# What Quants Want

I was at a meeting recently and got into a discussion about the difference between execution (flow) signals and signals that drive a CTA's positions. Even though both are busy predicting next period's prices, in many CTAs, the two are viewed as distinct and the execution research department may be running completely separately from the "main" research team. The joy of a smaller CTA is that you must handle all signals: the very fast and the very slow. This led me to thinking about the interaction between the two and the way we combine them.

This blog is going to take a simple example of two signals ("trend" and "flow") and show you how a quant's mind works and our thought process as we put these two signals together.

## Combining two alpha signals.

If you have two signals, A and B, your default, and safest, allocation method is a linear combination: $C = \alpha A + \beta B$. The optimal ratio between the two predictors' weights relate to each predictor's residual alpha: if B is simply A with extra noise, there is little value in adding B, but if A and B are uncorrelated, your weight ratio $\alpha:\beta$ reflects the (forward looking) Sharpe ratios you assign to each predictor.

## Nonlinearity creeps in

A linear combination works well: it can be viewed mathematically as a Bayesian aggregation. But modern machine learning approaches tell us that the dependency between two variables can also be non-linear and so not fully captured by correlation: Perhaps when A is large, B has a specific behaviour we need to capture? Carry, for example, is an indicator for inventories. Does trend work better or worse when inventories are tight?

## Design choices

Even if you think the two signals have a simple linear correlation structure, you may choose to aggregate them non-linearly because you may have a strong preference for one signal over the other: if you are a CTA, you may be reluctant to actually allocate to a signal other than trend. How can you use a secondary flow signal in a way that improves your trend's dynamics without "straying" too much from your primary signal?

Let us set out our minimum design requirements:
The combined signal will never trade against trend: if trend is positive, we cannot be short!
The additional risk, combined less trend, will always be in the same direction as flow
Our combined dynamics need to "help" trend when it goes against flow

## Identifying your primary signal's weak points

The last requirement is quite vague, so we start by identifying trend's weakness: small oscillations before a strong trend forms. Once there is a decent trend (say size 1), we tend to make good money but oftentimes, trend will oscillate between 0.2 to -0.3 and back to 0.4 and then to -0.1. These whipsaws are part and parcel of trend, but they are also expensive to trade, especially if trading costs are an issue (did anyone mention "Alternative markets"?)

We will be aiming to use flow to confirm trend and dampen those whipsaws and perhaps reduce our trading costs. As we shall see later, this can lead to some unintended consequences.

## Agree to disagree

The simplest non-linear approach for the combined signal is to:

- use trend if sign(trend)=sign(flow)
- use 0 if they disagree

```
def agree_to_disagee(trend, flow):
    combined = trend.copy()
    disagree = sign(trend)!=sign(flow)
    combined[disagree] = 0
    return combined
```

You can easily verify that the combined signal satisfies the first two conditions. How about the third condition? If flow was +1 and trend was whipsawing, we get this beautiful behaviour: flow cuts trend's downward oscillations!

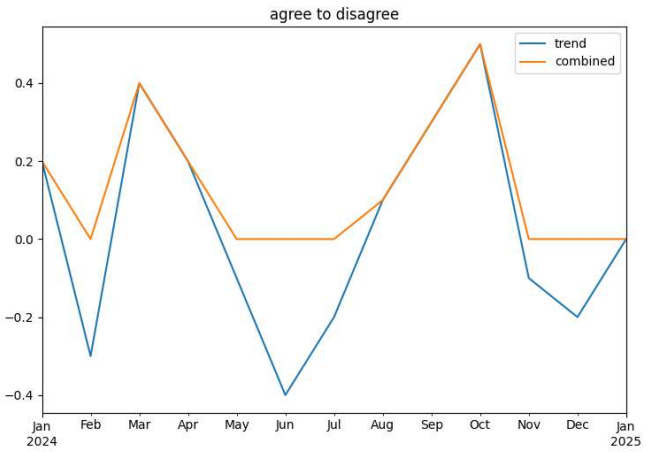


*Figure 1: If flow is positive, and the original trend goes negative, the combined signal simply "skips" these excursions*

