Integrity in Investing
Informed Strategy: Models and the Art of Science

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Integrative Wealth Management

> *"As far as the laws of mathematics refer to reality, they are not certain.*
> *As far as they are certain, they do not refer to reality.*
> – **Albert Einstein**, Sidelights on Relativity (1922)

This is part of a series exploring integrity in planning financial strategy

Key takeaways:

- Models are common in all areas of investment planning and management.

- Since any model simplifies reality, investors must be aware of each model's limitations.

- Portfolio "optimizers" are popular models, but are hazardous if judgement is not applied.

- The value of modelling is understanding more when you finish than when you began.

Checking the weather on Google? Using a roadmap to plan your next vacation? Guess what–you're using a model. While models can be highly useful for making good decisions, or at least pointing us in the right direction, they simplify reality. Users should be very conscious of the inherent limitations of any model, regardless of their confidence in a specific one, whenever used to make important decisions.

The most popular model gives us weather forecasts. From massive quantities of data transmitted for constantly changing weather conditions worldwide, a meteorologist must develop rules, based on certain assumptions, to select from all that data a model to forecast weather coming tomorrow. The modelled data helps us decide whether to bring an umbrella when leaving work. However, as anyone ever caught in a rain shower without an umbrella based on forecasted sunshine knows that reality is often very different than what the models predicted. Even a 30 percent chance of rain forecasted for next week is no guarantee of a dry Sunday picnic.

Financial researchers use sophisticated quantitative models to search for answers to "What drives asset returns?" Professional and institutional investors search vast amount of data for explanatory "factors" to develop complex statistical models. Such models may be developed for

the purpose of gaining research insights or a competitive advantage. Debates about whose model is bigger or better are frequently described in professional journals. Morningstar, a well-known investment research firm, has developed a 36-factor "Global Risk Model" to assess a variety of portfolio risks. Company materials claim, "Our model uses the [factor] exposures to go beyond standard models to project a stock or stock portfolio's vulnerability to extreme market events."[1]

Perhaps Morningstar's big model may be better for investors and their advisors. But users of such models must understand how risks of security or portfolio of securities, just like the weather, cannot be "explained" completely by any model. Investors should be especially wary of many industry-developed methodologies popular with financial advisors whose recommendations overly-depend on their "models" for planning investing outcomes.[2]

The Wrong Use of Models

Nobel laureate and financial economist Professor Robert Merton has astutely commented about the "incompleteness" of models: "You'll often hear people say, during the [financial] crisis or something, 'There were bad models and good models.' And someone will ask, 'Is yours a good model?' That sounds like a good question, a reasonable question. But, actually, it isn't really well-posed. You need a triplet: a model, the user of the model, and its application. You cannot judge a model in the abstract."[3]

Bridging financial theory with practical planning requires not only understanding a client's unique situation but also awareness of the limitations with the financial models available in order to know when and how each should be employed. No matter how mathematically sophisticated, no model captures everything that might matter. No model represents reality perfectly. In Professor Merton's words, "No model is complete."[4] Instead of asking "Is this model true or false?" (to which the answer is always false), a more informed question is, "How does this model help me better understand how my world works?" and then wonder, "In what ways can this model be wrong?" No matter how precisely a model may give answers, applying "art to science" requires making informed judgements.

The Model, The User, and The Application

Investment models rely on numerous inputs, just like weather forecasts. Instead of inputs like barometric pressure or prevailing wind directions, investment models look at variables like historical returns or price volatility. For example, one model popular among retail financial advisors for selling financial products determines an "optimal" asset allocation of securities to hold in a portfolio. The allocation of investment vehicles selected by the advisor is based on how return and volatility characteristics of the securities comprising those vehicles are expected to interact with one another over time. These financial advisors are not modeling asset class indexes, but modeling particular mutual funds, exchange traded funds and other financial products to facilitate their sale.

Computerized complicated mathematics provides the appearance of planning sophistication for unwary investors. As always, *caveat emptor*. The saying "garbage in, garbage out" applies equally to asset class optimization models. A model's output is only as good as its input. Not only can poor assumptions by the financial advisor lead to poor recommendations, but even with sound assumptions, placing excessive faith in inputs that are inherently imprecise exposes users to nonsensical portfolio outputs.

