STANDARD DEVIATION AND PORTFOLIO RISK
JARGON AND PRACTICE

K.L. Weldon
Department of Statistics and Actuarial Science
Simon Fraser University
Vancouver, Canada. V5A 1S6

1. Portfolio "Risk" - A Jargon Problem

In any academic discipline, jargon is used in an attempt to avoid ambiguity in academic discussions. However, when the jargon is used in everyday life, the everyday meaning of the word will be assumed to apply. This can cause confusion and even bad advice. The example I wish to address is the use of the word "risk" in the context of pension funds. Statistics instructors will be aware of the confusion caused by the jargon terms "significant", "normal", and "error", etc. One that arises in the investment side of actuarial science is "risk". There is a widespread use of the standard deviation of periodic returns as a measure of market risk. However the variability that is measured by the standard deviation is not risk in the laymen's sense, and this is especially true when applied to a defined-contribution (DC) pension portfolio. This failure of terminology has had important effects on accepted practices. We need to include in our courses an awareness in students of both the benefits and the costs of using jargon to explain technical concepts. Moreover, we need to spend some time in our courses helping students relate the jargon terms to the everyday meanings of the words. The example I will discuss in this talk is an example of how everyday use of jargon has caused confusion. The textbooks I have seen do not address this problem.
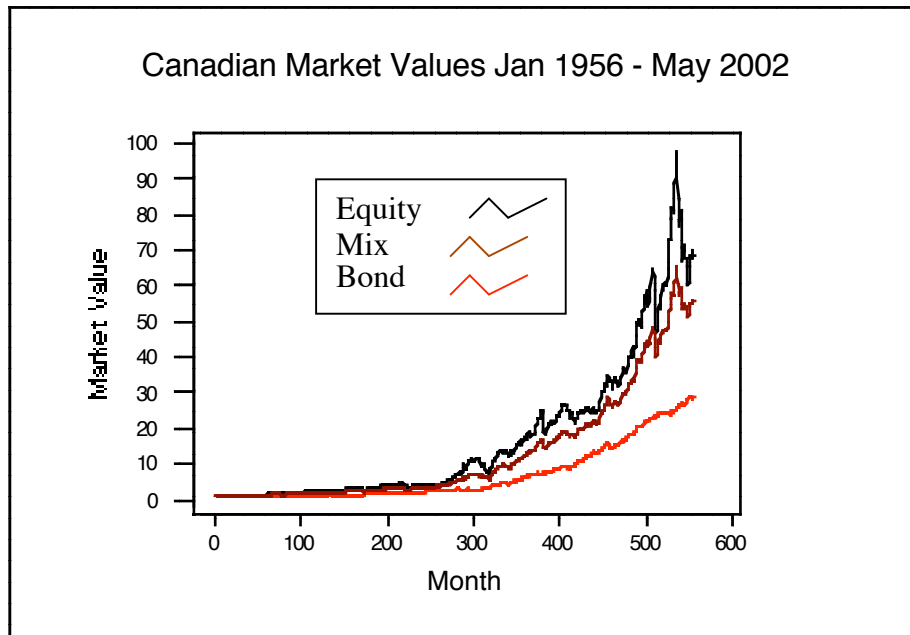

Fig 1: Long term performance of bonds and equities

2. A Bond&Equity Market

To focus on a particular market, consider the Canadian Experience during 1956-2002.
See Fig 1. Performance of equities is shown in black(highest), bonds in red(lowest), and
the mix is 40% bonds and 60% equities. Note the low monthly variability of bonds and
the high monthly variability of equities, and also the low long-term return of bonds, and
the high long-term return of equities.

