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# THE LEVERAGE SPACE TRADING MODEL

## Reconciling Portfolio Management Strategies and Economic Theory

RALPH VINCE

# The Leverage Space Trading Model

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*He that will not apply new remedies must expect new evils; for time is the greatest innovator.*

—Francis Bacon

# Preface

I can explain . . .

This material began as a panoply of notes for a series of talks I gave in late 2007 and in 2008, after the publication of *The Handbook of Portfolio Mathematics*.

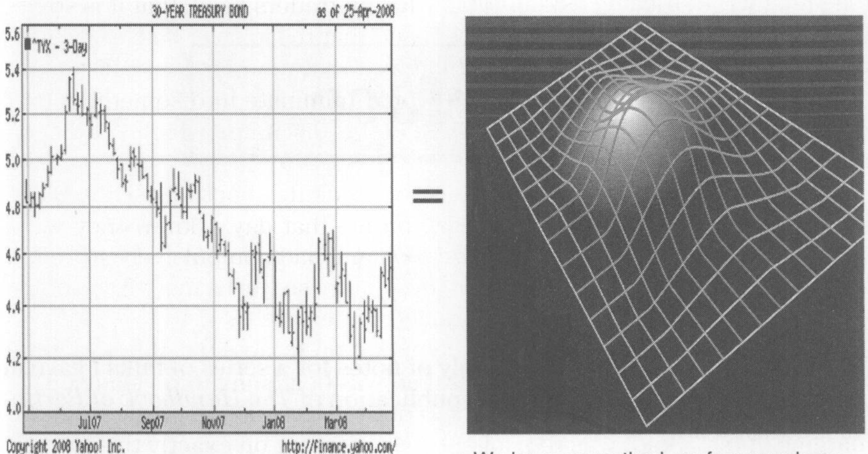
In those talks, I spoke of how there exists a plethora of market analysis, selection and timing techniques including charts and fundamental analysis, trading systems, Elliot waves, and on and on—all sorts of models and methods, technical and otherwise, to assist in timing and selection.

You wouldn't initiate a trade without using the analysis you specialize in, but there is another world, a world of quantity, a world "out there someplace," which has either been dark and unknown or, at best, fraught with heuristics. You will begin to understand this as I show you how those heuristics have evolved and are, very often, just plain wrong. Numerous Nobel Prizes have been awarded based on some of those widely accepted principles. I am referring specifically to the contemporary techniques of combining assets into a portfolio and determining their relative quantities. These widely accepted approaches, however, are wrong and will get you into trouble. I will show you how and why that is. They illuminate nothing, aside from providing the illusion of safety through diversification. In the netherworld of quantity, those flawed techniques still leave us in the dark.

There are still fund managers out there who use those atavistic techniques. They stumble blindly along the dim, twisted pathways of that netherworld. This is akin to trading without your charts, systems, or other analytical tools. Yet most of the world does just that. (See Figure P.1.)

And whether you acknowledge it or not, it *is* at work on you, just as gravity is at work on you.

Pursuing my passion for this material, I found there is an entire *domain* that I have sought to catalogue, regarding quantity, which is just as important as the discipline of timing and selection. This other area is shrouded in darkness and mystery, absent a framework or even a coordinate system. Once I could apply a viable framework, I found this dark netherworld alive with fascinating phenomena and bubbling with geometrical relationships.




We have a plethora of market analysis, selection, and timing techniques, but . . .

We have no method, no framework, no paradigm, for the *equally* important, dark netherworld of position sizing.

**FIGURE P.1** Market Analysis and Position Sizing (Both Equally Necessary)

Most importantly, the effects of our actions regarding quantity decisions were illuminated.

I have encountered numerous frustrations while trying to make this point since the publication of *Portfolio Management Formulas* in 1990: People are lazy. They want a card they can put into a bank machine and get money. Very few want to put forth the mental effort to think, or to endure the necessary psychological pain to think outside of their comfortable, self-imposed boxes. They remain trapped within their suffocating, limited mental notions of how things should operate. Incidentally, I do not claim immunity from this.

When I alluded to quantity as the "other, necessary half" of trading, I was being overly generous, even apologetic about it. After all, some of the members of my audiences were revered market technicians and notable panjandrums. Indeed, I believe that quantity is nearly 100 percent of the matter, not merely half, and I submit that you are perhaps better off to disregard your old means of analysis, timing, and selection altogether.

Yes, I said *100 percent*.