Mean-variance asset allocation recommendations are positioned along a curving line termed an "efficient frontier." At each point, expected returns are maximized relative to the level of standard deviation. These illustrations are helpful in educating investors about general benefits of diversifying their portfolio. While optimizers are useful in illustrating risk management issues of concentrated portfolios, that usefulness has very distinct limitations.

So-called "portfolio optimizers" are an extension of Modern Portfolio Theory" (MPT), and the relationship between the returns and the volatility of a group of securities forming a portfolio. Low-cost personal computers made routinely "optimizing" asset allocations possible.[5] Nobel laureate Harry Markowitz's MPT model gives us valuable insight into how proper diversification positively impacts risk and expected return considerations. However, using an optimizer for planning specific products to recommend was never contemplated by Markowitz. A high degree of trust is being placed in highly imprecise inputs, so investors are being exposed to unquantified investment risks.

Part of the allure of mean-variance optimization models is the salesman connecting himself with the tremendous cachet from associating their investment recommendations with "Nobel Prize-winning research." But portfolio optimizers merely create an illusion of scientific accuracy—compounded when salesmen magnify that illusion by illustrating their model's outputs in precise decimal points. Bad investing outcomes blamed on MPT are almost always due to misuse of their model, usually by an advisor with little or no knowledge of financial economics.

Professional Financial is installing a sophisticated financial and retirement planning modelling system for clients. It collaboratively considers client expectations and concerns, social security choices, mitigating income taxes, health care

Exhibit 1: OPTIMIZER INPUT ILLUSTRATION: "TRUE" RETURN WITH ESTIMATION ERRORS

ASSET CLASS	EXPECTED RETURN		
	TRUE	ERROR +	ERROR –
Mars Equity	**8.0**	**.50**	**.50**
US Equity	8.0	0	0
International Equity	8.0	0	0
Emerging Market Equity	10.0	0	0
Fixed Income	4.0	0	0

Expected return estimations for asset classes derived from Dimensional US Adjusted Market 2 Index, Dimensional International Adjusted Market Index, Dimensional Emerging Markets Adjusted Market Index, and Bloomberg Barclays U.S. Aggregate Bond Index from 1995 to 2016, rounded to nearest full percentage, assuming forward inflation as 2.5 percent based on Federal Reserve inflation target. Canadian historical returns are used as a proxy for standard deviation and correlations of Mars Equity.

costs, longevity ranges, and risk preference related to the current portfolio strategy. The probability of retirement planning success based on current (and new) goals, levels of savings or spending (and how they may change), and electing Social Security or pensions at different ages may be stress tested. The system has a series of structured multifactor portfolio models installed for benchmarking, but its portfolio optimizer has not been disabled.

Potential Mistake Maximizers

Parameters required to compute a mean-variance optimization are either historical or projected returns and standard deviations of each asset class, along with a correlation matrix of every asset class in the portfolio set. The required number of inputs for a portfolio of N asset classes is equal to $N x (N+3)/2$. With five asset classes, you must estimate twenty parameters, and this number increases dramatically with the addition of asset classes to the portfolio. The multifactor asset class set the Professional Financial system requires 135 estimated parameters. In the following example, we compute the optimal allocation (i.e., the one with the highest return expected for a given level of standard deviation) for a simple portfolio containing only five asset classes—one named Mars Equity, US Equity, International Equity, Emerging Markets Equity, and Fixed Income. We estimate projected returns for each asset class, as outlined in **Exhibit 1**, and use a historical data set for estimating correlations and standard deviations.

To illustrate the impact of input errors on outputs due to inaccurate estimations, let's pretend that nineteen of the twenty estimated parameters (four expected returns, five standard deviations, and ten correlations) are calculated with complete precision, all representing
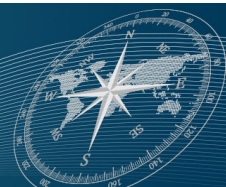
"true" parameters. However, let's assume that we cannot accurately estimate projected returns for one new asset class—Mars Equity. We could either underestimate or overestimate its expected return by 50 basis points (one-half a percent). This level of precision for projected return estimates is wildly conservative given the statistical noise of historical data. For example based on 1927-2010 data, the U.S. equity premium ranges from 3.5% to 12.1% at a 95% confidence interval.[6] Yet in **Exhibit 1** we have assumed a modest error range for only one parameter while pretending the remaining nineteen are completely accurate.