A very common graph that pension fund managers show to pension fund trustees is
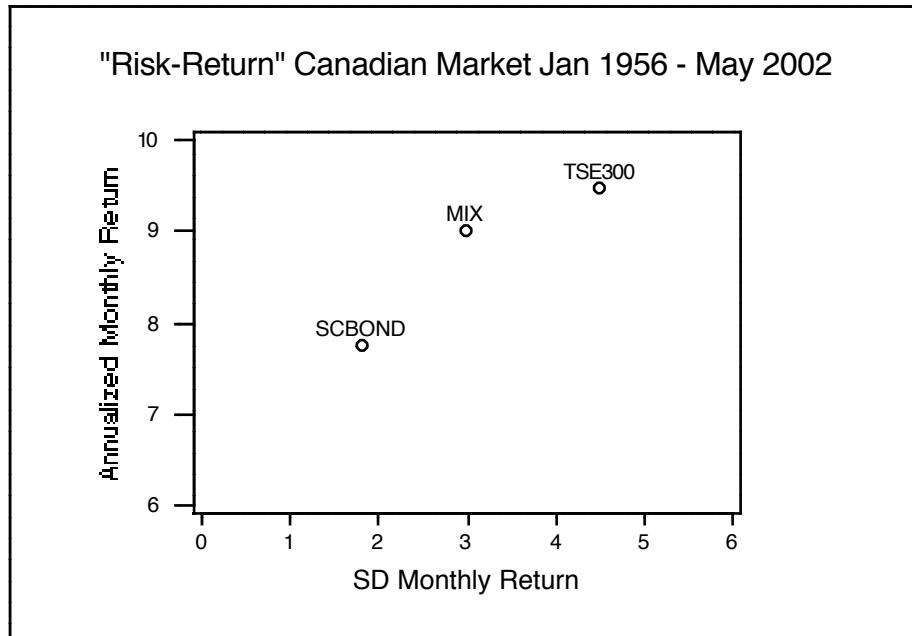illustrated by Fig 2.

Fig 2. Risk-Return for Canadian Market Assets, 1956-2002

"Risk" in this graph is measured by the standard deviation of total monthly returns, while
the Return is just the annualized total return over the period summarized.
Now "risk" to a layman who is considering a portfolio of securities for a pension
investment would involve the chance that the investment considerably under-performs
alternative investments in the long term. This has very little to do with short-term
variability. For example, a portfolio of bonds would almost certainly under-perform a
portfolio of equities over a twenty-five year period, although it would almost certainly
have the lesser short-term variability. Clearly the standard deviation does not measure
"risk" in a way that is meaningful to the pension investor, or even for any long term
investment.

3. Rationale of Risk as Variability

There is nevertheless a good reason why standard deviation is used to measure
risk over the medium term, such as a business cycle. This can be illustrated by using a

random walk model that is calibrated to mimic a broad equity index. Many investors expecting to be in the equity market for a few years would be upset if the market value of their investment were to decline to seventy-five percent of its initial value at any time over a business cycle. We can examine the relationship between day-to-day variability and the chance that the twenty-five percent dip occurs, using simulations. The result is shown in Fig. 3. Each point is based on at least ten simulations of seven years run.
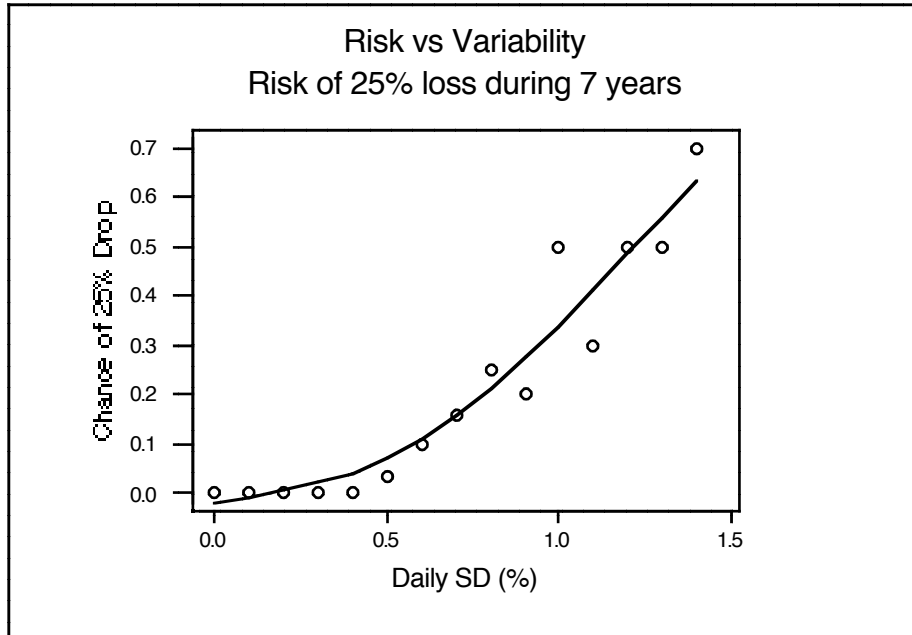

