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Article

AdTurtle: An Advanced Turtle Trading System

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Abstract: For this research, we implemented a trading system based on the Turtle rules and examined its efficiency when trading selected assets from the Forex, Metals, Commodities, Energy and Cryptocurrency Markets using historical data. Afterwards, we enhanced our Turtle-based trading system with additional conditions for opening a new position. Specifically, we added an exclusion zone based on the ATR indicator, in order to have controlled conditions for opening a new position after a stop loss signal was triggered. Thus, AdTurtle was developed, a Turtle trading system with advanced algorithms of opening and closing positions. To the best of our knowledge, for the first time this variation of the Turtle trading system has been developed and examined.

Keywords: algorithmic trading; Stop Loss; Turtle; ATR

1. Introduction

Thanks to advances in technology, automated trading systems have become a tool frequently employed by institutional investors as well as individual day traders. In this research, we implemented such an automated trading system based on the Turtle trading strategy, and examined its behavior with exclusion barriers added to the Turtle's stop loss strategy in order to prevent a new position from opening right after a stop loss signal was triggered.

Every trade executed in a market carries an inherent risk of the price of the asset moving in a direction which is the opposite of the originally anticipated one, and that could result in substantial losses. To mitigate this risk, various stop loss strategies have been introduced and examined over the years. In this paper, we are examining the efficiency of sliding* and variable* stop loss strategies combined with exclusion barriers based on the ATR indicator, which is a measure of volatility of an asset's price, added to the automated trading system described above.

* Sliding: the stop loss barrier slides in the same direction as the price moves to more profitable levels.

* Variable: the width of the stop loss zone adjusts using the latest ATR value.

2. Materials and Methods

2.1. Related Work and Background

Systems based on Donchian channels were examined—without parameter optimization—by (Beyoglu and Ivanov 2008), who delved—among other things—into two simple strategies based on the Donchian channels breakthroughs. The first with a 20-day period and the second with a 55-day period were implemented on stocks picked using the CAN SLIM method. They found that these strategies yielded moderate results, but also had small drawdowns, with the 20-day period securing higher profits, but also bigger drawdowns, than the 55-day period. (Jackson 2006) also used two systems based on the Donchian channels, with a wide range of periods, to examine through statistical methods whether technical analysis systems in general can yield profits when trading on bond markets. He found technical analysis to be a profitable tool to use when trading bond futures.

Donchian channels have also been used instead of other indicators as inputs in machine-operated learning systems used in trading, as it was done by (Fletcher et al. 2010). They used, among other things, the highest and lowest prices of various periods as inputs to a multiple kernel learning model and found them to be highly relevant when making predictions regarding the EURUSD exchange rate, provided they were used in combination with other indicators. (Chandrinou and Lagaros 2018) developed a Donchian channel breakout strategy on renko diagrams instead of price diagrams for Forex pairs, with parameters optimized over a 4-year period. The results of the optimized systems over a following 7-year period were extremely positive and promising, and the authors made the most of the systems in a following which involved producing forex portfolios.

The ATR indicator has also been used as input in machine-operated learning systems for trading, as was done by (Ghosh and Purkayastha 2017), who concluded that the Xg boost model outperforms the Support Vector Machine and Random Forest models in predicting the possibility of profit for a stock in the National Stock Exchange in India. (Vanstone and Finnie 2006) also utilized the ATR indicator in order to prove that artificial neural networks can be trained on the basis of technical indicators to identify stocks whose price will potentially rise significantly.

The ATR indicator has also been used in stop loss strategies. (Wilcox and Crittenden 2005) examined a strategy that entailed buying a stock at an all-time high, which we could argue is a form of a Donchian channel with a very high period, and using ATR to calculate exit price levels for selling it. These stop loss levels follow the price as it moves upwards after the long position has been opened. They prove that a $(-10 \times \text{ATR})$ stop loss level generates favorable results on average and that, in general, trend following on stocks does have positive results and can be used as a building block for a trading strategy. (Gilligan 2009) used a similar system on stocks picked by the CAN SLIM method. As an entry point, he employed the breakout from a Donchian high barrier with a period of 20 weeks. Exiting when price becomes lower than a barrier set using some multiple of the ATR value turned out to generate optimal results in comparison with all the other exit strategies examined.

(Levene et al. 2014) have also used ATR to calculate barriers to entry as well as to exit a position, on selected stocks. This system outperformed a gap strategy which was examined and yielded worse results than a trend following system they also examined, but when used in a combined system with the other two, the final result was a robust and consistent system. A different method of using the ATR indicator, known as ATR Ratchet, was scrutinized by (Cekirdekci and Iliev 2010). In ATR Ratchet, the stop loss barriers calculated using the ATR value became progressively narrower over the days following the purchase of a stock. They concluded that the ATR Ratchet exit strategy caused a lot of premature exits because of the price fluctuations during the trading session, which resulted in low returns when this exit strategy was used.

The ATR indicator combined with the Turtle trading strategy was also used by (Swart 2016) for position pyramiding as well as calculating stop loss levels. Through back-testing, he also examined the behavior of different ATR periods and multipliers on a variety of assets, and came to conclusions similar to ours, namely that bigger ATR multipliers when calculating the stop loss price barriers generate better results than smaller ones.

Something that had not been examined prior to our research was the behavior of the sliding and variable ATR-based stop loss technique combined with exclusion barriers when used on an automated trading system, based on a Turtle strategy, similar with the one described by (Vezeris et al. 2018b).

2.2. Automated Trading Strategy Development

2.2.1. The Donchian Channels

Donchian Channels are barriers formed around the price series by the high and low prices over a past period. For a period of n hours, the upper line indicates the highest price during the past n hour period, while the lower line indicates the lowest price during that past n hour period. An example of Donchian Channels can be seen in Figure 1.

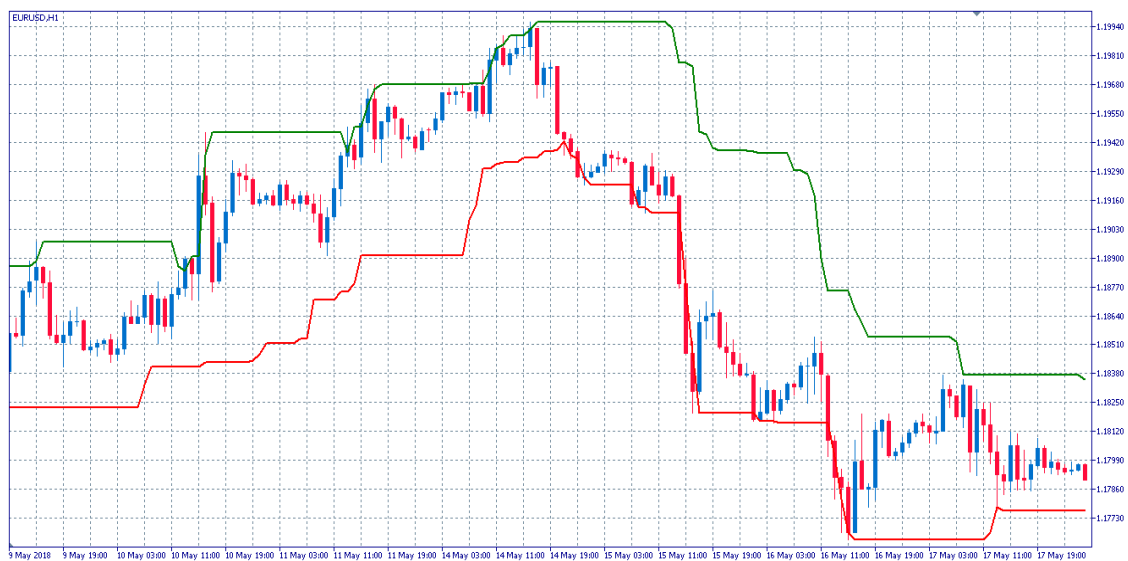


Figure 1. Donchian Channels of period 20 on a EURUSD H1 chart.

2.2.2. The Average True Range Indicator

The Average True Range Indicator measures the volatility of an asset’s price over a previous period. True Range is defined as

$$TR = \max[high - low, abs(high - close_{prev}), abs(low - close_{prev})]$$

and the Average True Range is calculated as

$$ATR = \frac{1}{N} \sum_{i=1}^N TR_i.$$

for the first time, and after that as

$$ATR_t = \frac{ATR_{t-1} \times (N - 1) + TR_t}{N}$$

In the original Turtle trading rules, the ATR indicator was used as a measure of volatility in order to determine which markets to enter and what size the positions should have. Additionally, it was used in order to set a stop loss barrier for each position as well as a barrier at which the Turtle trading system would add to the initial position. In our research, our choice of markets was determined by other reasons (outlined in Section 2.3). The use of ATR here, in addition to the uses mentioned above, is for the purpose of adding exclusion barriers to the Stop Loss strategy of the basic trading system.

2.2.3. The Turtle Trading Strategy

The Turtle trading system was introduced by Richard Dennis and William Eckhardt during the 1980s as described by (Curtis 2007). It utilizes trend following indicators to recognize and follow trends of an asset’s price, in order to enter or exit a position, like multiple Donchian Channels of different periods of high and low lines. The general rule is to open a long position when the price breaks above the high line of the past n days and hold the position until the price line breaks below the low line of the past m days where $m < n$. The same rule applies with regard to short positions, when the price line breaks the low line of the past n days then a short position is opened, and the position is held until the price line breaks the high line of a shorter m period.

A very important element in the trading system's profitability is the use of price levels to gradually invest more as the price continues to follow a trend. We did not implement hedging and non-hedging trading strategies as described by (Vezeris et al. 2018a). Instead, the Turtle trading system invests enough to risk losing only 4% of its account equity, if the price moves in the opposite direction by $X \times \text{ATR}(N)$ when opening a new position, and it would continue to add to the initial position investing enough to risk losing an additional 4% of its account equity each time the price moves by $Z \times \text{ATR}(N)$ in the direction of the trend. Where N is the period over which the ATR is calculated, X is a constant adjusting the width of the stop loss barrier and Z is a constant adjusting the width of the new position barrier at which the trading strategy adds to the initial position. The maximum number of permitted additions to the initial position is four, for a maximum risk of 20% of its account equity.

To avoid opening positions of the same type during periods of high volatility, the period of the high or low line used to open a new position is extended when the new position is of the same type as the previous one and when the previous one was profitable. For example, if we entered a long position because the price broke the high (40) line and then exited that long position because the price broke the low (20) line, then in order to open a new long position the price would have to break a high (60) line and in order to close that new long position the price would have to fall below the low (30) line. This rule is applied only when the previous trade had a profitable result. If the previous position closed with a negative profit or because a stop loss signal is triggered, then a new position of the same type can open again with the same period of high or low line.

This means that we have a total of 4 high indicator lines:

- (i) a close short position high line
- (ii) an open long position high line
- (iii) a close short position high line with extended period and
- (iv) an open long position high line with extended period

and 4 low indicator lines:

- (v) a close long position low line
- (vi) an open short position low line
- (vii) a close long position low line with extended period and
- (viii) an open short position low line with extended period.

There are also 4 different periods for these lines:

- a period x for opening new positions, used by lines (ii) and (vi)
- a period x/n for closing new positions, used by lines (i) and (v)
- an extended period y for opening positions, used by lines (iv) and (viii)
- an extended period y/m for closing positions, used by lines (iii) and (vii)

The various lines the Turtle trading strategy uses can be better seen in Figure 2.

In addition to the rules above, the Turtle trading system has a stop loss strategy on its own. It is based on the sliding and variable ATR Stop Loss zone described in Section 2.2.4, but without the exclusion barriers.

For our research, we chose to use the above automated trading strategy in the hourly timeframe (H1), as we wanted to examine the profitability of the system using exclusion barriers in combination with the Stop Loss strategy in a High Frequency Trading mode.

From this point onwards, we will refer to the abovementioned basic trading strategy as "classic Turtle expert advisor".

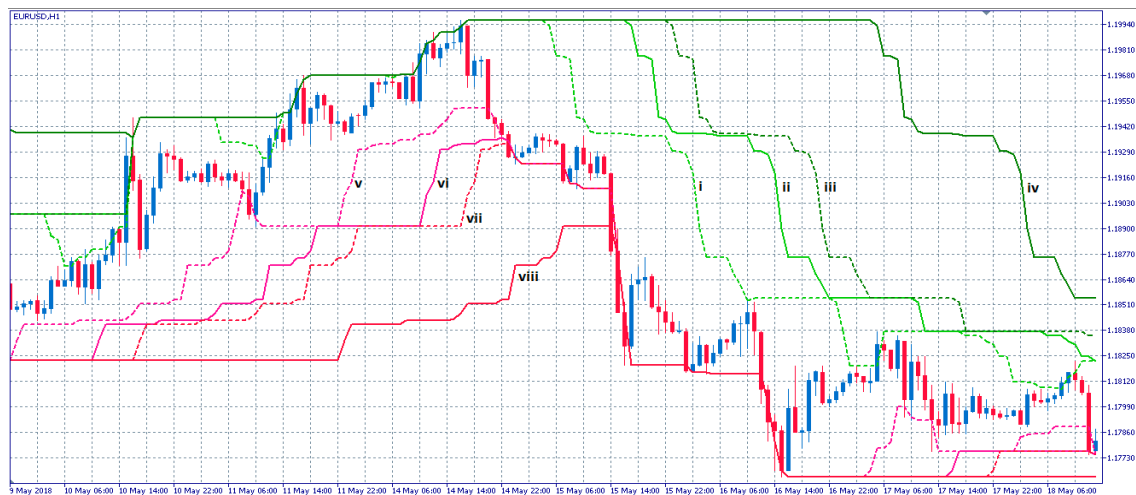


Figure 2. The lines used by the Turtle indicator as described above, on a EURUSD chart with $x = 24$, $y = 60$ and $n = m = 2$.