Even pretending impossible precision standards, targeting as 12.5% standard deviation causes the composition of the "optimal" asset allocation outputs to vary wildly, as shown in **Exhibit 2**. When the projected return on Mars Equity is overestimated by a mere 50 basis points, the optimal portfolio positions a 45% allocation to this asset class. When it is underestimated by the same amount, the allocation drops to only 2%. Consequently, unconstrained optimizer models can become mistake maximizers due to excess weightings for asset class with overestimated expected return, and vice versa. This shows why need to be used with considerable professional judgement.

Fundamental Flawed Premise

As we saw, optimizer output is extremely sensitive to the inputs, and even modest errors in estimations can result in dramatically different allocations for "optimal" portfolios. Therefore mean-variance optimization models usually have constraints with maximum and minimum limits specified for each asset class to compensate for that defect. But even if inputs could be precisely specified,

optimization models are based on a flawed premise regarding risk.

Even if someone knew enough to precisely input parameters for confident efficient frontier estimations, the entire concept of optimization assumes that portfolio variance, as measured by the standard deviation of the underlying assets classes, is a true, and therefore a complete measure of portfolio risk. Asset pricing seeks to understand the relationship between risk and expected return in market equilibrium. The original capital asset pricing model (CAPM) from the 1960s, followed MPT, and is the theoretical basis of the optimizer models in use. In that pre-computer era of limited price data and hand calculations, Sharpe's one-factor model required the simplifying assumption that a securities' volatility relative to the entire market of securities, termed as "beta," was the only compensated risk. After William Sharpe won a Nobel Prize for the CAPM model, "alpha" or the average excess return above the market return, became a golden ring for active managers because it implied market-beating skill.
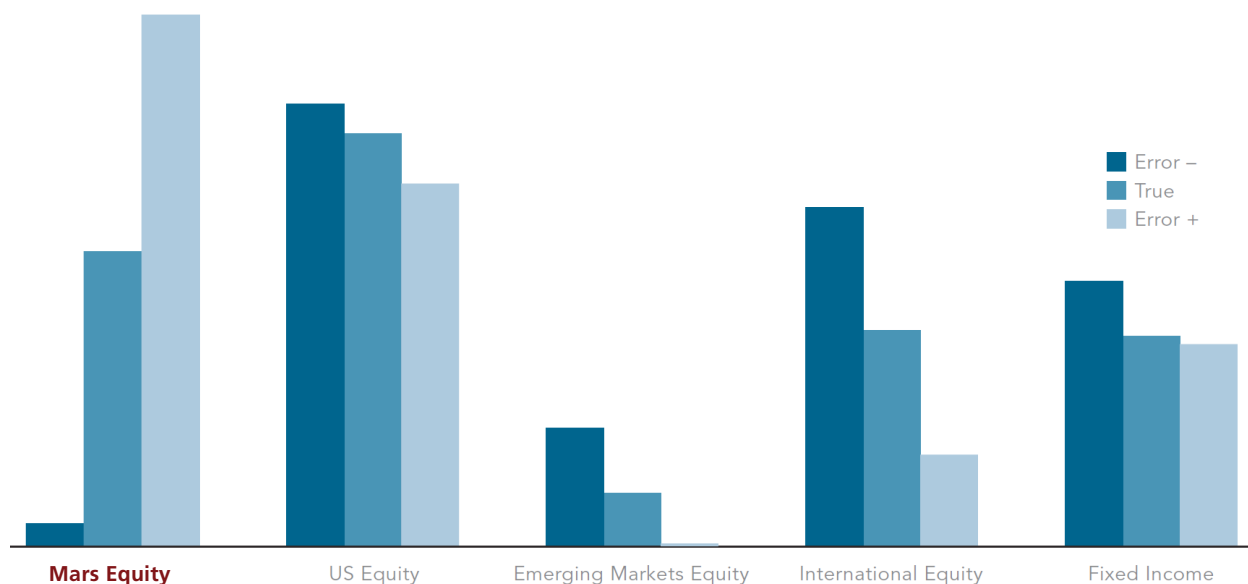
The old capital asset pricing model was simple, elegant, and intuitive. It's easy to compute and to explain to investors. Unfortunately it did not work as a stand-alone model. Indeed, CAPM is the framework for most asset pricing models of the financial industry, and for popular financial industry research services like Morningstar.