## Are we there yet?

Not by a long way! If you spend a few nanoseconds thinking about the above algorithm you will realize this implementation is plain silly, no self-respecting quant would ever possibly consider it. The problem is our dependency on sign(flow) rather than actual flow. This means that if flow is +0.1 instead of +1, we would still get the same output. More importantly, the signal is discontinuous when flow itself crosses from +0.1 to -0.1. This is what the signal looks like if trend is +1 and flow oscillates:

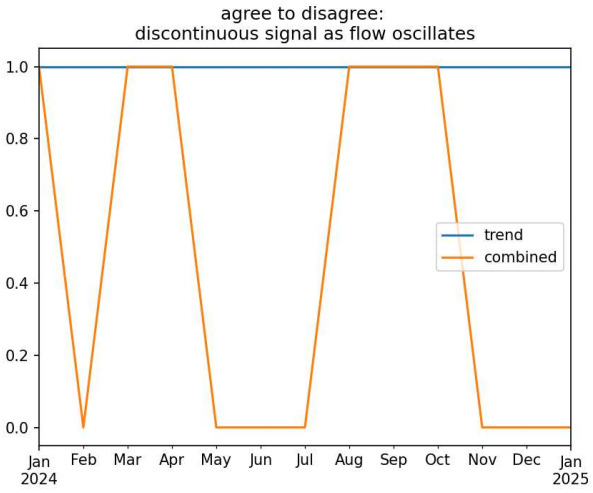


*Figure 2: If flow is near zero, the combined signal becomes discontinuous*

## Agree to slightly disagree

Our second attempt takes both these issues to heart: we use the *level* of flow to decide how much trend we can undo:

```
def agree_to_slightly_disagree(trend, flow):
    combined = trend.copy()
    disagree = sign(trend)!=sign(flow)
    combined[disagree] = 0
    together = trend + flow
    disagree_but_strong_trend = minimum(sign(trend) == sign(together), disagree)
    combined[disagree_but_strong_trend] = together[disagree_but_strong_trend]
    return combined
```

In effect, we created a “dead zone” around the origin, the size of the flow predictor.

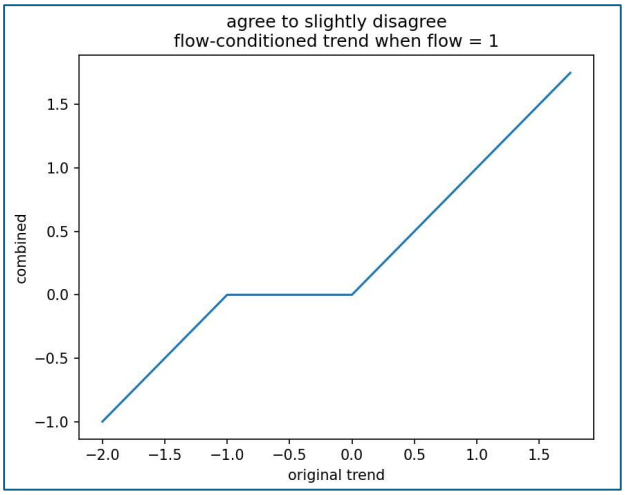


*Figure 3: The flow "dead zone": If flow is positive, we avoid opening a trend position in the opposite direction until trend's magnitude exceeds flow magnitude. As flow declines, the dead zone disappears, in a continuous fashion.*

When trend is only -0.2 while flow is +1, we avoid trading. If trend exceeds -1, we start putting on a negative position. We still satisfy all three design choice conditions, but in addition, as flow waxes and wanes, that dead-zones widens and narrows, so our new signal is continuous in both flow and trend. We can even check it does the "right thing" when trend oscillates:

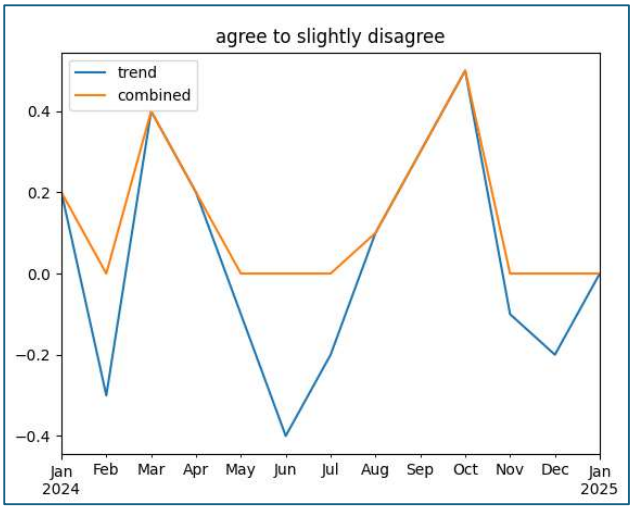


*Figure 4: If flow is positive and strong, we will "skip" trend's small negative excursions*

