Quantitative Proprietary Trading

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Chapter 1

Volatility targeting

Chapter 1 is about volatility targeting and about sizing trades for a given risk.

1.1 Unit Risk

The inputs would be a percentage risk tolerance and outputs is simply number of units of the asset to but to obtain that risk. First we define funding risk per unit of instrument as:

$$\sigma_{\mathbb{1},i} = \sigma_{\%,i} X_{t,i} fx_{t,i} \tag{1.1}$$

where:

$\sigma_{\%,i}$ is annual percentage volatility

$X_{t,i}$ is asset price

$fx_{t,i}$ is fx rate from asset price numeraire to funding numeraire example jpy to usd.

Note that estimating the annual percentage volatility can be a separate model on its own but using either ewm std or simple std is typically used. Taking the inverse of Eq. 1.1, we get:

$$\mathbb{N}_{\mathbb{1}} = \frac{1}{\sigma_{\mathbb{1},i}} \tag{1.2}$$

where

$\mathbb{N}_{\mathbb{1}}$ is the number of units to purchase to get \$1 of risk.

1.2 Volatility targeting in a portfolio

The point of documenting this is for figuring out how to trade a proper multi factor portfolio.

1.2.1 Risk Weights

This is how to implement it mechanically:

1. Obtain AUM for the portfolio: $V(t)$

2. Obtain portfolio target volatility: σ_{target} and obtain cash volatility target. This is hard coded. Compute daily cash vol:
$$\sigma_{target,daily} = \sigma_{target} V(t)/16 \tag{1.3}$$

$$\vec{W}_{base,\$} = \vec{w}_{base,i} \sigma_{target,daily} \tag{1.4}$$

3. Now convert to instrument units:

$$\vec{N}_{base} = \vec{W}_{base,\$} \mathbb{N}_{\mathbb{1}} \tag{1.5}$$

4. Finally adjust it using signals. We assume the usual -20 to 20 signal scale:
$$\vec{N}_{\alpha} = \vec{N}_{base} S/20 \tag{1.6}$$

1.2.2 Cash Weights

We can apply the same methodology to cash weights with the simple modification of not requiring to use unit risks.

1. Obtain AUM for the portfolio: $V(t)$
2. We assume we are given handcrafted cash weights: $W_{\%}$
3. We can obtain instrument level cash allocations:

$$W_{\$,i} = W_{\%} V(t) \tag{1.7}$$

4. Now convert to instrument units so that:

$$N_{\%,i} = W_{\$,i}/X_i \tag{1.8}$$

Note that the difference in both protocols comes down to the definition of the risk conversion numeraire. It is $\sigma_{\mathbb{I},i}$ if using risk weights but simply the price: X_t if using cash weights weighting. Trading any portfolio would only require knowledge of the AUM to invest in it. The same also applies for a multifactor portfolio. I would also like to use this to figure out how to trade various rebalancing schedules as a means for diversification.

Chapter 2

Systematic backtesting

Chapter 2 is about the implementation of a generic systematic backtester. Note that at the highest level, the system should basically spit out the trades required for the day. This would be a difference between the target portfolio and the current portfolio. Short of an automated trading strategy, the trader is expected to execute faithfully.

2.1 Data layer

Here's the vectorized data require and that can be precalculated:

$X_i(t)$ $\equiv$ price data at fixed frequency

$\sigma_{\mathbb{I}}$ $\equiv$ is the unit risk, meaning how many units to buy per \$1 of risk, where the funding units is arbitrary.

$fx_i(t)$ $\equiv$ is the fx conversion rate from asset price numeraire to funding numeraire example JPY to USD.

$\Delta PL_i(t) \equiv (X_i(t+1) - X_i(t))$ is the daily PL in [DOM] units for longing one unit of i

$\Delta PL_{i,\$}(t) \equiv \Delta PL_i(t) fx_i(t)$ is the daily PL in [\$] units for longing one unit of i

$\Delta PL_{i,C}(t) \equiv (r_{FOR} - r_{DOM})\,\delta t$ is the carry earned for longing one unit of i

$\delta\vec{X}(t) \equiv \vec{X}^{bid}(t) - \vec{X}^{ask}(t)$ is the bid ask spread for the portfolio per unit asset traded]

$\Delta\vec{P}L_{tcost}(t) = \vec{N}_{rebalance}(t) \circ \delta\vec{X}(t)/2 \circ \vec{fx}(t)$.

2.2 Portfolio backtest

Assuming we had a time series of target inventory: $\vec{N}(t)$, then we can compute the daily PL of the portfolio without transaction costs:

$$\Delta\vec{P}L(t) = \vec{N}(t-1) \circ \Delta P\vec{L}(t) \tag{2.1}$$

and the portfolio PL is simply given by:

$$\Delta PL(t) = \Delta\vec{P}L(t) \circ \vec{\mathbb{I}} \tag{2.2}$$

If we wish to include transaction costs, we need to assume rebalance flow.

$$\vec{N}_{rebalance}(t) = N(t\vec{-}1) - N\vec{(}t). \tag{2.3}$$

then the rebalance transaction cost can be estimated as:

$$\Delta\vec{P}L_{tcost}(t) = \vec{N}_{rebalance}(t) \circ \delta\vec{X}(t)/2 \circ \vec{fx}(t). \tag{2.4}$$

The full daily PL is then given by:

$$\Delta\vec{P}L_{tcost}(t) = \vec{N}_{rebalance}(t) \circ \delta\vec{X}(t)/2 \circ \vec{fx}(t). \tag{2.5}$$