Unfortunately, as a young Professor Eugene Fama (and future Nobel laurate) and other academic researcher of the 1980s found as computers and historical price data became available so the CAPM one-factor model could be empirically tested (in part to support his Efficient Markets Hypothesis model), they found too many anomalies. The CAPM was poor at explaining market reality. Market risk simply could not be reduced to standard deviation.[7] Subsequent work by Fama and Kenneth French implied that risk is multidimensional. By the 1990s they published compelling evidence that three equity dimensions (market, size, and relative price) and later by two bond dimensions (term and default) were needed to explain returns.[8] Adding the dimension of profitability, sensible global multifactor asset allocation portfolio models may be structured from simulated dimensional asset indexes.

Abstracting Models for Use

Let's review what we've learned. Models are abstractions of the world. They simplify reality. Models can be valuable to gain insights for making good decisions. But they can be hazardous when a model's particular limitations are poorly understood, and a user becomes overconfident when applying it. Market prices of stocks and bonds contain a far richer set of information than any model captures, including the academic model of **Exhibit 3** that Dimensional uses for designing its strategies.

Exhibit 2: OPTIMAL ALLOCATIONS FOR AN ANNUAL STANDARD DEVIATION OF 12.5%

Legend: Error −, True, Error +

Mars Equity · US Equity · Emerging Markets Equity · International Equity · Fixed Income

Exhibit 3: FOUR-FACTOR EQUITY MODEL FOR EXPECTED RETURN ESTIMATIONS

$$R_{p(t)} - R_{f(t)} = a_p + \beta_p[R_{m(t)} - R_{f(t)}] + s_p SMB_{(t)} + h_p HML_{(t)} + p_p RMW_{(t)} + e_{(t)}$$

| average expected return | average excess return | market factor | size factor | relative price factor | profitability factor | error term |

Priced Variation
- Positive expected return
- Systematic
- Economic
- Long-Term
- Investing

Unpriced Variation
- Zero expected return
- Noise
- Random
- Short-Term
- Speculating

A good research model is one that is empirically testable with data and that yields useful insights about financial markets. The financial planning models Professional Financial employs need accurate client data in many areas to test the impact of longevity variations, different tax rates, Social Security or health care elections, or the likelihood or necessity of a client working until a targeted date.

Expertise is needed to distinguish what assumptions are meaningful when using financial planning models vs. what opens the door to needless poor outcomes. Let's review (1) the tradeoffs that we believe must be considered when evaluating models and (2) research ideas in order to build robust client strategies. This means that instead of asking "Is the model good or bad," it is better to ask "How will planning certain choices with this model help us better understand your likely retirement outcome?" and "In what ways can this model go wrong?"

Type I vs. Type II Error[9]

For example, consider the decision facing the Food and Drug Administration when they assess a new drug. If they do not approve the drug, they give up the potential benefit that the drug may be able to help people. On the other hand, if they approve the drug, the risk is that the drug may not have sufficient health benefits that offset the risk of dangerous side effects.

This tradeoff can be framed as a balance between type I and type II error. Type I error, or a false **positive,** occurs if researchers approve a drug that is not beneficial or has high risk of harmful side effects. Type II error, or a false **negative,**

occurs if a beneficial drug fails to get approval. If you minimize one error, the chance of the other becomes larger.