## One tiny little niggling problem…

We can now plug the solution into a simulated trend signal and see the impact of a time-varying flow on a time varying trend signal:

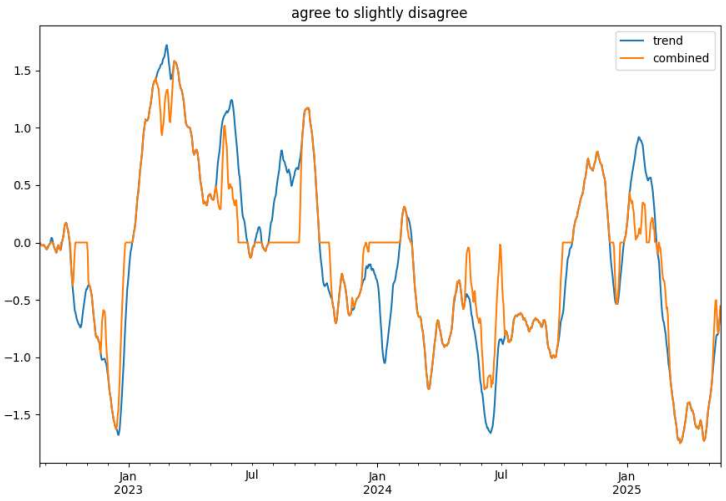


*Figure 5: A simulated impact of flow on a trend signal using the "dead zone". We see that the combined signal is always smaller in magnitude than the original signal.*

The conditioned signal does not look too bad but there is a problem lurking in the shadows: our method always uses flow to *reduce* risk. This means that although our trading has reduced, so has our overall risk. In fact, the turnover (trading per unit risk) has increased!

Sometimes trading more aggressively is warranted, especially if we are adding a new source of alpha. But regardless of alpha, I would be very reluctant to implement a solution that goes completely against our design aim!

## Is all hope lost?

Of course not. The trick is to realize that we can use flow to avoid opening up positions, but we can also use flow to avoid closing them! I am not going to include the code for this one, there is such thing as oversharing, but here is the new code in action:

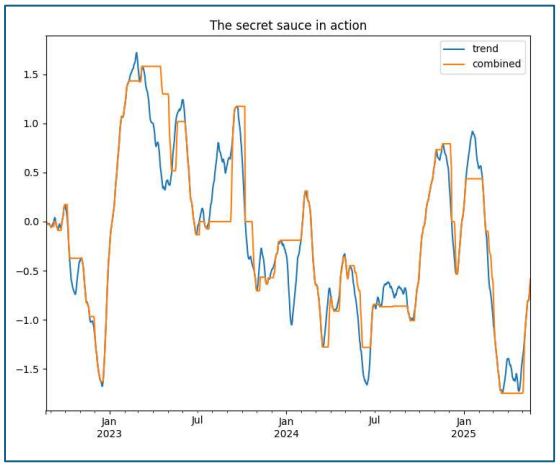


*Figure 6: The impact of using flow to avoid closing trades as well avoiding opening them. In the (simulated!) chart below, in March 2023 the flow signal prevented us from closing a trade until June. Again, in November 2023, it prevented us from closing a trade until late December. Conversely, In July/August 2023 and in Jan 2024 it prevented us from opening a trade.*

The new combination of flow and trend satisfies all three design conditions: it trades always in the direction of trend, any additional risk is always in the direction of flow, and it does help dampen trend whipsaws.

## Are we there yet?

There is plenty more to do. Specifically, I haven't even considered any properties of the new combined signal's P&L! Does performance increase? Does cost decrease? What about skew? Or the correlation between my multiple markets? But does performance matter? I very much like that my combined signal behaves mechanically over time in a way that makes sense to me: it gives me exposure to both signals and it allows me to avoid trend whipsaws while trading in a sensible fashion. I value performance but to me, performance is secondary to sanity.

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