On Saturday, 26 January 2008, I was having lunch in the shadow of Tokyo Tower with Hiroyuki Narita, Takaaki Sera, and Masaki Nagasawa. Hiro stirred the conversation with something I had only marginally had bubbling in my head for the past few years.

He said something, almost in passing, about what he really needed as a trader. It knocked me over. I knew, suddenly, instantly, that what he was (seemingly rhetorically) asking for is what all traders need, that it is something that no one has really addressed, and that the answer has likely been floating in the ether all around us. I knew at that moment that if I thought about this, got my arms around it, it would fulminate into something that would change how I viewed everything in this discipline which I had been obsessed with for decades.

In the following days, I could not stop thinking about this. Those guys in Tokyo didn't have to do a hard sell on me that day. I knew they were right, and that everything I had worked on and had compulsively stored in a corner of my mind for decades was (even more so) just a mere framework upon which to construct what was really needed.

I might have been content to stay holed up in my little fort along the Chagrin River, but an entirely new thread was beginning to reveal itself.

On the flight home, in the darkness of the plane, unable to sleep, in the margins of the book I was reading, I began working on exactly this.

That's where this book is going.

RALPH VINCE<br>
*Selby Library, Sarasota*<br>
*August 2008*

# Contents

# Introduction

This is a storybook, not a textbook. It is the story of ideas that go back roughly three centuries, and how they have, and continue, to change. It is the story of how resources should be combined, when confronted with one or more prospects of uncertain outcome, where the amount of such resources you will have for the next prospect of uncertain outcome is dependent on what occurs with this outcome. In other words, your resources are not replenished from outside.

It is a story that ultimately must answer the question, "What are you looking to accomplish at the end of this process, and *how* do you plan to implement it?" The answer to this question is vitally important because it dictates what kinds of actions we should take. Given the complex and seemingly pathological character of human desires, we are presented with a fascinating puzzle within a story that has some interesting twists and turns, one of which is about to take place.

There are some who might protest, "Some of this was published earlier!" They would certainly be correct. A lot of the material herein presents concepts that I have previously discussed. However, they are necessary parts of the thread of this story and are provided not only for that reason but also in consideration of those readers who are not familiar with these concepts. Those who *are* familiar with the past concepts, peppered throughout Parts I and II of this story, can gloss over them as we build with them in Part III.

As mentioned in the Preface, this material began as a panoply of notes for a series of talks I gave in late 2007 and in 2008 after the publication of *The Handbook of Portfolio Mathematics* (which, in turn, built upon previous things I had written of, along with notes of things pertaining to drawdowns, which I had begun working on in my spare time while at the Abu Dhabi Investment Authority, a first-rate institution consisting of first-rate and generous individuals whom I had the extreme good fortune to be employed by some years ago). I designed those talks to illustrate the concepts in the book, in a manner that made them simpler, more intuitive, essentially devoid of mathematics and, therefore, more easily digestible. I have drawn from those talks and fleshed them out further for this book, with their mathematical derivations and explanations of *how* to perform them. This comprises a good portion of the early sections of this text. This background, at least conceptually, is necessary to understand the new material.

One idea, discussed at length in the past, needs to be discussed before we begin the story. It is the concept of *Mathematical Expectation*. This is called "Expected Value," by some, and it represents what we would expect to make, on average, per play, when faced with a given "prospect"—an outcome we cannot yet know, which may be favorable or not. The concept is introduced in 1657 in a treatise by the Dutch Mathematician and Physicist Christian Huygens, at the prompting of Blaise Pascal.

This value, the Mathematical Expectation (ME), is simply the sum of the products of the probabilities and payoffs of all the ways something might turn out:

$$ME = \sum_{i=1}^{n} (P_i * A_i)$$

where: $P_i$ = the probability associated with the $i^{\text{th}}$ outcome
$A_i$ = the result of the $i^{\text{th}}$ outcome
$n$ = the total number of possible outcomes

For example, assume we toss a coin and if it's heads we win two units and if it's tails we lose one unit. There are two possible outcomes, +2 and −1, each with a probability of 0.5.

An *ME* of 0 is said to be a "fair" gamble. If *ME* is positive, it is said to be a favorable gamble, and if negative, a losing gamble. Note that *in a game with a negative ME (that is, most gambling games), the probability of going broke approaches certainty as you continue to play.*

The equation for Mathematical Expectation, or "expected value," is quite foundational to studying this discipline.