Different people may look at the same data and come to different conclusions depending on how much weight they choose to give to type I vs. type II error. Uncertainty about the outcomes, such as the potential for greater harm, may also lead different people to different conclusions. For example, some patients might be happy to try an experimental drug without a proven track record, especially if they may die anyway, while others are less willing to take a chance simply due to personal fears or unpleasant side effects. Some advisors may be more or less willing to make a recommendation if it may jeopardize a relationship or create compliance issues.

Management Applications

For example, when a new solution offered by Dimensional is evaluated for inclusion for our portfolio constructions, we need to evaluate similar tradeoffs. What potential benefits may a new premium or enhancement bring to client portfolios? What are the potential costs, and how might we reduce those costs through regular progress meetings? How much uncertainty is there around estimated advantages? What if early outcomes disappoint clients and decide they want to restore a previous portfolio strategy?

This tradeoff can be reframed in terms of type I and type II error. Type I error occurs if a Dimensional solution is substituted for another allocation but does not have an expected net benefit. It is the risk of implementing a bad

idea. Type II error occurs if a Dimensional solution is not implemented but would have a net benefit to the portfolio. It is the risk of not implementing a good idea. Type I error can be minimized by never making replacements or reallocations. Traditional index funds follow such an approach. Type II error is minimized by having a low bar for the implementation of new ideas. This might describe a quant approach that uses many signals with the hope that there are enough good signals to offset the bad. Offering an exchange traded fund developed around a newly identified factor or new sector is another example of this.[10]

If we must pick one type of error to minimize, the evidence from many performance studies suggests that it should be to minimize the risk of implementing a bad idea. Studies show it is difficult for active managers to beat benchmark indices, suggesting that performance-enhancing ideas are not easy to discover or develop effectively.[11] This partly explains our consistent Dimensional relationship over nearly two decade—the likelihood of a costly mistake by using different vehicles may have a lasting negative impact which we cannot be overcome by making certain adjustments afterwards. However, the question should not be which error to minimize. We believe more robust portfolios and reliable investment outcomes can result from balancing both types of errors.

Type I: Defending against Bad Ideas and High Costs

There are a number of ways Dimensional Fund Advisors reduces the risk of implementing a bad idea for client portfolios. One way is to defend against data mining. This is by rigorously considering whether a premium is sensible and backed by robust empirical evidence. However, even good economic rationale combined with solid empirical research cannot completely eliminate uncertainty. Dimensional may have strong confidence a premium is positive, but expected returns are still only estimates and never guarantee an expected outcome.

Even with a good idea, type I error can result from poor implementation. This is why it is important to make sure the costs of pursuing the new idea are low. Costs directly come in the form of trading costs, which is why Dimensional looks at whether a new idea can be implemented

with low turnover. Costs can come indirectly in the form of reduced diversification, which is why Dimensional examines whether an idea can be implemented in portfolios that are well diversified across issuers, sectors, and countries, whenever those considerations are relevant.

Pushing too hard on a model or idea can magnify the risk of type I error and increase the probability of catastrophic outcomes, as in the case of unconstrained optimization leading to concentrated risks. An investor can have high conviction in the size premium but may not want to have a portfolio consisting of only the 10 smallest companies. The momentum premium is robust in historical simulations, but Dimensional lacks the conviction that it will be high enough in the future to warrant high turnover and overcome the high associated costs. Quant managers, in particular those using multiple and frequently changing trading signals, have much higher probability of maximizing false positives due to high uncertainty about the inputs their model.

"Dimensions" of expected returns are premiums in which Dimensional has the highest level of confidence. Dimensions are sensible, persistent, pervasive, robust, and cost-effective to pursue in well-diversified portfolios. Other factors from academic research might not rise to the level of a dimension but may still be considered as a portfolio enhancement if costs are low. For example, using momentum as a reason to delay trades does not increase the level of turnover. The cost per unit of turnover should not increase because traders can be even more patient when trading. And if momentum ever disappears, the portfolios will still have potential expected outperformance over benchmarks due to targeting size, value, and profitability premiums.

Type II: What Are We Missing?