2.2.4. The Turtle Expert Advisor Combined with the ATR Indicator for the Stop Loss Strategy

The ATR indicator is combined with the Turtle expert advisor so that stop loss barriers can be created in addition to the barriers used by the Turtle expert advisor itself. For example, when a new long position is opened then a stop loss barrier can be set at

$$\text{Stop Loss Barrier} = \text{Opening Price} - X \times \text{ATR}(N)$$

or when a new short position is opened a new stop loss barrier can be set at

$$\text{Stop Loss Barrier} = \text{Opening Price} + X \times \text{ATR}(N)$$

where X is a constant adjusting the width of the stop loss zone and N is the period over which the ATR is calculated.

As the price moves to more profitable levels after a position is opened, it could be smart to slide the ATR stop loss window accordingly, so that some of the profits are secured in the event of a downtrend.

Therefore, each time the price breaks out of the ATR stop loss zone towards a profitable direction, the $\pm X \times \text{ATR}(N)$ stop loss zone is redrawn around that price.

The ATR stop loss zones have a width that is determined by a constant, as well as the ATR value at the time the position was opened and the zone was created. However, variability (and consequently the value of ATR) can change over the time a position is held, so it could be meaningful to adjust the width of the stop loss zone using the latest ATR value for each timeframe.

Therefore, in addition to sliding, we can implement the ATR window to change its width, too, using the recent value of ATR for each timeframe.

Moreover, ATR can form zones of exclusion after a position is closed due to a stop loss, so that new positions are not immediately opened especially in periods of high volatility. So after a position is closed, in order to open a new long position the price must rise above

$$\text{New Position Barrier} = \text{Closing Price} + Y \times \text{ATR}(N)$$

and in order to open a new short position the price must drop below

$$\text{New Position Barrier} = \text{Closing Price} - Y \times \text{ATR}(N)$$

where Y is a constant for adjusting the width of the new position barrier.

Flowcharts of the advanced Turtle Expert Advisor can be seen in Figures 3–6.

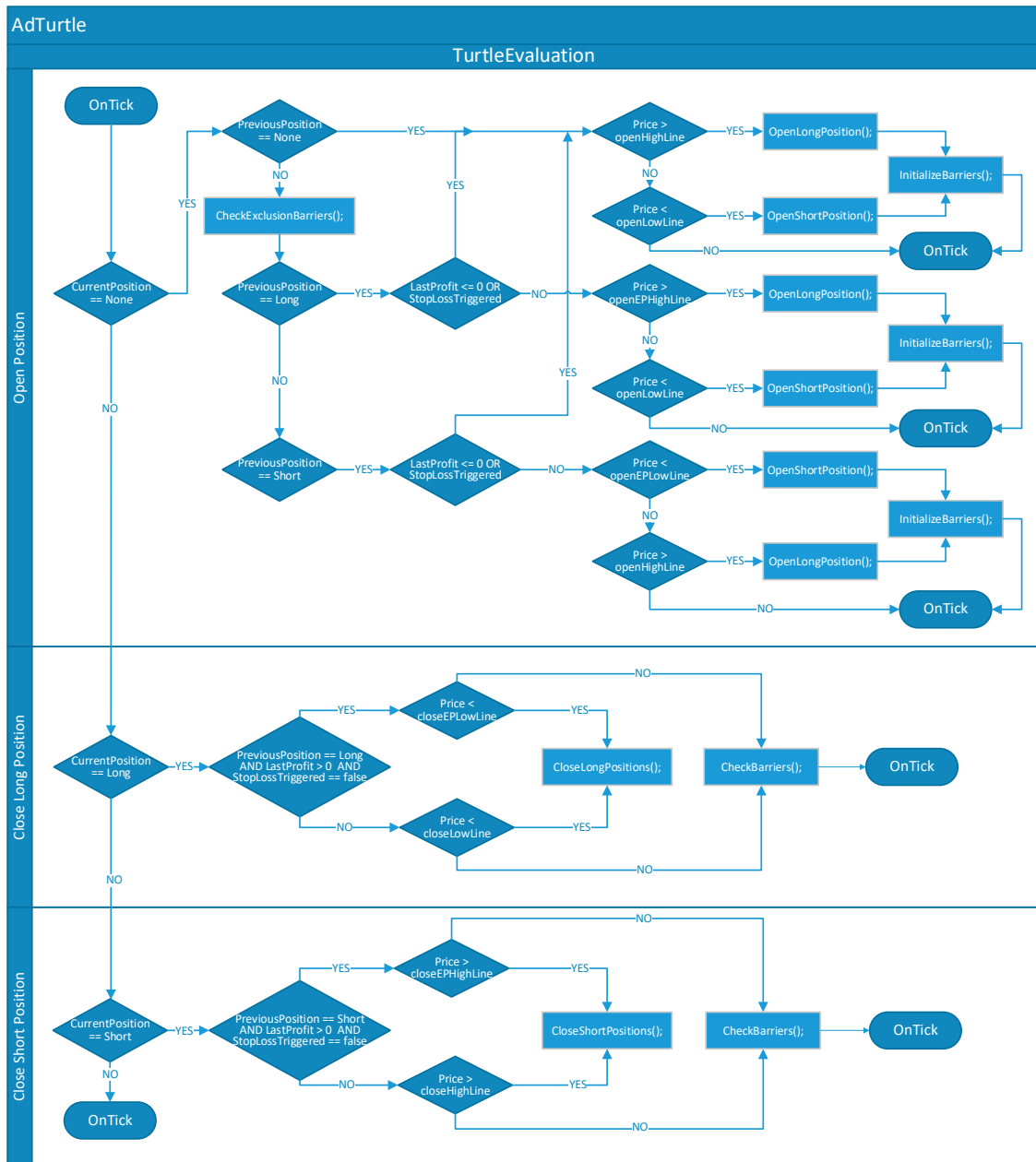


Figure 3. The Turtle basic strategy, showing when a position is opened or closed based on the open high or low lines as described in the sections above.

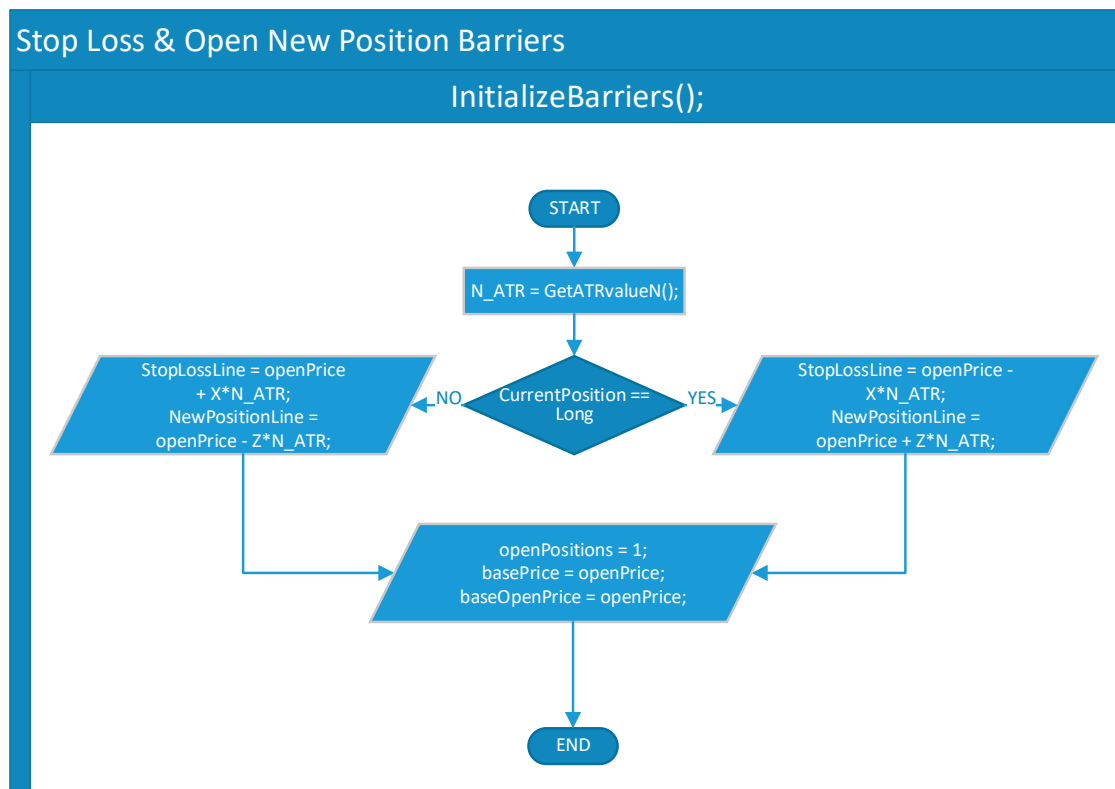


Figure 4. Initialization process after opening the first position. N_ATR is the ATR value at the time the position is opened, X is a constant adjusting the width of the stop loss zone and Z is a constant adjusting the width of the new position zone at which the trading strategy adds to the initial position.

2.3. Data and Implementation

To examine the stop loss strategy described above we used the Metatrader 5 trading terminal by Metaquotes to conduct the back tests and Microsoft SQL Server to store and initially process the results.

We experimented on a total of 8 assets, namely AUDUSD, EURUSD, GBPUSD, USDCHE, USDJPY, XAUUSD, OIL and BTCUSD over a six-month period, from 3 September 2017 to 24 February 2018, with data from ForexTime, GEBinvest and OctaFX. We chose these assets as we wanted to examine the performance of the ATR Stop Loss strategy in High Frequency Trade mode (hourly timeframe) on markets that trade globally on a 24 h base or close to a 24 h base. This is also the reason for not choosing assets from categories such as equities or rates that were also traded in the original Turtle trading system. As these automatic trading systems would be used in High Frequency Trading, we determined that a six-month testing period would be enough for the examined strategies to unravel their potential and to draw conclusions about their performance.

We set the initial capital for each test at \$10,000 for all assets except for BTCUSD, whose high price demanded a high margin, so in this case we set the initial capital at \$10,000,000 and adjusted the results to make them comparable to the other assets.

We also decided that it is best not to hold open positions over the weekend based on the results by (Vezeris et al. 2018b).