Mathematical Expectation is a cornerstone to our story here. Not only is it a cornerstone to gambling theory, it is also a cornerstone to principles in Game Theory, wherein payoff matrices are often assessed based on Mathematical Expectation, as well as the discipline known as Economic Theory. Repeatedly in Economic Theory we see the notion of Mathematical Expectation transformed by the theory posited. We shall see this in Chapter 6.

However prevalent and persistent the notion of Mathematical Expectation, it must be looked at and used with the lens of a given horizon, a given lifespan. Frequently, viable methods are disregarded by otherwise-intelligent men because they show a negative Mathematical Expectation (and vice versa). This indicates a misunderstanding of the basic concept of Mathematical Expectation.

By way of example, let us assume a given lottery that is played once a week. We will further assume you are going to bet \$1 on this lottery. Let us further assume you are a young man, and you plan to play this for 50 years. Thus, you expect $52 * 50 = 2{,}600$ plays you will be able to make.

Now let's say that this particular lottery has a one-in-two-million chance of winning a \$1 million jackpot (this is for mere illustrative purposes, most lotteries having much lower probabilities of winning. For example, "Powerball," as presently played in the United States, has less than a 1-in-195,000,000 chance of winning its jackpot). Thus we see a negative expectation in our example lottery of:

$$1/2{,}000{,}000 * 1{,}000{,}000 + 1{,}999{,}999/2{,}000{,}000 * -1 = -0.4999995$$

Thus, we expect to lose −\$0.4999995 per week, on average, playing this lottery (and based on this, we would expect to lose over the course of the 50 years we were to play this, $2{,}600 * -0.4999995 = -\$1{,}300$).

Mathematical Expectation, however, is simply the "average," outcome (i.e., it is the mean of this distribution of the ways the future plays might turn out). In the instant case, we are discussing the outcome of 2,600 plays taken from a pool of two million possible plays, allowing for sample and replacement. Thus, the probability of seeing the single winning play in any randomly chosen 2,600 is:

$$1/2{,}000{,}000 * 2{,}600 = .0000005 * 2{,}600 = .0013$$

From this, we can say that $(1 - .0013 = .9987)$ 99.87 percent of the people who play this lottery every week for the next 50 years will lose \$2,600. About 1/8 of 1 percent (.0013) will win \$1 million (thus netting $1{,}000{,}000 - 2{,}600 = \$997{,}400$). Clearly the mode of the distribution of outcomes for these 2,600 plays is to lose \$2,600, even though the mean, as given by the Mathematical Expectation, is to lose \$1,300.

Now, let's reverse things. Suppose now we have one chance in a million of winning \$2 million. Now our Mathematical Expectation is:

$$1/1{,}000{,}000 * 2{,}000{,}000 + 999{,}999/1{,}000{,}000 * -1 = 1.000001$$

A positive expectation. If our sole criteria was to find a positive expectation, you would think we should accept this gamble. However, now the probability of seeing the single winning play in any randomly chosen 2,600 is:

$$1/1{,}000{,}000 * 2{,}600 = .000001 * 2{,}600 = .0026$$

In this positive expectation game, we can expect 99.74 percent of the people who play this over the next 50 years to lose \$2,600. So is this positive expectation game a "good bet?" Is it a bet you would play expecting to make \$1.000001 every week?

To drive home this important point we shall reverse the parameters of this game one more time. Assume a lottery wherein you are given \$1 every week, with a one-in-one-million chance of losing \$2 million. The Mathematical Expectation then is:

$$999,999/1,000,000 * 1 + 1/1,000,000 * -2,000,000 = -1.000001$$

Thus, we expect to lose $-1.000001$ per week, on average, playing this lottery (and based on this, we would expect to lose over the course of the 50 years we were to play this, $2,600 * -1.000001 = -\$2,600$).

Do we thus play this game, accept this proposition, given its negative Mathematical Expectation? Consider the probability that the 2,600 weeks we play this for will see the two million loss:

$$1/1,000,000 * 2,600 = 0.000001 * 2,600 = .0026$$

Thus, we would expect that 99.74 percent ($1 - .0026$) of the people who play this game will never see the \$2 million loss. Instead, they will be given a dollar every week for 2,600 weeks. Thus, about 399 out of every 400 people who play this game will not see the one-in-a-million chance of losing \$2 million over the course of 2,600 plays.

I trace out a path through 3D space not only of the places I go, but on a planet that revolves roughly once every 24 hours, about a heliocentric orbit of a period of roughly 365 1/4 days, in a solar system that is migrating through a galaxy, in a galaxy that is migrating through a universe, which itself is expanding.