Type II error occurs when Dimensional passes on research that may have benefited portfolios, or when Professional Financial clients are not placed in new Dimensional strategy because tools to analyze it are not available or the best way to arrange fund replacement is unclear. But how large are these forgone benefits? Given that the majority of active managers fail to beat passive benchmarks, it seems reasonable to conclude that value-enhancing ideas are

hard to come by. We believe this suggests that one should be more cautious about implementing a bad idea than worrying about missing out on a good idea even when offered by Dimensional.[12]

However, because Dimensional strategies already incorporate several dimensions and enhancement techniques, we believe type II error is likely small, relative to type I error. Market, size, relative price, and profitability dimensions already explain a very substantial portion of differences in average returns. Exclusions such as small low profitability and enhancements such as the momentum screens further improve expected returns and such techniques are typically incorporated into the existing portfolios.

A diminishing marginal benefit is associated with each addition to Dimensional portfolios. The probability whether benefits from changes will overcome costs has becomes progressively smaller. Dimensional is committed to continually investigating enhancements for client strategies, and works hard so that basis points of value and of cost savings keep adding up. But detrimental changes to portfolios are always possible. New research is viewed with special skepticism. Given the high quality of the Dimensional strategies in use, since the benefit of changing portfolios or due to various trading costs or taxable impacts is marginal, the greater the probability that harmful consequences from mis-perceived benefits due to type I errors increases.

Process Clarity Promotes Discipline

For commitment to an investment policy strategy through varying market conditions over a planning lifetime, clients must trust that their wealth management consultant makes wise decisions, exclusively for their benefit. However, that same consultant's ability to evaluate various managers and vehicles for investment management, and explain to the client the essential elements of that manager's methodology depends on the transparency of that manager's process. If clients don't understand the reasoning behind investment decisions—which is typical with actively trading stock managers or quant managers—then clients are left with no choice but to evaluate manager results on past performance, usually comparing with a popular but inappropriate index. For wealth management clients who attracted to
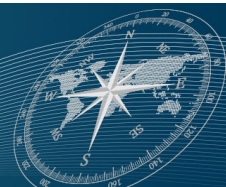
a firm due based in investment past performance, this is important since they are more likely to quit when outcomes disappoint.

Investors distrustful of the opaque decisions of active managers could decide to trust only the market. Outsourcing the actual portfolio construction, index funds and many ETFs will accomplish that goal simply by holding market cap-weighted portfolios. With no authority to deviate, an index fund manager's goal is to minimize tracking error relative to a specified asset class benchmark. A high level of transparency is achieved that requires little or no manager trust from an investor. When investment returns are poor, investors simply blame the market (or their own choice of an asset class), rather than a manager's bad management decisions.

Trusting the market by investors can be implemented less rigidly than with an index fund approach. Dimensional's investing process relies on current market prices to identify differences in expected returns across securities. They apply discretion regarding type I and type II errors when deciding what premiums to pursue. Dimensional applies expertise when designing multifactor portfolios to target premiums unavailable to index managers that they determine are worthwhile. This is all done managing the tradeoffs for making purchases or sales due to cash flows that arise as prices move every day—all done with an eye toward reducing execution costs.

Professional Financial places enormous trust in Dimensional's ability to exercise good judgment with their models. Dimensional has earned and retained our trust by making decisions for 35 years based on solid economic rationale and robust empirical research. For a client to place trust in Dimensional is to place trust in market prices and in the collective wisdom of thousands of market participants. It is to place trust in robust research that is well accepted throughout the academic community. Unlike the blind trust that is required of an opaque stock picker or quant manager, Dimensional earn your trust daily through disciplined strategies, research and implementation.

"The Earth is Round," Investing, and Abstraction

Consider the shape of the earth. One model describes the earth as a round sphere. While this is a fair approximation, it is not completely accurate. In reality, the earth is an imperfect oblate spheroid—fatter at the equator and more squashed at the poles than a perfect sphere. Additionally, the surface of the planet is varied and ripples extensively: There are mountains, rivers, plains, valleys as well as seas and oceans—it is not perfectly smooth. So how should we judge the elementary model of "the earth is round"?

For a parent teaching their child about the solar system or for a manufacturer of globes, assuming the earth is a perfect sphere is a good application of that model. For a geologist studying sea levels or NASA engineers launching an object into space, it would be a poor model. The difference lies in who is the particular user of the model and what is the specific application of that model by the user.