Fig 3: Showing how "risk" does depend on SD

In Fig.3 the day-to-day standard deviation is arranged to be 0.5 percent of the market value, with movement five times as large about one percent of the time. Moreover, the calibration of the random walk provides for an average annual return of ten percent. These features are typical of the large cap equity index used in Canada called the TSE 300 index. To ensure a business cycle is included we use a seven year simulation. A random walk over 7*250=1750 steps, with exponential step size of .5% and a with a daily step-up probability of .54 will mimic this real life process.

Fig 3. confirms that standard deviation does measure, indirectly, the "risk" of a large cap portfolio over a business cycle, even when "risk" is interpreted in a way that would seem natural to the lay investor. But a business cycle is short-term compared to the time horizon of pension investments.

4. Long-term risk

Defined Contribution pension funds are usually the responsibility of a board of trustees, and these trustees may well consider risk in the lay sense, that is, as the chance of long-term under-performance rather than the short-term variability of market value. The trustees will usually employ financial managers to manage portfolios of investments and

report to the trustees periodically. The trustees have the authority to hire and fire managers, and may even have the liability for making bad decisions on this. Managers do not want to report a twenty-five percent loss! In fact, poor performance of a manager over a business cycle, or even a shorter period, may well induce trustees to replace the manager. Medium-term variability is something managers wish to avoid. The manager's income is usually proportional to the amount of assets under management. From the managers point-of-view, standard deviation *does* measure "risk" - too much medium-term variability will result in lost accounts for the manager.

Summing up so far, we have medium-term variability measured by short-term standard deviation, and very relevant to portfolio managers - at the same time, medium-term variability is of no concern to the long term investor, the member of a DC pension plan. Now long-term return is of interest to both the manager and the investor, but it is more critically relevant to the investor. The manager makes more money by achieving modest returns on several portfolios than by achieving superior returns on very few portfolios.

Thus the managers interest is to achieve, in the short and medium term, acceptable returns with very little variability. On the other hand, the pension investor wants long term returns that are as high as possible, and such that the worst return that is likely to occur is still acceptable - medium term variability is not a factor here.
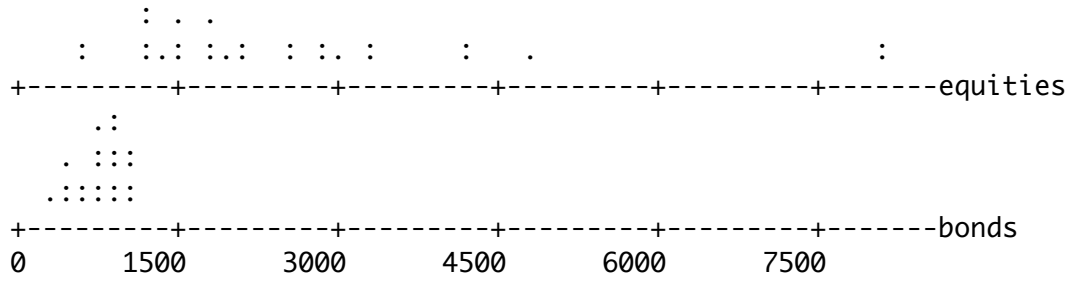
5. Simulating the long-term effect of variability-reduction