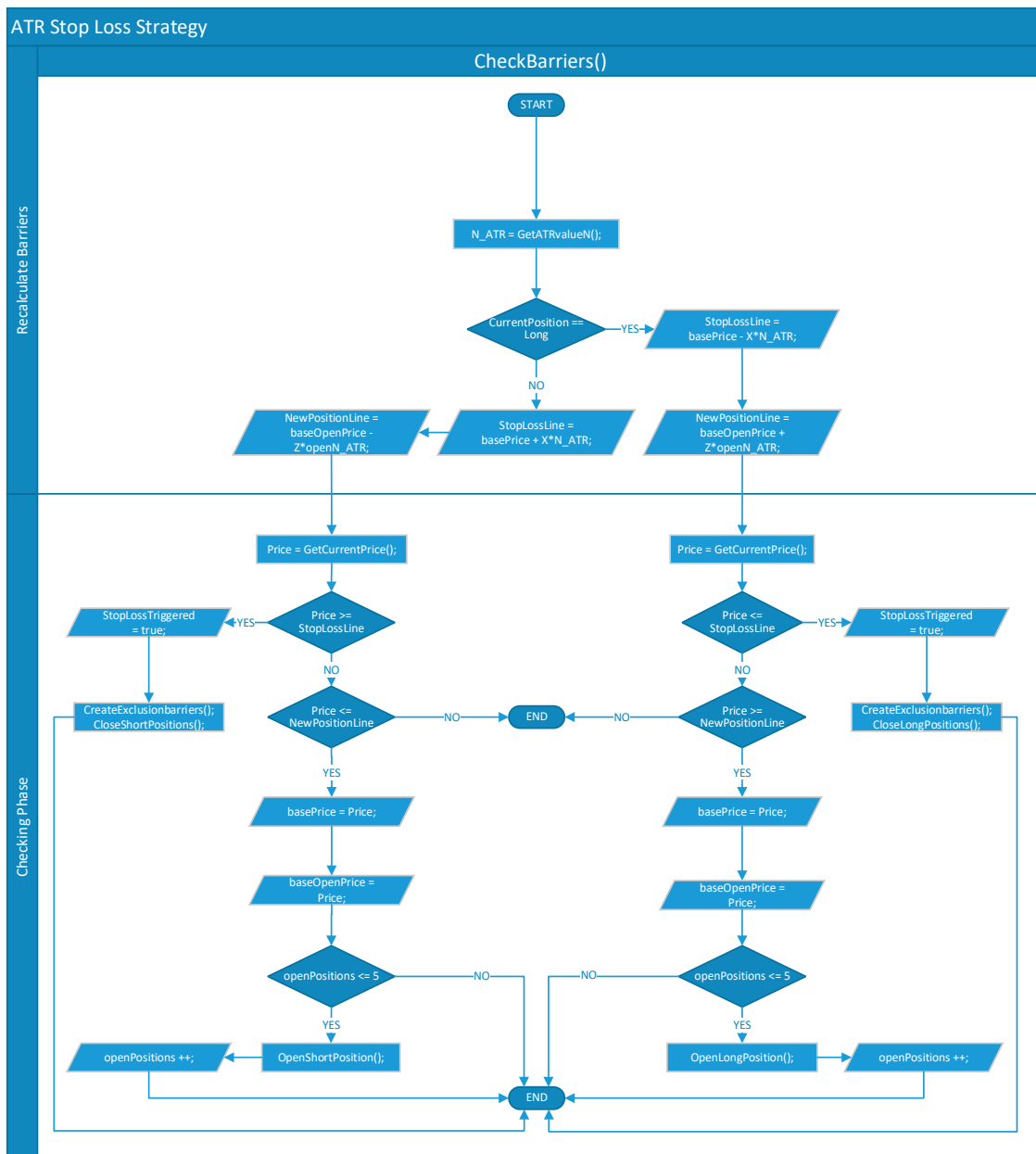


Figure 5. Recalculation and checking point of the stop loss and open new position barriers in order to close or open a position if needed.

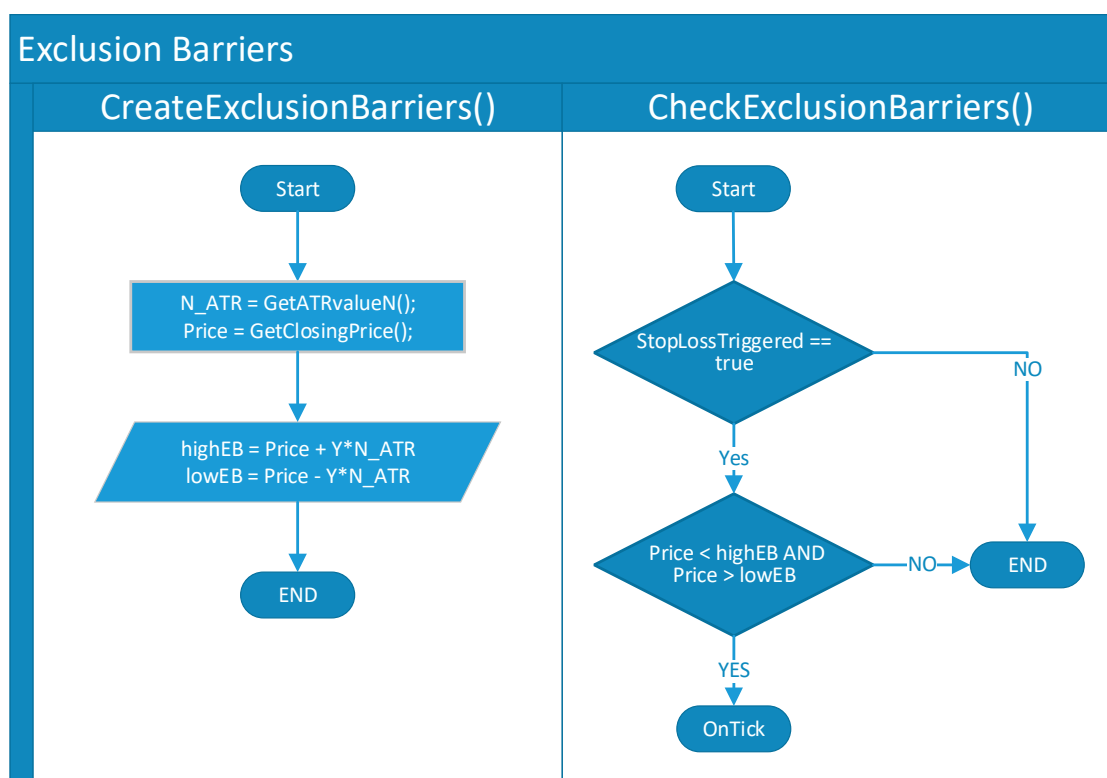


Figure 6. Creating the exclusion zone after a stop loss was triggered and preventing the opening of a new position until the price level escapes the upper or lower exclusion barrier.

3. Results and Discussion

3.1. Default/Selected Parameters

Initially we set the frequency divisors for closing lines to the following values: $n = 2$ and $m = 2$, the ATR period to 24 and the constant parameter X of the stop loss barrier to 2 as per the Turtle original rules. We used three different sets of parameters for fast, medium and slow paced opening lines, that were selected randomly instead of using the d-Backtest PS method described by (Vezeris et al. 2016) that was later used by (Vezeris and Schinas 2018) to compare the performance of different automated systems. The parameters can be seen in Table 1. We then compared results from (a) the classic Turtle Expert Advisor with the default parameters of $x = 24$ and $y = 60$, (b) the classic Turtle Expert Advisor with the fast selected parameters, (c) the classic Turtle Expert Advisor with the medium selected parameters, and (d) the classic Turtle Expert Advisor with the slow selected parameters. The results of these four experiments can be seen in Table 2, Figures 7 and 8.

Table 1. Randomly selected parameters.

Period	x	y
Fast	20	40
Medium	40	80
Slow	80	160

Table 2. Classic Turtle’s gross profits, gross losses and net profits for experiments (a), (b), (c) and (d).

	(a) Default Parameters (24, 60)			(b) Fast Parameters (20, 40)		
	Net Profit	Gross Profit	Gross Loss	Net Profit	Gross Profit	Gross Loss
AUDUSD	−9636.01	16,914.7	−26,550.7	−9674.94	15,818.43	−25,493.4
EURUSD	−8087.32	12,017.26	−20,104.6	−7832.53	13,364.93	−21,197.5
GBPUSD	−7898.31	39,862.89	−47,761.2	−7836.9	47,196.86	−55,033.8
USDCHF	−9081.14	12,108.09	−21,189.2	−9752.17	8478.36	−18,230.5
USDJPY	−8827.44	13,201.94	−22,029.4	−9010.45	18,294.17	−27,304.6
XAUUSD	−9161.71	8763.07	−17,924.8	−9286.01	7455.89	−16,741.9
OIL	−8153.81	75,642.93	−83,796.7	−9276.26	33,808.78	−43,085
BTCUSD	−1267.01	1474.76	−2741.77	−1205.69	1717.41	−2923.10

	(c) Medium Parameters (40, 80)			(d) Slow Parameters (80, 160)		
	Net Profit	Gross Profit	Gross Loss	Net Profit	Gross Profit	Gross Loss
AUDUSD	−9297.96	13,484.47	−22,782.4	−8434.49	11,016.81	−19,451.3
EURUSD	−3794.34	21,024.66	−24,819	13,971.05	43,305.2	−29,334.2
GBPUSD	−5431.3	38,974.89	−44,406.2	−2756.01	32,226.36	−34,982.4
USDCHF	−8597.67	13,870.83	−22,468.5	−7190.73	11,746.55	−18,937.3
USDJPY	−8801	8942.25	−17,743.3	−8682.88	4479.6	−13,162.5
XAUUSD	−8954.82	4888.77	−13,843.6	−8234.85	4186.42	−12,421.3
OIL	−6531.24	63,501.81	−70,033.1	−3192.86	32,739.15	−35,932
BTCUSD	−950.56	1293.62	−2244.18	−937.85	948.26	−1886.11

As Figures 7 and 8 illustrate, results from using the slow parameters are generally more profitable and have less drawdown compared with the ones using the default, fast or slow parameters.

From now on in our experiments, we will use our selected parameters. The pseudocode of the Advanced Turtle trading system can be found in Appendix A. Detailed results for the experiments that will follow can be found in Appendix B.

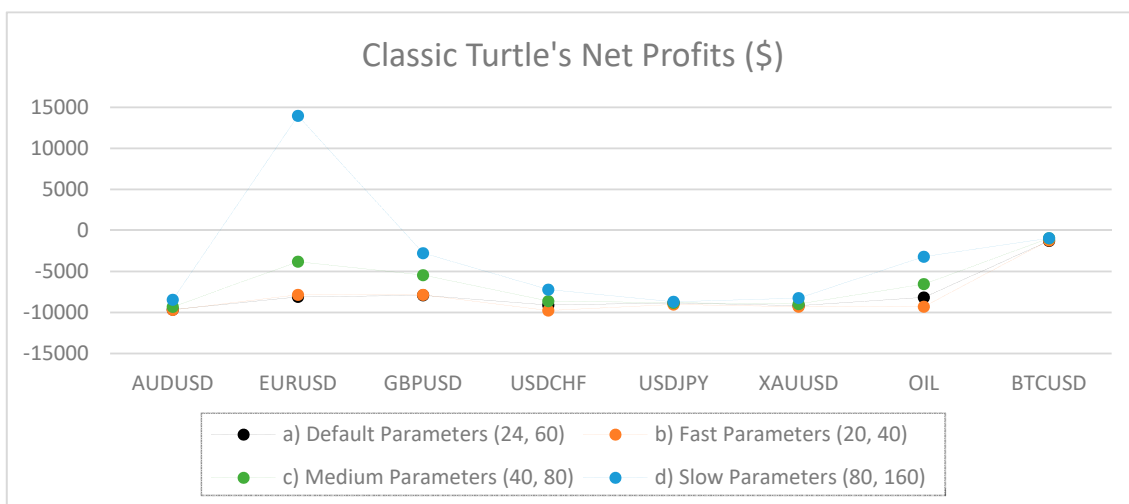


Figure 7. Net profits for experiments (a), (b), (c) and (d).

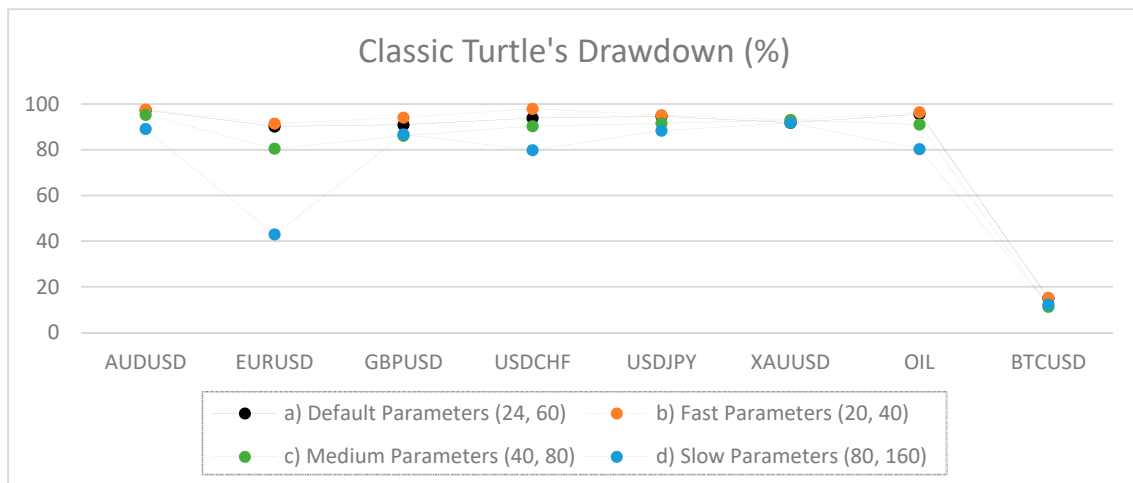


Figure 8. Drawdown as percentage of equity for experiments (a), (b), (c) and (d).

3.2. Sliding and Variable ATR Zone

Next, we examined (e) the stop loss strategy of the sliding and variable ATR zone, where a stop loss barrier is formed at $\pm X \times ATR(N)$ after a new position is opened. We tested every combination of parameters for N: {12, 24, 36, 48}, and X: {1, 2, 3, 4} for every set of the selected parameters and compared the results with the ones from (f) the stop loss strategy of the sliding and variable ATR zone as described in Section 2.2.4, where apart from the stop loss barrier, an exclusion barrier is formed at $\pm Y \times ATR(N)$ after a position is closed due to a stop loss being triggered. Again, we tested every combination of parameters for N: {12, 24, 36, 48}, X: {1, 2, 3, 4} and Y: {1, 2, 3, 4} for every set of the selected parameters. Figures 9–14 show the averages of profits and the averages of drawdowns of the assets for every combination of N, X and Y for the fast, medium and slow parameters respectively.

