Moving Averages, CrossOvers and the MACD

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Introduction: Moving averages are the most widely used indicators in technical analysis, and help smoothing out short-term fluctuations (or volatility) in order to highlight a longer-term trend. Traders classically use the past daily (or intraday) prices to compute their time series, applying different variations of moving averages. We are going to look at the two popular ones: the Simple and Exponential Moving Averages.

1 Simple Moving Average (SMA)

The SMA is an arithmetic moving average that is calculated usually taking the closing prices p_t as a time series. It has only one parameter n, which is the number of periods, and is computed as the following:

$$SMA_t = \frac{1}{n} \sum_{i=0}^{n-1} p_{t-i} \tag{1}$$

You can implement a basic trading strategy where you would go long if current spot rate of a currency pair is above its SMA and short if it is below. However, I don't trade on those signals, and I prefer to look at the SMA lines as resistance or support in order to set up my entry levels, stops and exit levels. For instance, the *popular* SMA is the 200-day moving average. Figure 1 shows the daily USD/EUR spot rates over the past 2 years with its 200-day SMA in red. I highlighted a few moments when we saw a technical *rebound* after the currency pair was flirting with its long-term moving average. These opportunities can be interesting for a ST intraday trader who assumes that currency pairs usually experience a short-term consolidation when they *hit* their 200 SMA.

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Figure 1: USD/EUR spot rate and the 200-day SMA

2 Exponential Moving Average (EMA)

In contrast to a simple moving average, the EMA adds more weight to the latest data and therefore reacts faster to price changes. The EMA has one parameter (number of periods n) and is computed in two steps. There are different ways of computing the EMA, but here are the calculations I used in my Excel file. The general formulation of the EMA is expressed as the following:

$$EMA_t = p_t * multiplier + EMA_{t-1} * (1 - multiplier) \qquad (2)$$

where p_t corresponds to the [closing] price observed at time t and *multiplier* (we called it Smoothing Constant in our VBA macro) is the weighting multiplier, which is computed as the following:

$$multiplier = \frac{2}{n+1} \qquad (3)$$

As we can notice in equation (2), the EMA computation at time t depends on the EMA value at time *t-1*, hence the question that we should ask immediately is: "How do we compute the first term EMA_0"?
Again, there are several ways to solve this, for instance some people set the first term at zero ($EMA_0 = 0$), but I just take the previous [closing] price to compute the first term instead of the previous EMA:

$$EMA_0 = p_t * multiplier + \mathbf{p}_{t-1} * (1 - multiplier)(4)$$

We now have all the elements to compute some trend-following strategies using those moving averages. The first popular one is called CrossOvers, and use two moving averages (simple, exponential or mixed) to set up the signals. The second is the MACD (Moving Average Convergence Divergence) oscillator, developed in the late 1970s by Gerald Appel, which uses a combination of EMA.

3 Crossovers

In this strategy, traders build a trading signal based on moving average crossovers, by taking a long position if the shorter (faster) moving average is above the longer (slower) moving average, and a short position if the shorter moving average is below the longer moving average. In equities, the famous terms 'Golden Cross' and 'Death Cross' result from crossovers of the 50 SMA and the 200 SMA. As you can imagine, 'Death Cross' is when the 50 SMA crosses the 200 SMA to the downside, signaling a potential long-term bear market.

In the FX market, we know that momentum strategies work using short-term developments, hence the popular crossovers are the 5 and 20 (day) SMA or EMA. If we apply the 5-20 EMA crossover strategy to the USD/AUD using daily spot rates from August 4th 2015 to July 3rd 2017, we get a Sharpe ratio of 1.45, much higher than the 0.23 of (just) being long USD/AUD:

Table 1: Annualized Perf. and Ratios for EMA(5,20)

Perf.	Benchmark	L/S Portfolio
Excess ret. (%)	2.39	14.72
Volatility (%)	10.48	10.17
SR	0.23	**1.45**