Most managers agree that equity portfolios will outperform bond portfolios in the long term. However, the greater variability of the equity portfolio is often considered to be something to avoid, and balanced portfolios with both asset classes included are the norm. One way to study the long term performance of these asset classes is to use a modified random walk model over a long term, such as a thirty-year period. The model assumes a certain average for the percentage change each day, a certain probability that the change will be in the positive direction. These parameters are chosen to produce reasonable expected annual returns for the asset classes. In particular, the models are calibrated as follows:

	Average Annual Rate of Return	Average Day-to-day Percentage change	Step-Up Prob'y
Pure equity portfolio	10%	0.5%	.540
Pure Bond portfolio	7%	0.3%	.547

Assuming the initial market value of either portfolio is $100, the dotplots below (Fig 4.) show the market value after 30 years (250 days per year) of both portfolios.   Each dot summarizes the accumulated market value of one $100 portfolio. (While $100 is too small to hold a diversified portfolio, it may be considered to be one unit of a diversified portfolio.)

Fig 4:   Simulation Outcomes for Long-Term Portfolios

```
                  :  .  .
        :    :.: :.: : :. :      :   .                    :
+---------+---------+---------+---------+---------+-------equities
    .:
  . :::
 .:::::
+---------+---------+---------+---------+---------+-------bonds
0        1500       3000      4500      6000      7500
```

The reader is invited to consider which portfolio is more "risky" as an instrument to provide for a comfortable retirement. (Of course the $100 may be considered a "unit" and a typical investor would accumulate many units, but some would be invested over a shorter time period).   The simulations do produce the expected long run returns: for the median return, 10.5% for equities and 7.1% for bonds; for the mean return, 10.3% and 7.0% respectively.   Figure 5 and 6 show a typical experience of these two portfolios.
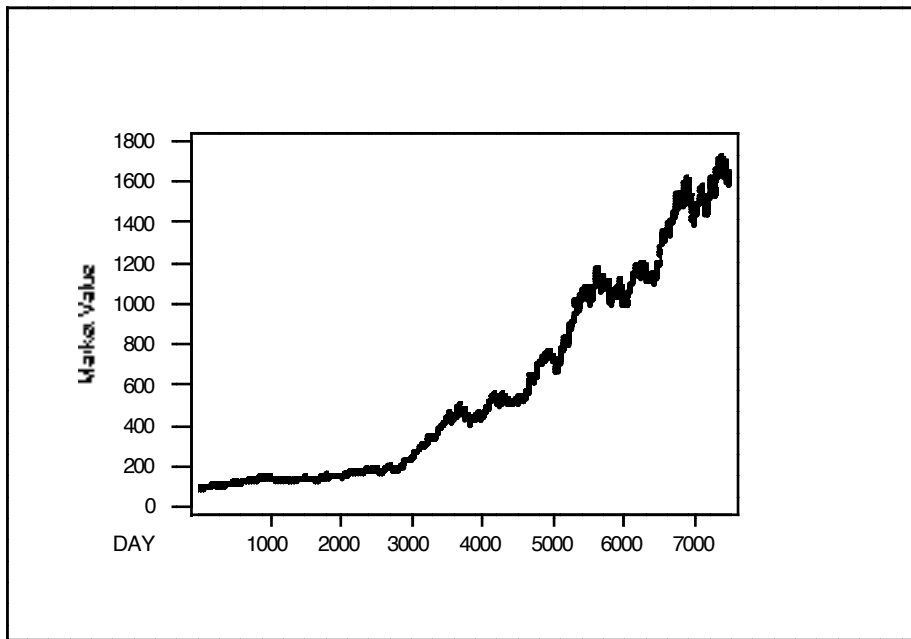