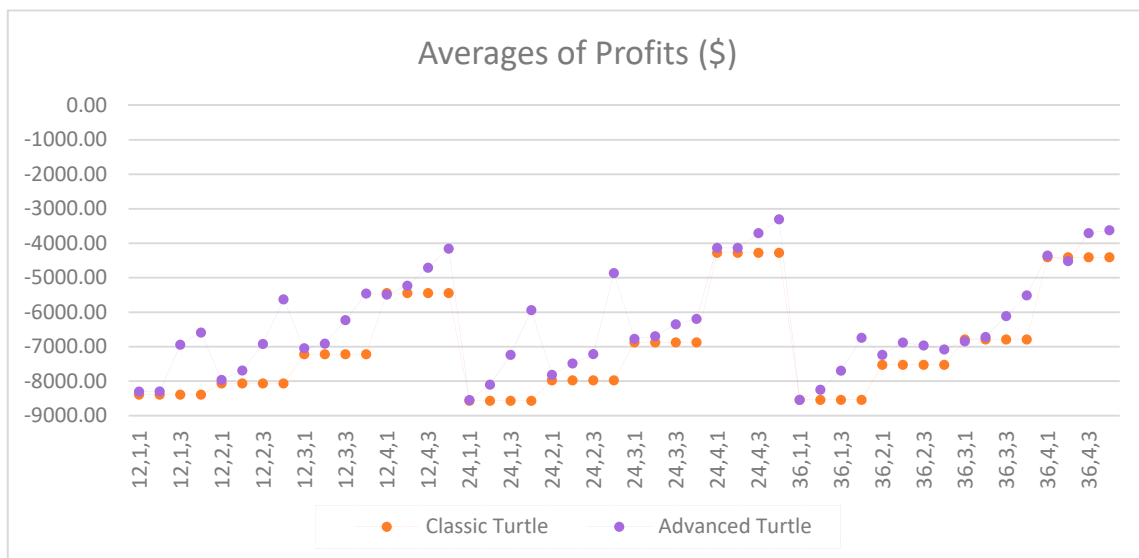


Figure 9. Averages of profits between the classic and the advanced Turtle systems for every combination of N, X, Y for the fast parameters (20, 40).

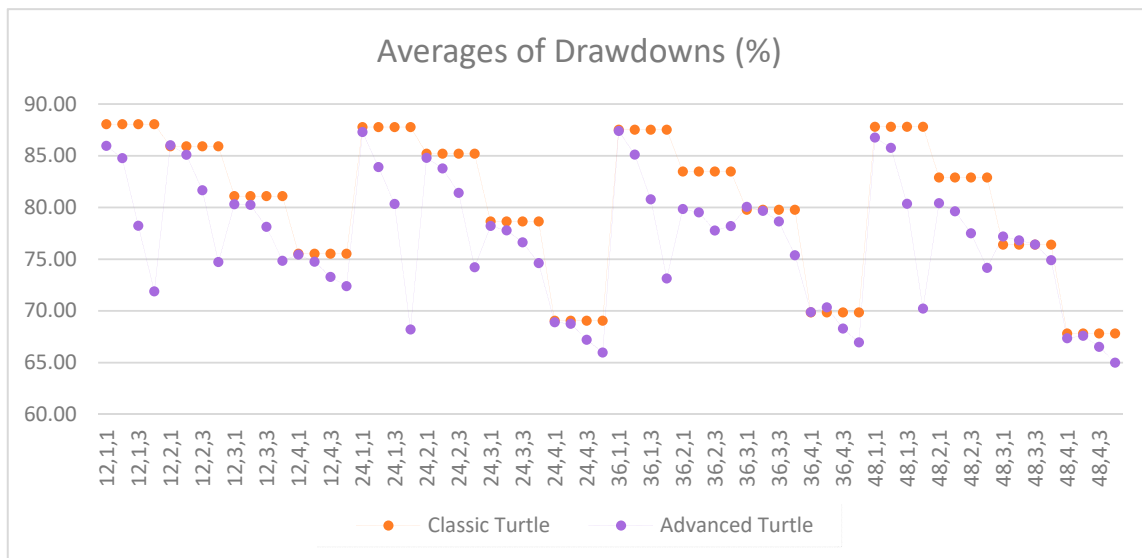


Figure 10. Averages of drawdowns as percentage of equity between the classic and the advanced Turtle systems for every combination of N, X, Y for the fast parameters (20, 40).

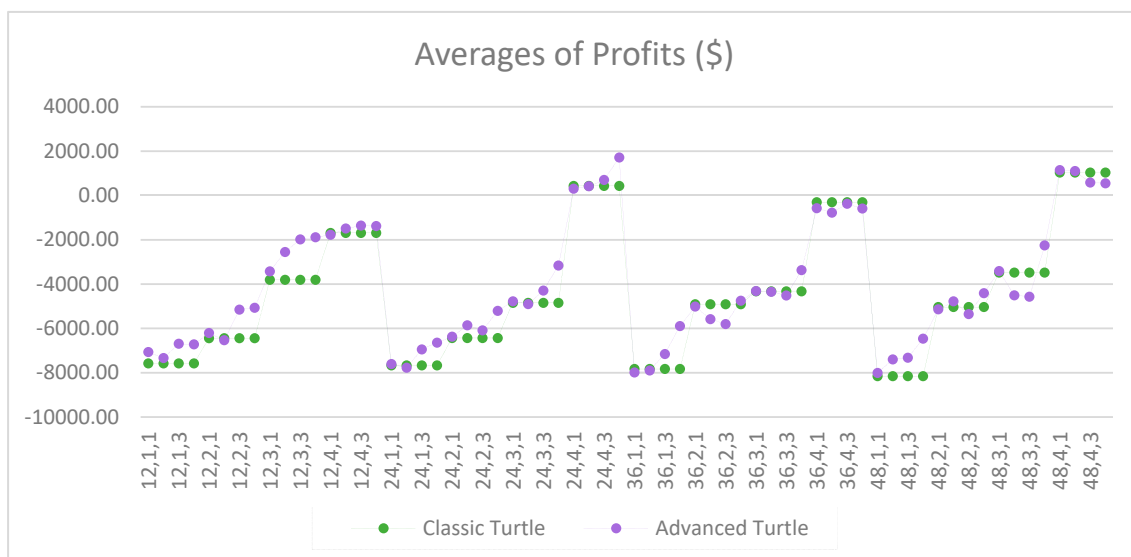


Figure 11. Averages of profits between the classic and the advanced Turtle systems for every combination of N, X, Y for the medium parameters (40, 80).

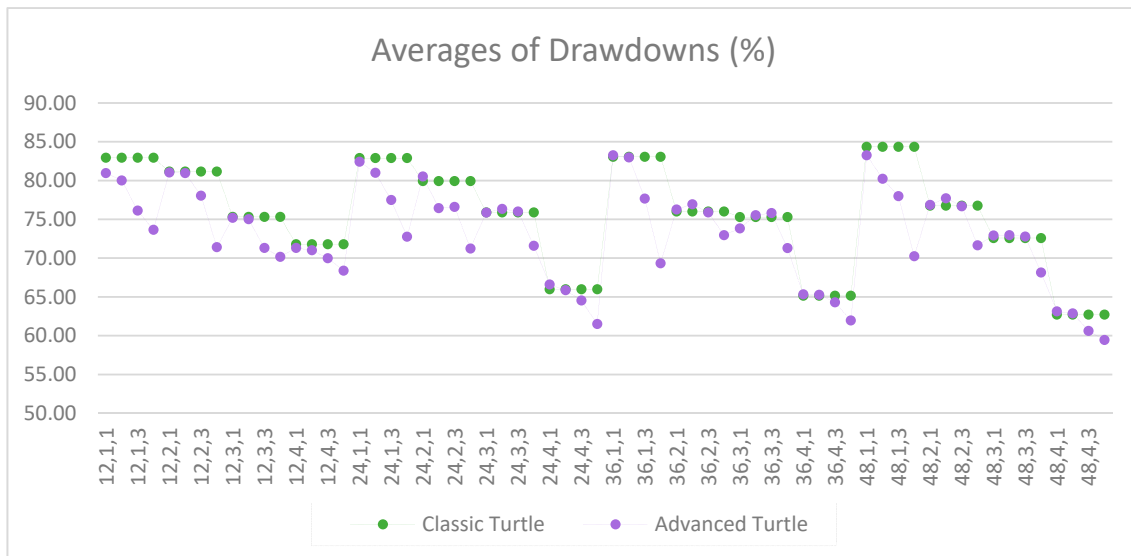


Figure 12. Averages of drawdowns as percentage of equity between the classic and the advanced Turtle systems for every combination of N, X, Y for the medium parameters (40, 80).

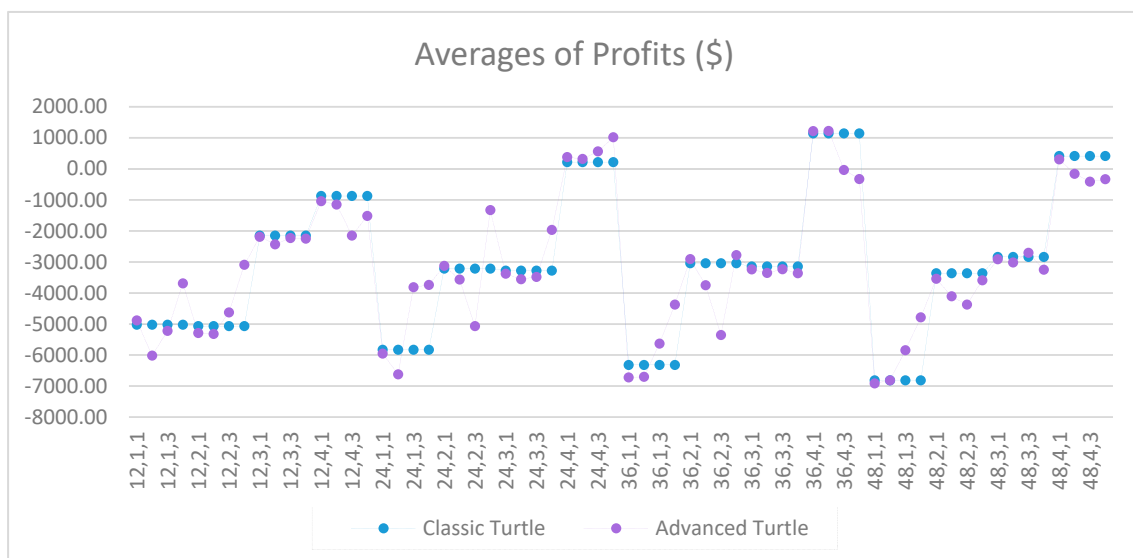


Figure 13. Averages of profits between the classic and the advanced Turtle systems for every combination of N, X, Y for the slow parameters (80, 160).

It can be observed that the advanced Turtle expert advisor performs better than the classic Turtle expert advisor. This is apparent in Figures 9 and 11 with the fast and medium parameters, but we can also clearly distinguish many peaks in Figure 13 with the slow parameters, where, with the addition of exclusion barriers, the Turtle expert advisor yields better results.

Additionally, a trend is evident as profits tend to be higher for bigger values of X. Less drawdown also coincides with higher profits as it can be seen when contrasting Figures 9 and 10. Similar results can be observed by contrasting Figures 11 and 12 as well as Figures 13 and 14.

At this point, it is established the Turtle expert advisor can benefit from the introduction of the sliding and variable ATR stop loss strategy combined with exclusion barriers. Also, we have better results with higher values of the stop loss multiplier X and the exclusion zone multiplier Y. Different values of the ATR period N do not seem to influence the results much other than for N = 12, where there are worse results from the other values of N that was examined.

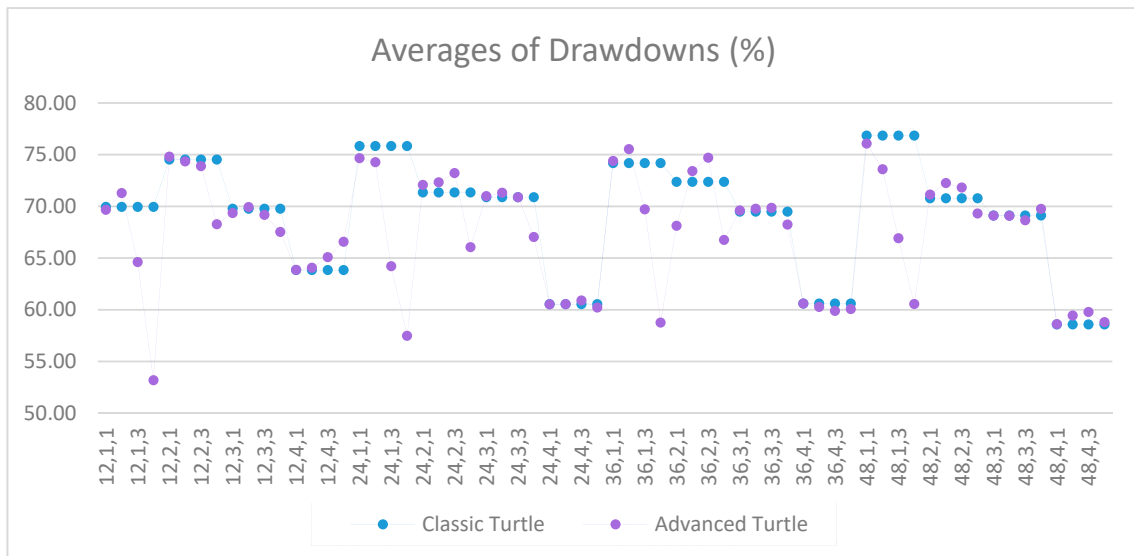


Figure 14. Averages of drawdowns as percentage of equity between the classic and the advanced Turtle systems for every combination of N, X, Y for the slow parameters (80, 160).

