at PWL Capital, a Canadian wealth management firm known for its publicly available thought leadership. PWL creates resources for Canadian investors including white papers, model portfolios, and research content. Benjamin co-hosts a podcast, the Rational Reminder, and is the host of a YouTube channel which together reach hundreds of thousands of people in Canada and around the world. Benjamin joined PWL Capital in 2013 after completing a degree in mechanical engineering and an MBA in financial management. He is a CFA charterholder and a CFP professional.

Raymond Kerzérho CFA,
Senior Researcher, Head,
Shared Services Research

Raymond contributes to PWL with his thirty years of experience in investment strategy and fixed income portfolio management. A passionate blogger, he writes a monthly column in French-language newspaper Les Affaires and hosts the French podcast “L’investissement Décomplexé”. Raymond also teaches finance part-time at McGill University.

PWL

PWL Montreal
3400 de Maisonneuve O.
Suite 1501
Montreal, Quebec
H3Z 3B8

T 514.875.7566
1-800.875.7566
F 514.875.9611
montreal@pwlcapital.com
www.pwlcapital.com/montreal

PWL Ottawa
265 Carling Avenue,
8th Floor,
Ottawa, Ontario
K1S 2E1

T 613.237.5544
1-800.230.5544
F 613.237.5949
ottawa@pwlcapital.com
www.pwlcapital.com/ottawa

PWL Toronto
8 Wellington Street East
3rd Floor
Toronto, Ontario
M5E 1C5

T 416.203.0067
1-866.242.0203
F 416.203.0544
toronto@pwlcapital.com
www.pwlcapital.com/toronto

PWL Waterloo
20 Erb St. West
Suite 506
Waterloo, Ontario
N2L 1T2

T 519.880.0888
1-877.517.0888
F 519.880.9997
waterloo@pwlcapital.com
www.pwlcapital.com/waterloo