The equity curve also looks interesting (Figure 2); even though the Aussie Dollar has been trading within a 10-cent range against the greenback over the past couple of years (AUDUSD trading between $0.70 and $0.80), the EMA(5,20) managed to *capture* short-term developments, especially for the past year.
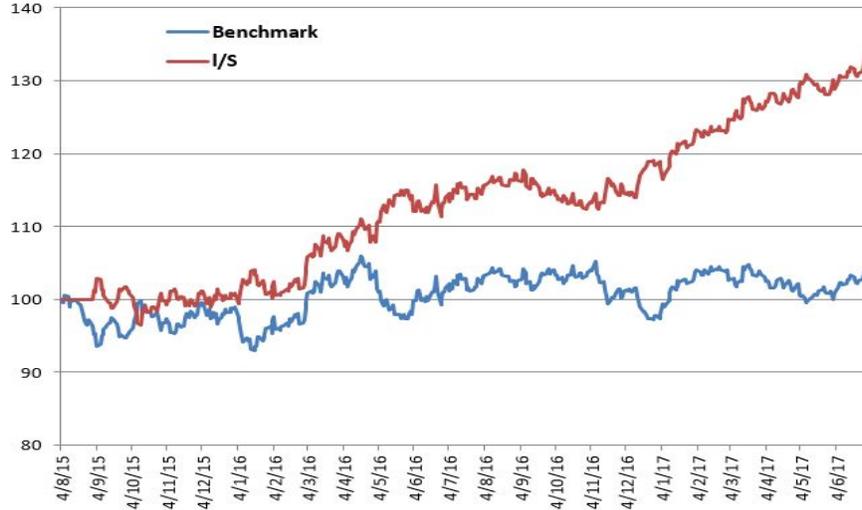
Figure 2: L/S Portfolio using EMA(5,20) as signal

4 MACD: Moving Average Convergence Divergence

Different trading signals can be built from the MACD, but the main trading strategy is to capture short-term momentum in periods of *volatile* markets (The MACD should not be used in ranging markets). The traditional MACD is computed in two steps using exponential moving averages. First, we compute the difference between the fast (12 periods) and slow (26 periods) EMA of the [closing] prices:

$$MACD_t(12, 26) = EMA_t(12) - EMA_t(26) \tag{5}$$

Then, we compute the signal line by taking the 9-day EMA of the MACD:

$$Signal_t = EMA(9, MACD_t) \tag{6}$$

One basic signal that we can built using the data we have is to look at the MACD Histogram (Also called the MACD Forest), which is the difference between the MACD Line and the Signal Line:

$$MACDForest_t = MACD_t(12, 26) - Signal_t \tag{7}$$

The strategy then consist in taking a long position when the MACD Forest is positive, and a short position when the MACD Forest is negative. The MACD Forest (of USD/AUD) is represented in green (histograms) in the sub-chart of Figure 3.

Figure 3: USD/AUD and the MACD Forest

As you can see, if the MACD Forest is oscillating around zero (red line in Figure 3), the volalitity on the currency pair USD/AUD is low and therefore the signals are unreliable. In addition, if we backtest the strategy in our Excel File, we can see that the returns are pretty poor (3.69% annualized) for a Sharpe ratio of 0.37.

Therefore, a more *profitable* strategy using the MACD trading signal consist in looking at large swings in the MACD and Signal lines. In that case, we are going to look at the MACD and Signal lines instead of the MACD Forest. Figure 4 represents the USD/AUD on the top chart and the MACD and Signal Lines on the botom chart. We used green arrows for entry levels (i.e. long position) and red arrows for exit levels (i.e. liquidate our long position). The orange line (of the sub-chart) represents the MACD line and the blue line the Signal line. As you can see, we take a long position if the MACD line crosses the Signal line to the upside if and only if the two lines are diverging far below the zero horizontal line. In the other hand, there are two different ways of exiting the trade: the first one is if the MACD Line crosses the Signal line to the downside if the two lines are [well] above the zero line, or the second one is if the MACD and Signal lines start to trade around the zero line (the one that I circled on Figure 4).
IF the two lines are oscillating around the zero line, it means that the volatility is low and that you should get out of the trade for the moment and potentially do some range trading.
This strategy is more discretionary and relies on the conviction of each specific trader, hence I did not *program* it in the excel file.

Figure 4: USD/AUD and the MACD *Swing* Lines