4. Exceptions

We tried using extraordinary values of the stop loss multiplier X: {5, 6, 7} and examined the classic and the advanced Turtle using the slow parameters {80, 160} as they provided better results. Figure 15 shows the average of profits of the assets and Figure 16 the average of drawdowns of the assets for every combination of N, X and Y.

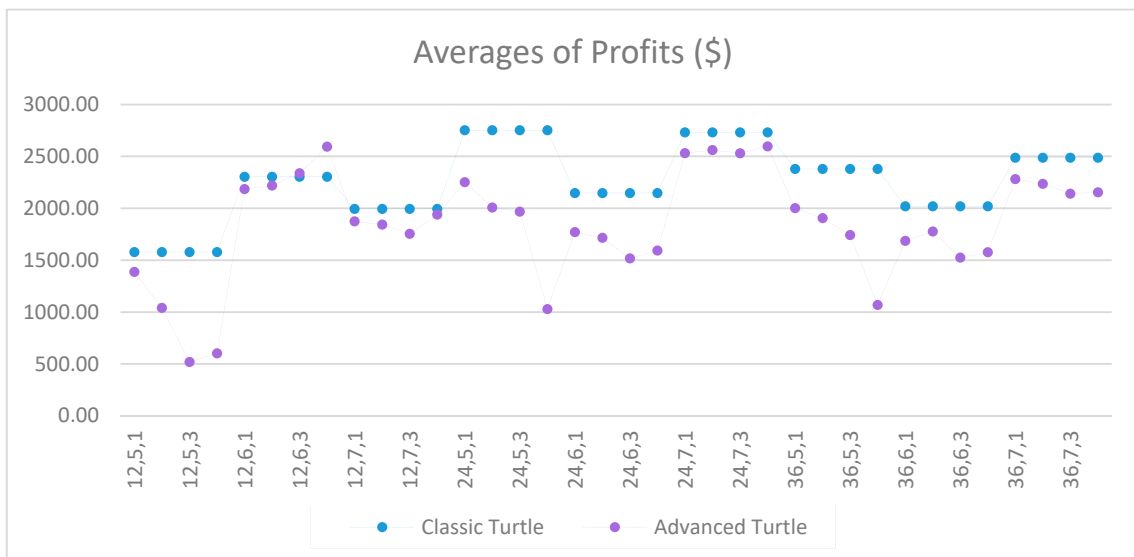


Figure 15. Averages of profits between the classic and the advanced Turtle systems for every combination of N, X, Y for the slow parameters (80, 160), where X ≥ 5.

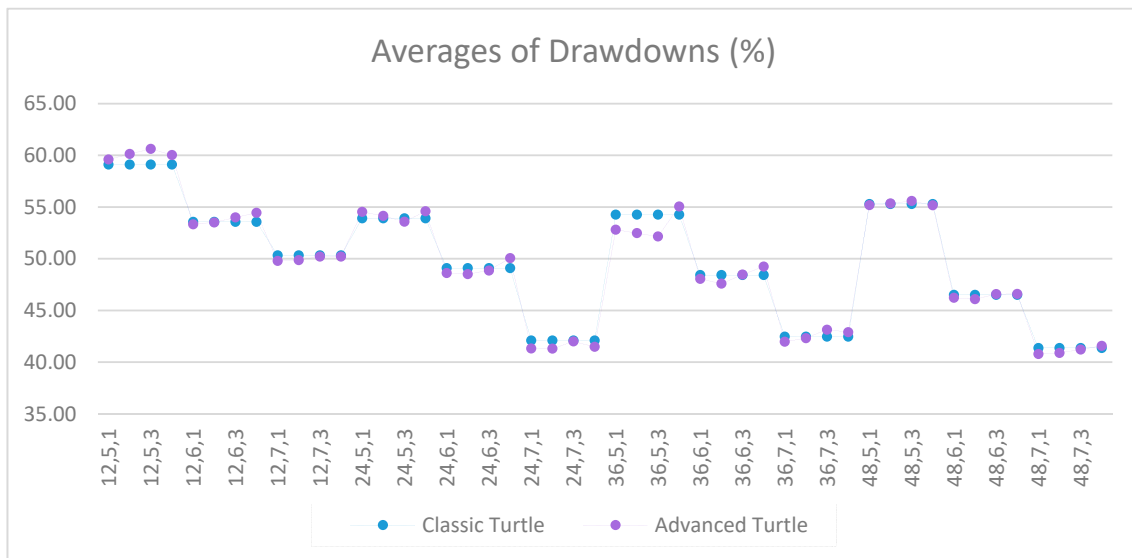


Figure 16. Averages of drawdowns as percentage of equity between the classic and the advanced Turtle systems for every combination of N, X, Y for the slow parameters (80, 160), where $X \geq 5$.

Using extraordinary values for the stop loss multiplier X, the classic Turtle outperforms the advanced Turtle. Additionally, comparing Figures 13 and 15, profits are higher with higher values of X, a fact which makes the stop loss zone wider, while chances of a stop loss being triggered are slimmer. In other words, the less our Turtle expert advisors use the ATR stop loss windows, the better the results are bound to be, and the exclusion zone becomes redundant.

5. Conclusions

In our research, we examined exclusion barriers added to a classic Turtle automated trading system used in trading 8 assets from the Forex, Metals, Commodities, Energy and Cryptocurrencies categories.

With this research we concluded that an automated trading system based on a Turtle strategy can benefit from the introduction of exclusion barriers added to its stop loss strategy, for values of the stop loss multiplier X less than 5. Thus, the Adapted Turtle trading system or AdTurtle is developed.

On the contrary, in cases where extraordinary values of X (more than or equal to 5) are used, the Classic Turtle system turns out to be more profitable.

Author Contributions: Conceptualization, D.V.; Investigation, D.V.; Methodology, D.V.; Software, I.K. and T.K.; Supervision, D.V.; Visualization, I.K.

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Appendix A

Pseudocode of the basic Turtle trading strategy as described in Section 2.2.3.

```
OnTick() {
  if(currentPosition == None) {
    if(previousPosition == None) {
      if(price > open_high_line) openLongPosition();
      else if(price < open_low_line) openShortPosition();
    }
    else if(StopLossTriggered == true) {
      if(price < high_Exclusion_Barrier && price > low_Exclusion_Barrier)
        return;
    }
    else if(previousPosition == Long) {
      if(lastProfit <= 0 || StopLossTriggered == true) {
        if(price > open_high_line) openLongPosition();
        else if(price < open_low_line) openShortPosition();
      }
      else {
        if(price > open_extended_period_high_line) openLongPosition();
        else if(price < open_low_line) openShortPosition();
      }
    }
    else if(previousPosition == Short) {
      if(lastProfit <= 0 || StopLossTriggered == true) {
        if(price > open_high_line) openLongPosition();
        else if(price < open_low_line) openShortPosition();
      }
      else {
        if(price > open_high_line) openLongPosition();
        else if(price < open_extended_period_low_line) openShortPosition();
      }
    }
  }
  } //continues in next section ...
```

```

else if(currentPosition == Long)
{
    if(previousPosition == Long && lastProfit > 0 &&
StoplossTriggered == false) {
        if(price < close_extended_period_low_line) closeLongPosition();
    }
    else {
        if(price < close_low_line) closeLongPosition();
    }
}
else if(currentPosition == Short) {
    if(previousPosition == Short && lastProfit > 0
&& StoplossTriggered == false) {
        if(price > close_extended_period_high_line) closeShortPosition();
    }
    else {
        if(price > close_high_line) closeShortPosition();
    }
}
}
}

```

Pseudocode of the Turtle trading strategy initializing the barriers after opening the first position.

```

OnTick() {
    if(position_opened_for_the_first_time) {
        N_ATR = ATR(N);
        if(currentPosition == Long) {
            StopLossLine = openPrice - X*N_ATR;
            NewPositionLine = openPrice + Z*N_ATR;
        }
        else {
            StopLossLine = openPrice + X*N_ATR;
            NewPositionLine = openPrice - Z*N_ATR;
        }
        basePrice = baseOpenPrice = openPrice;
        openPositions = 1;
    }
}
}

```

Pseudocode of the Turtle trading strategy with the ATR Stop Loss strategy, as described in Section 2.2.4.

```
OnTick() {
  if(positionIsOpened) {
    N_ATR = ATR(N);
    if(currentPosition == Long) {
      StopLossLine = basePrice - X*N_ATR;
      newPositionLine = baseOpenPrice + Z*N_ATR;

      if(currentPrice <= StopLossLine) {
        StopLossTriggered = true;
        N_ATR = ATR(N);
        CloseLongPositions();
        return;
      }
      if(currentPrice >= newPositionLine) {
        basePrice = currentPrice;
        baseOpenPrice = currentPrice;
        if(openPositions < 5) {
          OpenLongPosition();
          openPosition += 1;
        }
      }
    }
  }
  // continues in next section ...
}
```

```
else{
    StopLossLine = basePrice + X*N_ATR;
    newPositionLine = baseOpenPrice - Z*N_ATR;

    if(currentPrice >= StopLossLine) {
        StopLossTriggered = true;
        N_ATR = ATR(N);
        CloseShortPositions();
        return;
    }
    if(currentPrice <= newPositionLine) {
        basePrice = currentPrice;
        baseOpenPrice = currentPrice;
        if(openPositions < 5) {
            OpenLongPosition();
            openPosition += 1;
        }
    }
}
}
if(noPositionIsOpened) {
    if(StopLossTriggered == true) {
        high_Exclusion_Barrier = closingPrice + Y*N_ATR;
        low_Exclusion_Barrier = closingPrice - Y*N_ATR;
    }
}
}
```

Appendix B

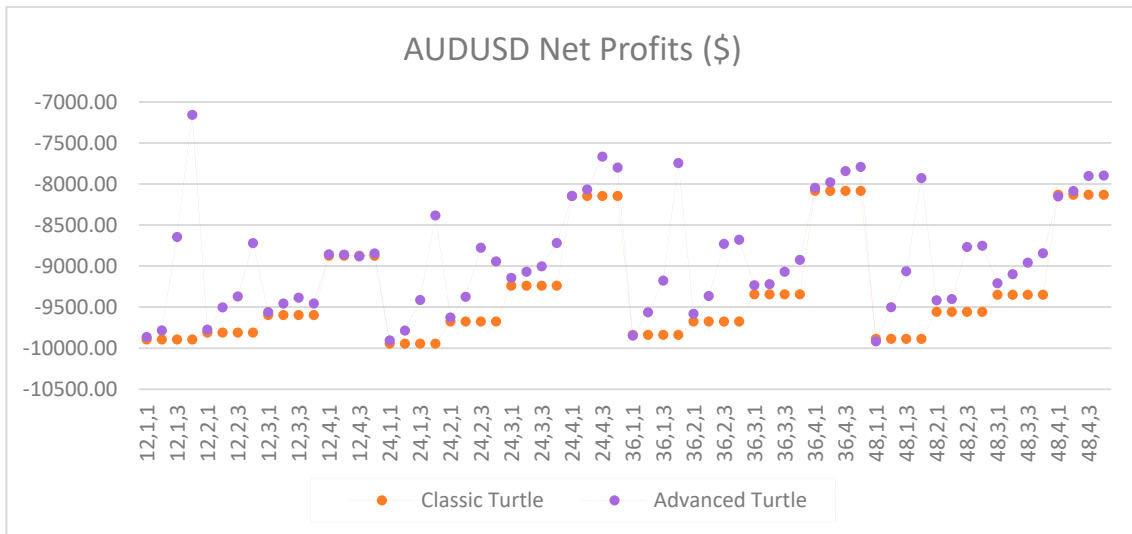


Figure A1. Net profits of AUDUSD between the classic and the advanced Turtle systems for every combination of N, X, Y for the fast parameters (20, 40).