Likewise, investors should pay attention to how a model will inform their real-world financial planning strategies. The efficient market hypothesis (EMH) is a useful model stating that asset prices reflect all available information.[13]

The EMH model informs investors that they can rely on market prices, so that trying find a manager able to actively outguess prices set collectively by millions of market participants is not worth the effort. Yet when applying that model to actual investing to bridge the gap between theory and practice, several nuances must be understood. For example, even if prices quickly reflect information, EMH does not protect investors from the ill effects of unlucky timing. High trading costs and trading with asymmetric information or illiquidity issues are other significant issues. And working with advisors having substantial conflicts of interest can lead to poor or at least worse outcomes.

So how should investors approach using financial models once aware of their limitations and the need for trust in their application? When evaluating investing methodologies, understand a manager's ability to test and implement applications garnered from their models. Further, when engaging a wealth management consultant, understand that advisor's level of knowledge and their ability to make judgments about the financial planning models they use. While the transparency of conventional index funds requires only a low level of trust for an advisor because evaluating how their model is managed is simple, very few models have such simplicity. As we observed before,

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Exhibit 4: THREE ESSENTIAL PORTFOLIO STRUCTURE DECISIONS

Capital Market Allocation Equity/Fixed Income Separation	**Geographic Allocation for each Asset Class by Region** US/International/Emerging Market	**Dimensions of Expected Return for each Asset Class by Region** Size/Value/Profit and Term/Credit

Considerations

- **Tolerance for volatility**
  Lower tolerance for volatility may require smaller equity allocation.

- **Human capital**
  Higher present value of future earnings (e.g., younger investor) may enable greater equity allocation.

- **Social insurance benefits**
  Social Security, Medicare, government and/or private pensions and insurance may enable greater equity allocation.
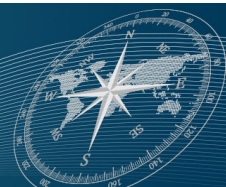
Considerations

- **Home country bias**
  Dividend tax credits on domestic dividends and withholding taxes on foreign dividends may encourage higher domestic allocation.

- **Prevailing term and credit spreads**
  Concentrating in countries with greater term or credit spreads vs. global diversification.

Considerations

- **Risk preferences**
  Increased exposure to dimensions of higher expected return may increase risk but may not increase volatility.

- **Tracking difference sensitivity**
  Increased exposure to dimensions of higher expected return may result in periods of underperformance relative to the market.

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for opaque complex quantitative strategies, the requisite level of trust required for an advisor is much higher, and for stock pickers making market bets, the required level of trust is higher still. For investors employing so-called "hedge fund" managers, the required level of trust is enormous and in most cases, unjustified. Investors must learn how to select trusted professional specialists with the expertise and ability to abstract from models for wealth management.

Exhibit 4 summarizes three steps of a portfolio structuring decision process for informed investment planning. In our opinion, investors whose consultants model with multi-dimensional portfolio strategies should forget "optimal" asset allocations and instead focus on "sensible" asset allocations for structuring comprehensive portfolio positions. Optimizers have no place in planning except as an educational tool.

Conclusion: The Best Advice

To quote Professor Merton again, successful use of a model is "10% inspiration and 90% perspiration." In other words, having a good idea is only the starting point. The gap between theory and practice is bridged only by meticulously developed methods that cost-effectively capture the returns which global capital markets have to offer. And we have trusted Dimensional for almost twenty years to provide investment strategies for our clients that we are confident will maintain secure lifestyles, providing the retirement income they need through the years they planned.

Investment models designed from financial science that employ sound judgment and thoughtful implementation but don't blindly following a model are far more likely to have outcomes consistent with successful retirement planning. By working closely with a firm having decades of proven experience putting financial research into practice, one that has successfully executed an approach balancing transparency with a value-added model year after year, clients committing to their investment policy model should experience great peace of mind and confidence for the future.