Within this universe is an arbitrary-sized chunk of matter, making its own tangled path through 3D space. There is a point in time where my head and this object will attempt to occupy the same location in 3D space. The longer I live, the more certain I will see that moment.

Will I live long enough to see that moment? Likely not. That bet is a sure thing; however, its expectation approaches 1.0 as the length of my life approaches infinity. Do you want to accept that bet?

Clearly, Mathematical Expectation, a cornerstone of gambling theory, of money management as well as Economic Theory, must be utilized with the lens of a given horizon, a given lifespan. Hence the often-overlooked caveat in the definition provided earlier for Mathematical Expectation, "as you continue to play."

Often you will see the variable $N$ throughout. This refers to the number of components in a portfolio, or the number of games played simultaneously. This is not to be confused with the lowercase *n*, which typically herein will refer to the total number of ways something might turn out.

Readers of the previous books will recognize the term "market system," which I have used with ubiquity. This is simply a given approach applied to a given market. Thus, I can be trading the same market with two different approaches, and therefore have two separate market systems. On the other hand, I can be trading a basket of markets with the same system and then have a basket of market systems. Typically, a market system is one component in a portfolio (and the distribution of outcomes of a market system is the same as the distribution of prices of the market comprising it, only transformed by the rules of the system comprising it).

Some of the ideas discussed herein are not employed, nor is there a reason to employ them. Among these ideas is the construction of the mean-variance portfolio model. Readers are referred to other works on these topics, and in the instant case, to Vince (1992).

I want to keep a solitary thread of reasoning running throughout the text, rather than a thread with multiple tentacles, which, ultimately, is redundant to things I have written of previously. Any redundancy in this text is intentional and used for the purpose of creating a clean, solitary thread of reasoning. After all, this is a storybook.

Therefore, some things are not covered herein even though they are necessary in the study of money management. For example, dependency is an integral element in the study of these concepts, and I recommend some of the earlier books I have written on this subject (Vince 1990, 2007) to learn about dependency.

Some other concepts are not covered but could be, even though they are not necessary to the study of money management. One such concept is that of normal probability distribution. As mentioned above, I've tried to keep this book free of earlier material that wasn't in the direct line of reasoning that this book follows. With other material, such as applying the optimal $f$ notion to other probability distributions (because the ideas herein are applicable to non–market-related concepts of geometric growth functions in general), I've tried to maintain a market-specific theme.

Furthermore, some concepts are often viewed as too abstract, and so I am trying to make their applicability empirically related, for instance, by using discrete, empirically derived distributions in lieu of parametric ones pertaining to price (since, as mentioned earlier, the distributions of trading outcomes are merely the distributions of prices themselves, altered by the trading rules). The world we must exist in, down here on the shop floor of planet earth, is so often *not* characterized by normal distributions or systems of linear equations.

One major notion I have tried to weave throughout the text is that of walk-through examples, particularly in Chapters 4, 5, and 7, covering the more involved algorithms. In these portions of the text, I have tried to provide tables replete with variate values at different steps in the calculations, so that the reader can see exactly what needs to be performed and how to do it. I am a programmer by profession, and I have constructed these examples with an eye toward using them to debug attempted implementations of the material.

Where math is presented within the text, I have tried to keep it simple, straightforward, almost conciliatory in tone. I am not trying to razzle-dazzle here; I am not interested in trying to create *Un Cirque du Soleil Mathématique*. Rather, I am seeking as broad an audience for my concepts as possible (hence the presentation via books, as opposed to arcane journals, and where the reader must do more than merely scour a free web page) in as accessible a manner as possible. My audience, I hope, is the person on the commuter train en route home from the financial district in any major city on the planet. I hope that this reader will see and sense, innately, what I will articulate here. If you, Dear Reader, happen to be a member of the world of academia, please keep this in mind and judge me gently.

Often throughout this text the reader may notice that certain mathematical expressions have been left in unsimplified form, particularly certain rational expressions in later chapters. This is by intent so as to facilitate the ability of the reader to "see" innately what is being discussed, and how the equations in question arise. Hence, clarity trumps mathematical elegance here.

Finally, though the math is presented within the text, the reader may elect not to get involved with the mathematics. I have presented the text in a manner of two congruent, simultaneous channels, with math and without. This is, after all, a story about mathematical concepts. The math is included to buttress the concepts discussed but is not necessary to enjoy the story.