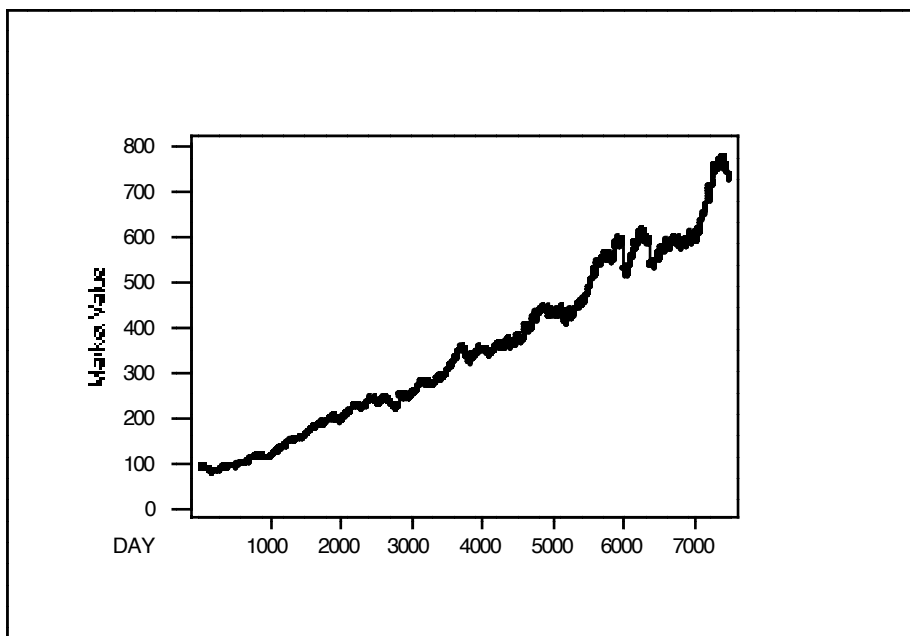Fig 5: Typical thirty-year simulation of an equity portfolio.

Fig. 6 Typical thirty-year simulation of an bond portfolio.

The point of the simulation is not that a small differential in annual return makes a huge difference over thirty years – this is well understood. The point is that bonds are not really *less* risky than equities for a long term investment. The lowest decile of the equity returns is about the same as the highest decile of the bond returns.

These results show that short-term variability that is typical of an equity portfolio is of minor importance to the long-term investor, while the lower return of a bond portfolio does seem to be more important.

Experienced fund managers will say that control of variability of portfolio market value is a feature that investors expect and part of the service they provide. However in the case of pension accumulation funds, the trustees main interest should be to maximize the pension funds available at retirement of pension plan members. Trustees should endeavor to educate pension plan members about the cost of reducing variability.

Many financial advisors recommend diversification of a pension portfolio by asset class – the main effect of this is to include bonds and equities in a "balanced" portfolio. But we can see that this will almost certainly cost the investor heavily during the retirement draw-down. Again, the reduction of variability may be in the interest of the portfolio manager, since it will allow him to keep his naïve clients, but is not a reasonable goal for the investor.

To be fair to the investment industry, I should mention that this particular problem is recognized by a few consultants. A newsletter from the asset consulting group of Towers-Perrin suggests that an investors objectives are much more complicated than

maximizing return for a given level of variability (AlfaBeta: Vol 6, no. 2, July 1997). They state:

"Given that investment return volatility, as measured by the standard deviation of returns, has very little direct relationship to whether investors are able to achieve their objectives, it is surprising that risk/return charts, based on return volatility, continue to be a standard way that pension companies assess risk."

6. Translating Jargon

With this extended example, I have attempted to accomplish three goals:
i) to illustrate the hazard of using jargon in lay circles
ii) to suggest that the lay meanings of jargon words can even confuse the experts
iii) to illustrate i) and ii) in a context of relevance to actuarial scientists

We need jargon to teach concepts without ambiguity. Students will be able to converse within the academic world with precision. But for students to use the jargon-based concepts, they need to communicate them to non-experts. This translation process is as important as understanding the concepts themselves. When we teach jargon-related concepts, we need to simultaneously teach students how to describe these concepts to non-specialists. When we use the word "risk" to describe the attribute of a portfolio that is measured by variability, we need to explain the shortcomings of this interpretation. In particular, we need to discuss in finance classes what "financial risk" might mean to various lay-persons. I would suggest that this is not merely "service course" material - it is needed by the experts too.