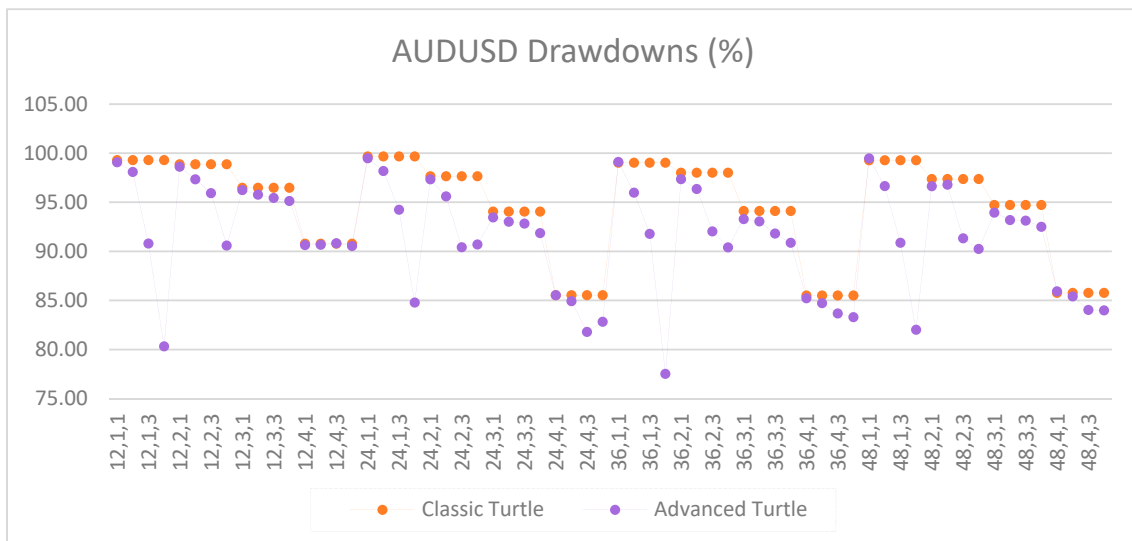


Figure A2. Drawdowns of AUDUSD as percentage of equity between the classic and the advanced Turtle systems for every combination of N, X, Y for the fast parameters (20, 40).

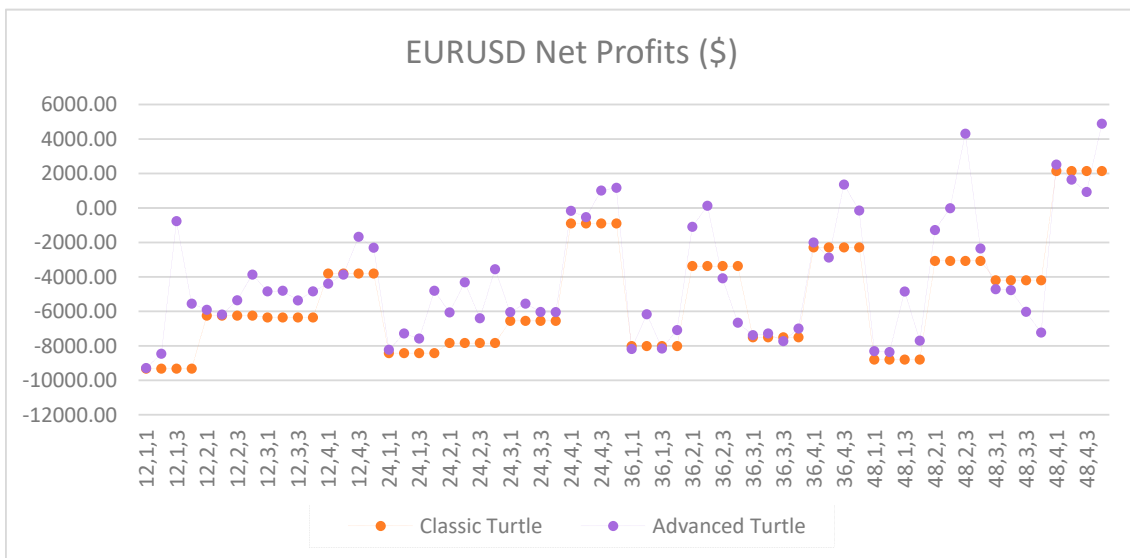


Figure A3. Net profits of EURUSD between the classic and the advanced Turtle systems for every combination of N, X, Y for the fast parameters (20, 40).

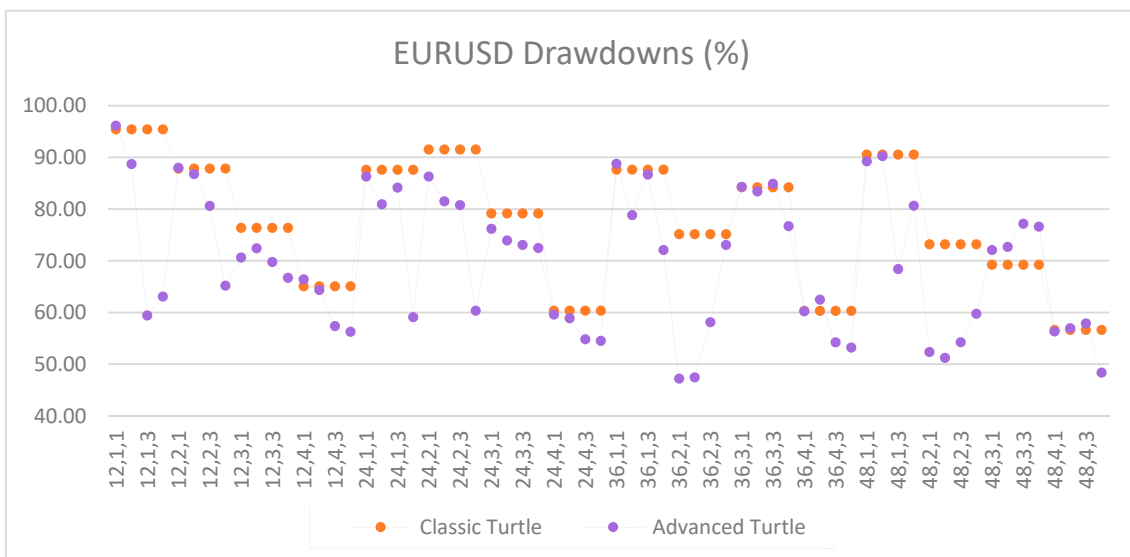


Figure A4. Drawdowns of EURUSD as percentage of equity between the classic and the advanced Turtle systems for every combination of N, X, Y for the fast parameters (20, 40).

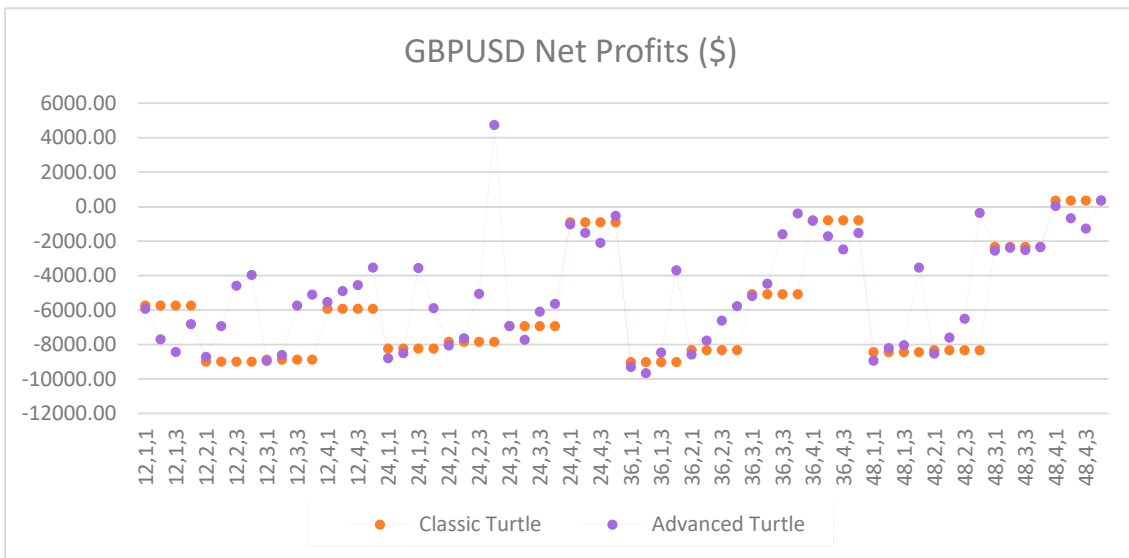


Figure A5. Net profits of GBPUSD between the classic and the advanced Turtle systems for every combination of N, X, Y for the fast parameters (20, 40).

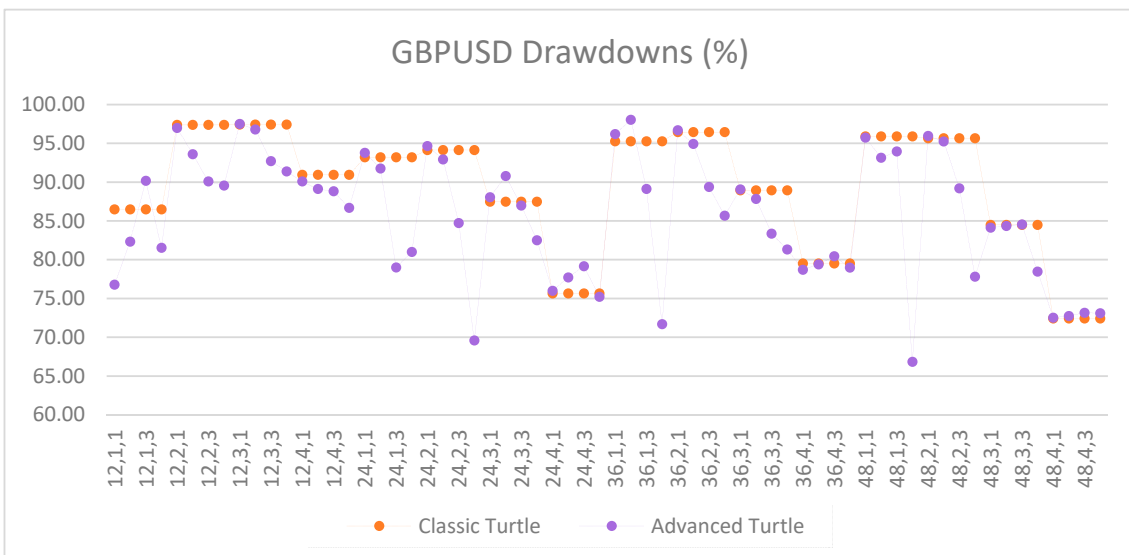


Figure A6. Drawdowns of GBPUSD as percentage of equity between the classic and the advanced Turtle systems for every combination of N, X, Y for the fast parameters (20, 40).

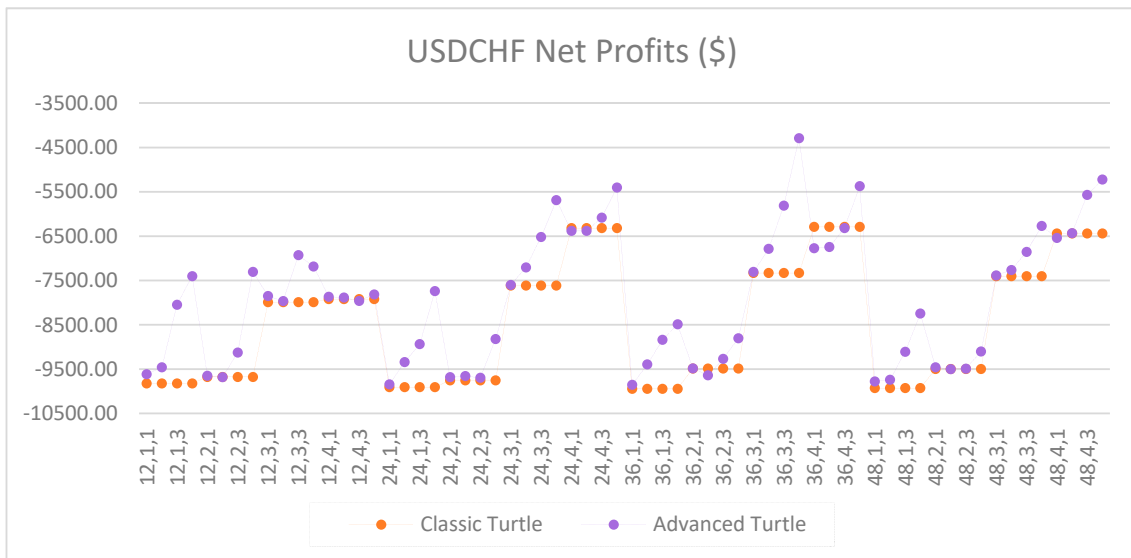


Figure A7. Net profits of USDCHF between the classic and the advanced Turtle systems for every combination of N, X, Y for the fast parameters (20, 40).