The "Father of Modern Finance" and Nobel laurate Professor Eugene Fama once spoke in a CNN/Money interview about "the best advice I ever got." He recalled how the subject of finance was not yet an economic discipline when he was a PhD student in 1960 at the University of Chicago. Financial models did not exist. Fama described how the professor from his first statistics class taught him both an attitude and a philosophy, not only about statistics and models, but about the very discipline of learning.

With formal statistics, the professor told him, you merely test a theory or hypothesis, whether it is true or false. But the professor taught that the true goal "should be not whether you can reject or accept the hypothesis, but what you can learn from the data. The one thing you can do is use the data to enhance your description of the world. That has been the guiding light of my research. You should use the data to understand. . . . No model is ever strictly true. The real criterion should be: Do I know more [about the world] . . . when I'm finished than when I started?"

Every family must make informed decisions using the right models with regard to achieving their hopes, goals and dreams. We believe the most important wealth management decision is not about learning—because no one can ever learn enough—but it is deciding, who can you trust? Who has the education, expertise and judgement to ask the right questions you don't know to ask? A trusted Certified Financial Planner professional with an integrative wealth management process can guide you and your family step-by-step, and also advise on mitigating taxes, passing wealth to heirs, protecting assets from unjust loss, making a charitable impact, and so much more. You can never know all there is, but you can know enough to make informed planning decisions for enjoying a great retirement.

Endnotes:

1 For those interested in such arcane matters, the database for this model being in 2003, completely excluding the tech bust years or the preceding tech boom years. For evaluating the model's reliability, Morningstar should test it over a longer time period. But Morningstar's goal is to promote services, not to advance financial science.

2 See Robert Novy-Marx, "Pseudo-Predictability in Conditional Asset Pricing Tests," NBER Working Paper 18063 (2012). "Explaining Anomaly Performance with Politics, the Weather, Global Warming, Sunspots, and the Stars" presented at Dimensional Funds Advisors Global Conference (September 2014).

3 To view the full Dimensional Fund Advisor interview of Robert Merton with David Booth, please click this link: Models Interview.

4 Kurt Friedrich Gödel's "incompleteness" theorems of mathematical logic demonstrate the impossibility of proving everything using mathematics.

5. Harry Markowitz, *Portfolio Selection: Efficient Diversification of Investments* (1953) following his ground-breaking 1952 article.

6 For the purposes of Professional Financial asset class models, they are built on Fama-French multifactor expected return estimations of U.S. historical data, assuming the default inflation rate figure of 2.5% used in the Money Guide Pro system and adding those premiums on top of estimated fixed income and then rounded to the nearest whole percent. The results were found to be similar to the historical returns of our Dimensional live return model for the last twenty years. We assume that expected returns of comparable non-U.S. asset classes will be similar, and add another 1% for non-growth emerging market asset classes. The system comes with a default set of return assumptions provided based on the older CAPM which was useless for clients holding Dimensional multifactor strategies.

7. Perversely, Fama inadvertently discovered this anomaly while attempting to use the old CAPM to support his Efficient Markets Hypothesis.

8 Eugene F. Fama and Kenneth R. French, "The Cross Section of Expected Stock Returns," *Journal of Finance* 47, no. 2 (June 1992): 427–465. See also "Common Risk Factors in the Returns of Stocks and Bonds," *Journal of Financial Economics* 33, no. 1 (February 1993): 3–56.

9 This section adapted from Marlena Lee, "Models, Uncertainty and the Importance of Trust," Dimensional *Research Matters* (January 2017).

10 The July 2017 issue of ETF Report in their U.S.-listed ETF Data section by asset class lists 640 of $250 million or more in AUM in 79 asset class categories.

11 For example, see Eugene F. Fama and Kenneth French, "Skill vs. Luck in the Cross Section of Mutual Fund Returns" *Journal of Finance* (2010)

12 See *Mutual Fund Landscape*, Dimensional Fund Advisors (2017). Annually updated publication.

13 Nobel laureate Eugene F. Fama of the University of Chicago introduced the Efficient Market Hypothesis model from his PhD thesis fifty years ago in "The Behavior of Stock Market Prices," *Journal of Business* (1966). Provided the most comprehensive study of the statistical properties of stock prices at the time.