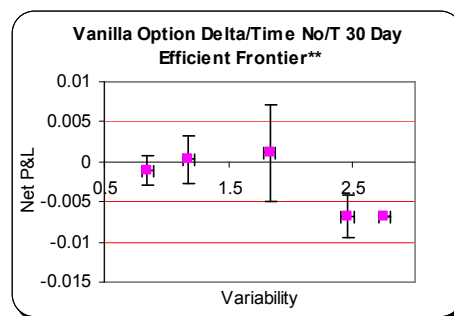


Aside: Comprehensive analysis requires repeating each of simulations many times to determine the “statistical reliability” of the simulations results. Although such deeper analysis is deferred to [2], [8.c], and [14], the image to the right illustrates the results of repeating the above and then plotting also the 1-standard deviation error bars (both y- and x- error bars) to give an idea of the “beginnings” of such “simulation reliability” analysis.



The dynamic results (pink) are (more or less) intuitive compared to the “implications” of BSM. Although there is some variability in the P&L’s, they mostly hover around “0”, implying that for this set of simulations the rebalancing process generated approximately the same amount of income to net out the option’s premium. That is, the results are approximately correct synthetic replication (not quite up to the amount expected equalling the risk-free rate of return, but that is quite small and may be “buried” in the statistical “noise”, see [8.a], or [14]).

The trend in the P&L is downwards with decreasing rebalance frequency. This seems counterintuitive, since “increasing risk should be accompanied by increasing returns” in the real world.

Nevertheless, at this point BSM appears to be somewhat OK’ish, especially for high frequency rebalancing (i.e. in this plot, the higher frequency rebalances are towards the left side), which can be further demonstrated by “statistical” analysis of repeating each of the simulations many times to test for the “simulations P&L variability”, as in [2], [8.a], [8.c], and [14].

### 22.2.5.2 Example 1: Longer Dated

Repeating the simulations for a 180-day (red) and a 360-day (aqua) option with Daily, 2-Day, Weekly<sup>660</sup>, Monthly, and Bi-Monthly calendar rebalances to bring the position Delta flat produces the results in Figure 22.2 – 12.

<sup>660</sup> Again, Weekly in these simulations is “bus day Weekly” of 5-day increments. The actual time steps in the simulation were 1, 5, 30, and 48.

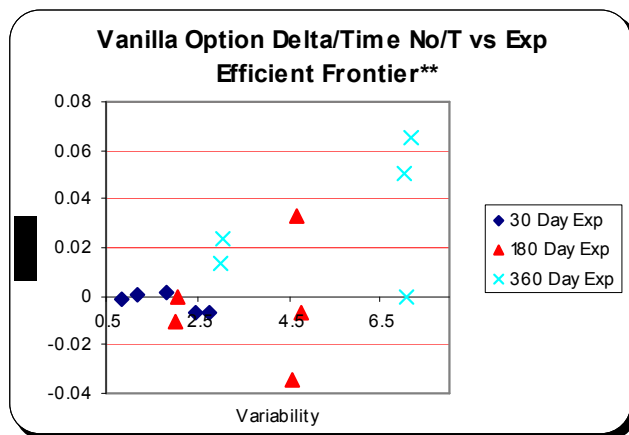


Figure 22.2 – 12. Ave P&L and P&L “width” for four PaR simulation varying rebalances frequencies from Daily, 2-Day, Weekly, Monthly, and Bi-Monthly for a 180 and 360 day option, compared to the 30 day options results.

The longer dated options results have fundamentally different characteristics compared to the short dated case. The most important result is that the character of the longer dated results fails to show any “reasonable” risk/return relationship. In particular, once the rebalance interval exceeds some basic level (e.g. 2-Day), the remaining values are “all over the place”. For example, the three red triangles showing the lower frequency rebalances for the 180-day option have the same P&L variance (around 4.5), but with very different P&L’s, are not all that “risk/return commensurate”.

This is a serious problem for traders, since it now becomes impossible to relate rebalance strategy with risk-adjusted returns.

Aside: Remember that these results are “statistical” and the points have both vertical and horizontal error-bars (not shown). Thus, deeper analysis should be considered to determine if the Monthly is truly off the EF, or just appears to be so due to statistical noise, see above and, [8.c] and [14] for details.

This “departure” from expected/required risk/return trade-off is even more noticeable with the 360-day option (aqua). This is as it should be since the longer the option, the greater the expected variability for any given rebalance strategy. Notice also that the Time Triggered rebalances are “absolute” in that a 1-week rebalance for a 30 day option has different implication (on a relative basis) compared to a 360-day option.

In short, longer dated options and especially anything other than very high frequency rebalancing via Time/Calendar Triggers fails to reproduce BSM even approximately, and worse, has a “disjoint” or “chaotic” risk/return relationship.

This result should be expected, as longer dated options, or options far from expiration will experience P&L swings that are primarily related to swings in the underlying price (i.e.