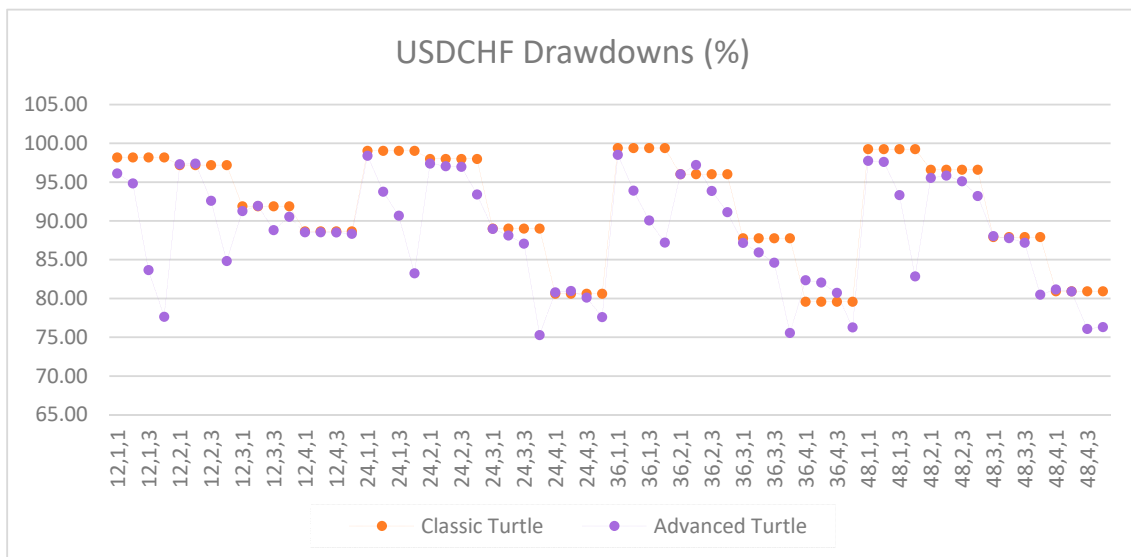


Figure A8. Drawdowns of USDCHF as percentage of equity between the classic and the advanced Turtle systems for every combination of N, X, Y for the fast parameters (20, 40).

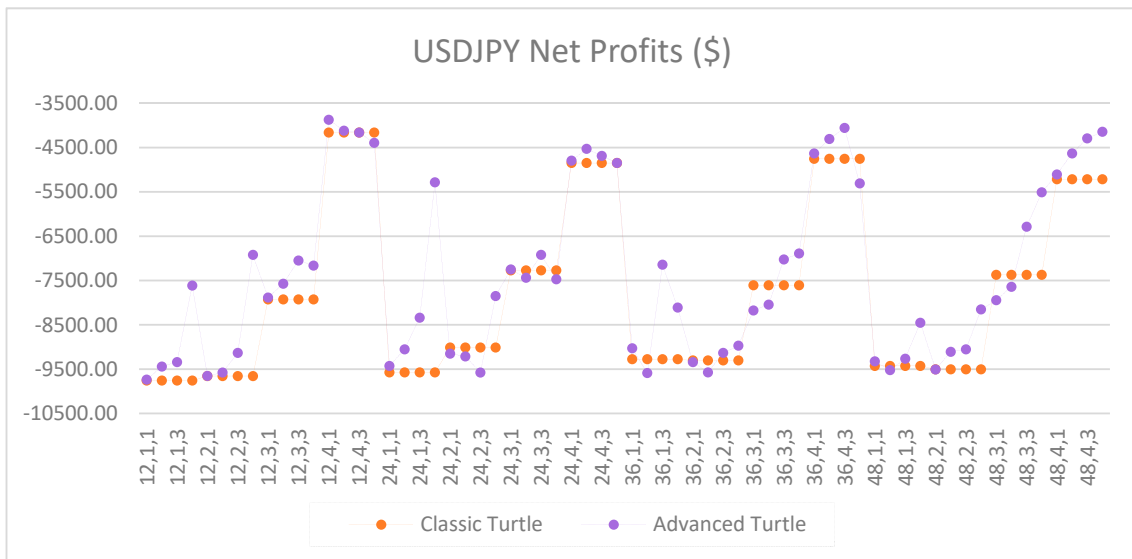


Figure A9. Net profits of USDJPY between the classic and the advanced Turtle systems for every combination of N, X, Y for the fast parameters (20, 40).

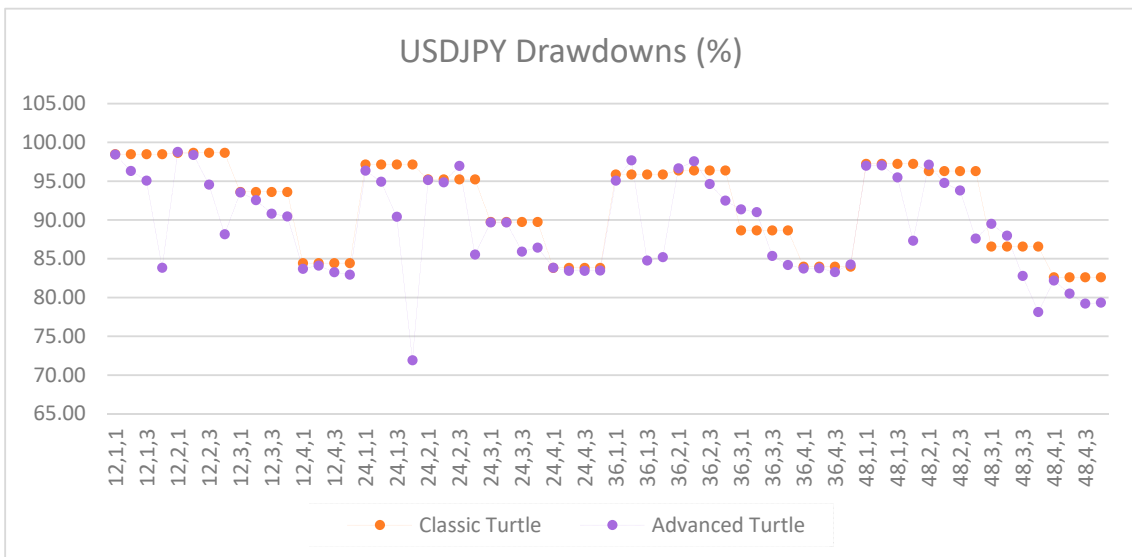


Figure A10. Drawdowns of USDJPY as percentage of equity between the classic and the advanced Turtle systems for every combination of N, X, Y for the fast parameters (20, 40).

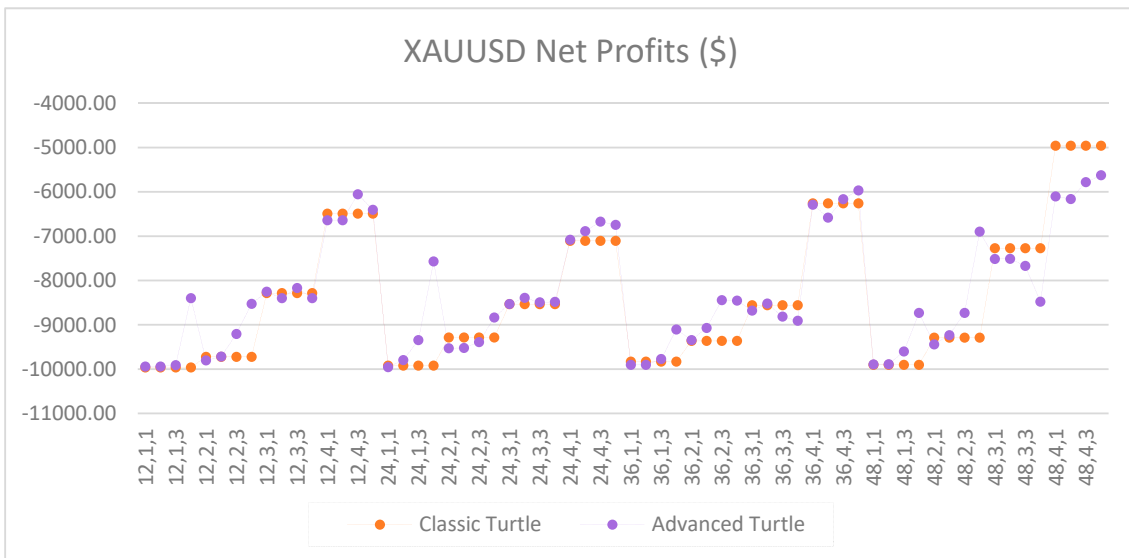


Figure A11. Net profits of XAUUSD between the classic and the advanced Turtle systems for every combination of N, X, Y for the fast parameters (20, 40).

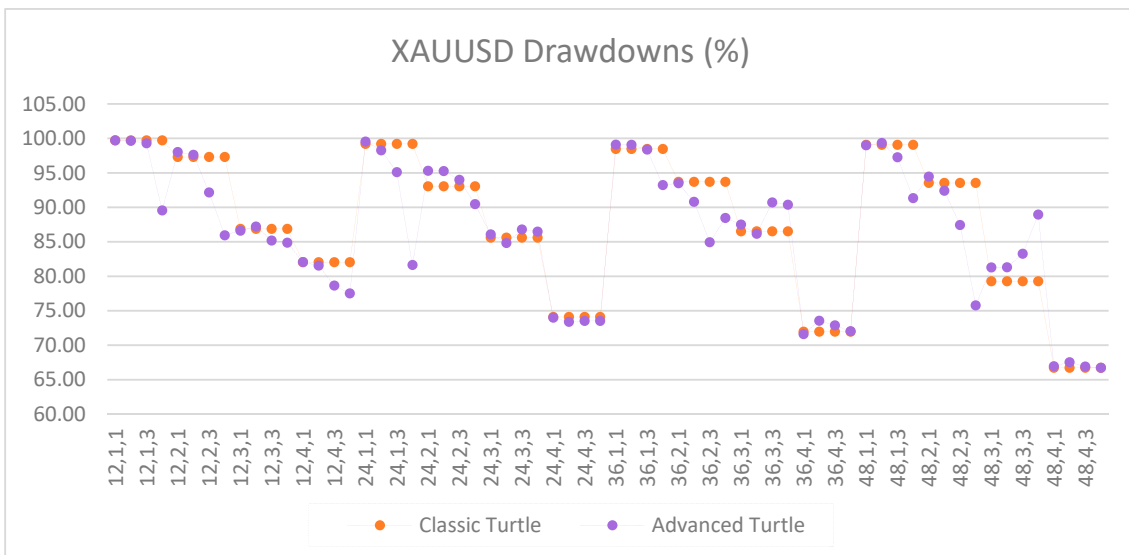


Figure A12. Drawdowns of XAUUSD as percentage of equity between the classic and the advanced Turtle systems for every combination of N, X, Y for the fast parameters (20, 40).

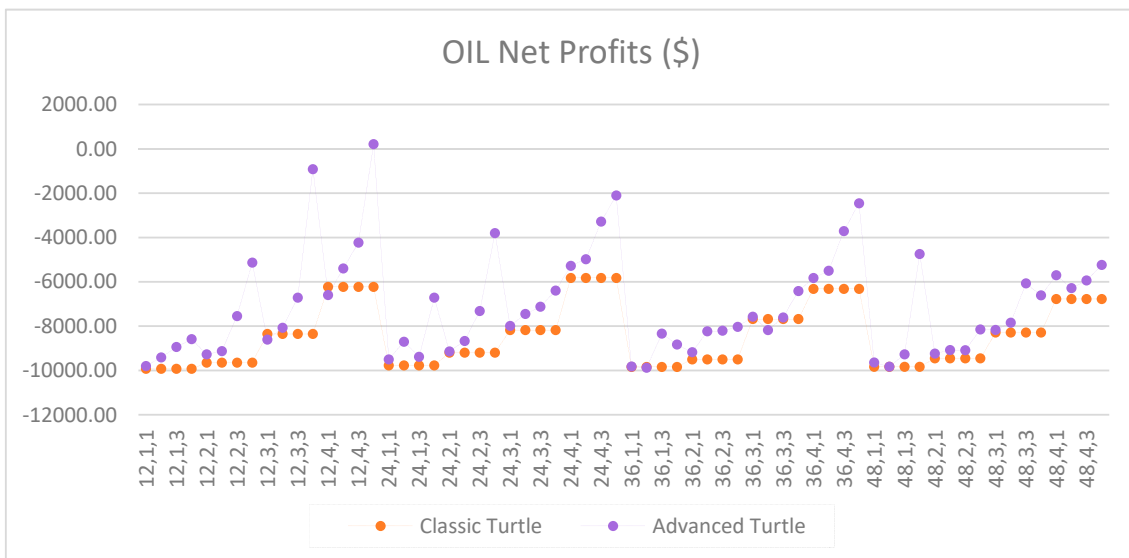


Figure A13. Net profits of OIL between the classic and the advanced Turtle systems for every combination of N, X, Y for the fast parameters (20, 40).

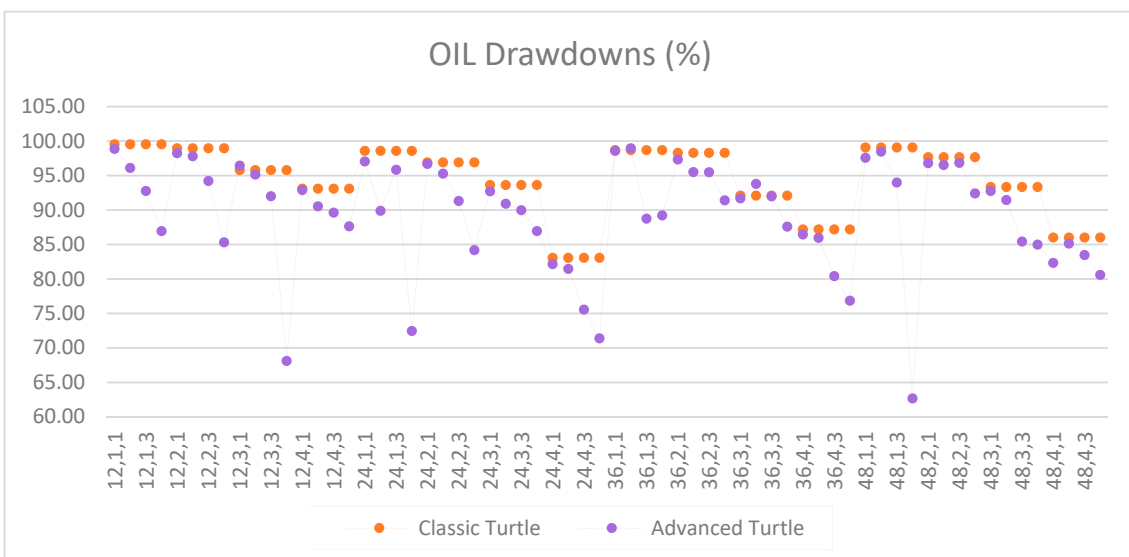


Figure A14. Drawdowns of OIL as percentage of equity between the classic and the advanced Turtle systems for every combination of N, X, Y for the fast parameters (20, 40).

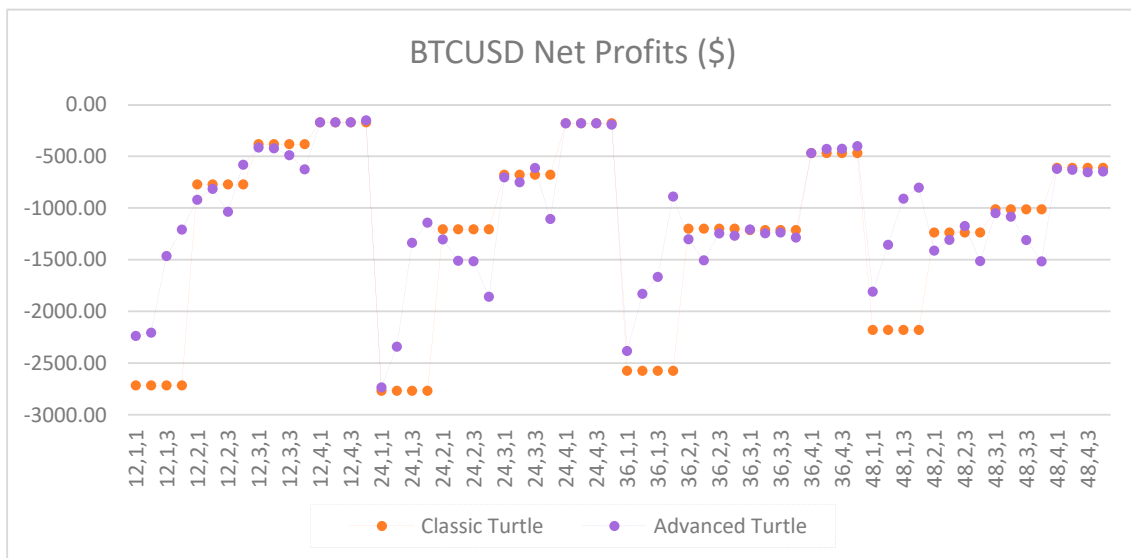


Figure A15. Net profits of BTCUSD between the classic and the advanced Turtle systems for every combination of N, X, Y for the fast parameters (20, 40).

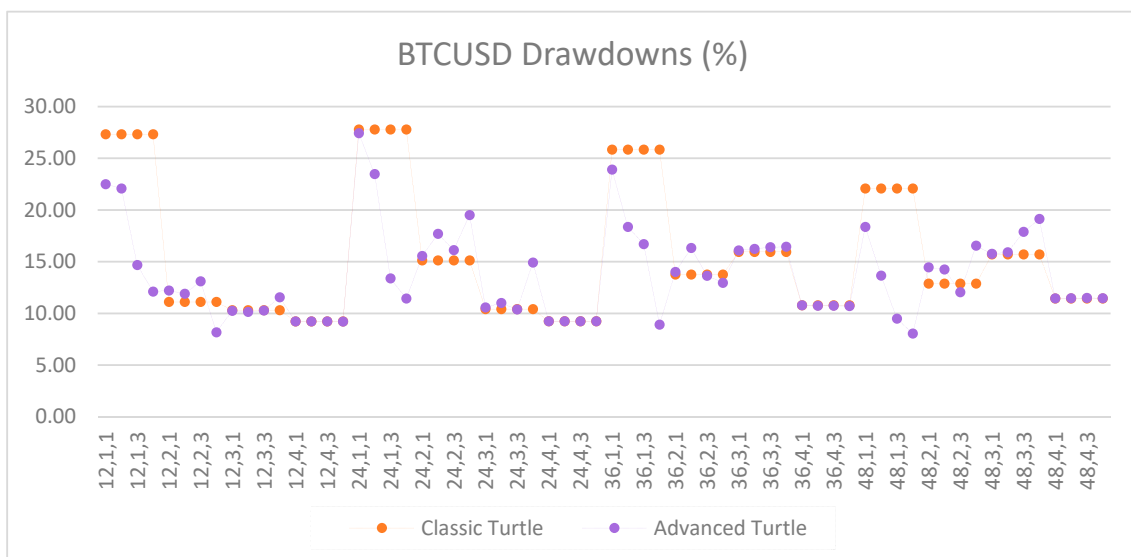


Figure A16. Drawdowns of BTCUSD as percentage of equity between the classic and the advanced Turtle systems for every combination of N, X, Y for the fast parameters (20, 40).

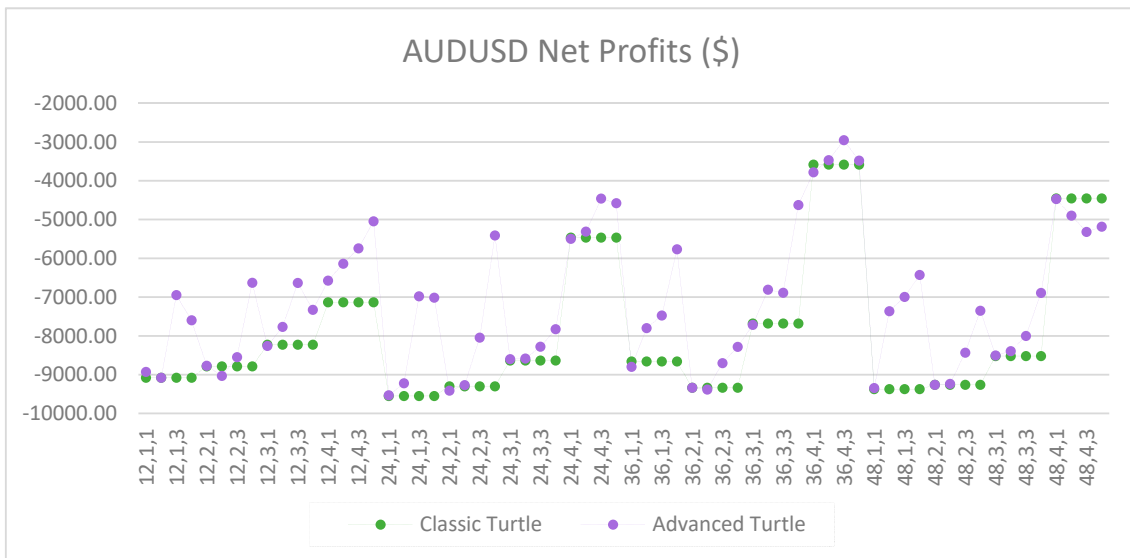


Figure A17. Net profits of AUDUSD between the classic and the advanced Turtle systems for every combination of N, X, Y for the medium parameters (40, 80).

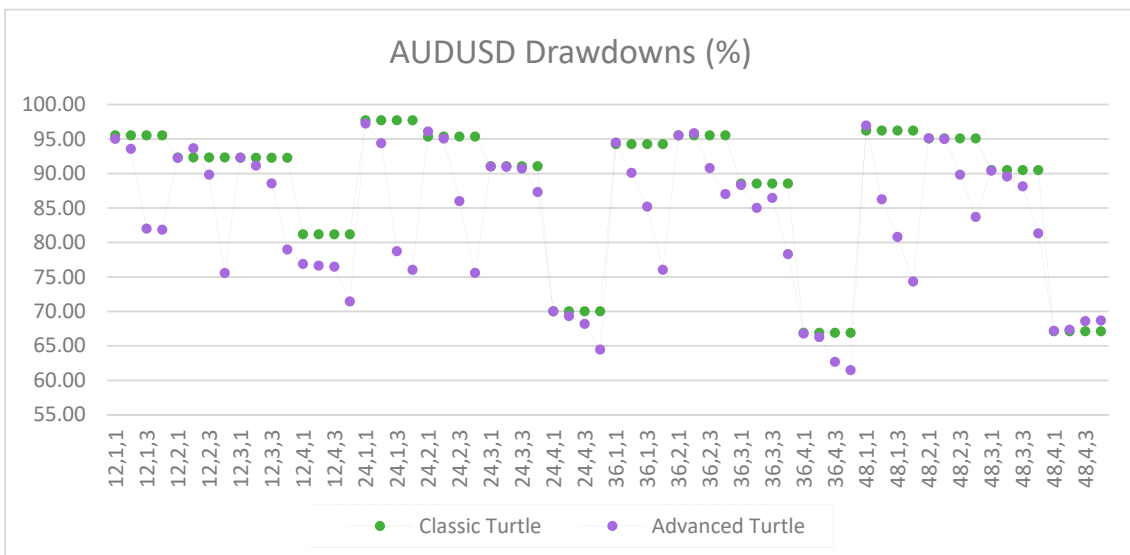


Figure A18. Drawdowns of AUDUSD as percentage of equity between the classic and the advanced Turtle systems for every combination of N, X, Y for the medium parameters (40, 80).

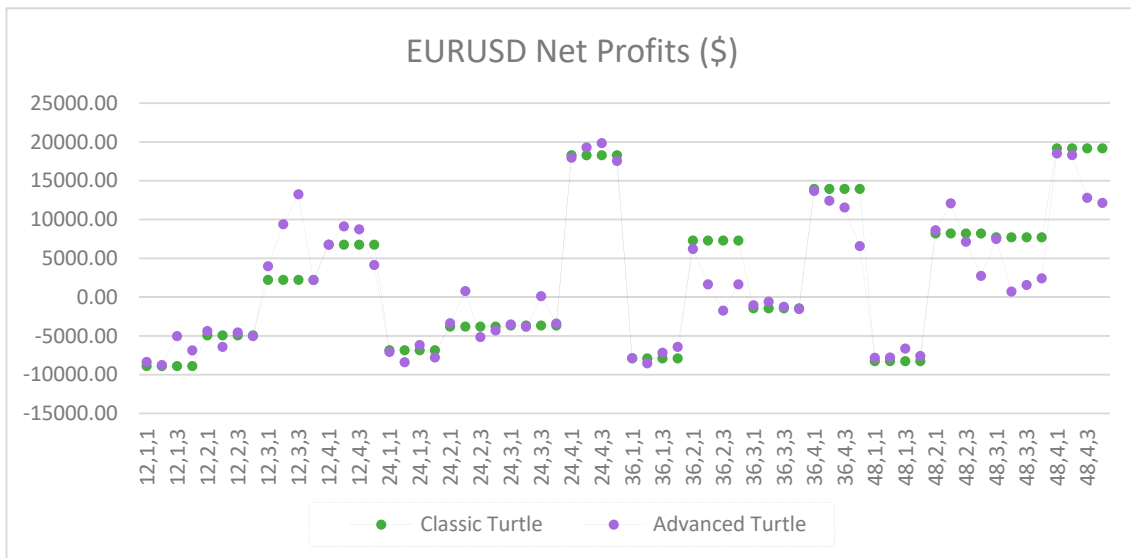


Figure A19. Net profits of EURUSD between the classic and the advanced Turtle systems for every combination of N, X, Y for the medium parameters (40, 80).

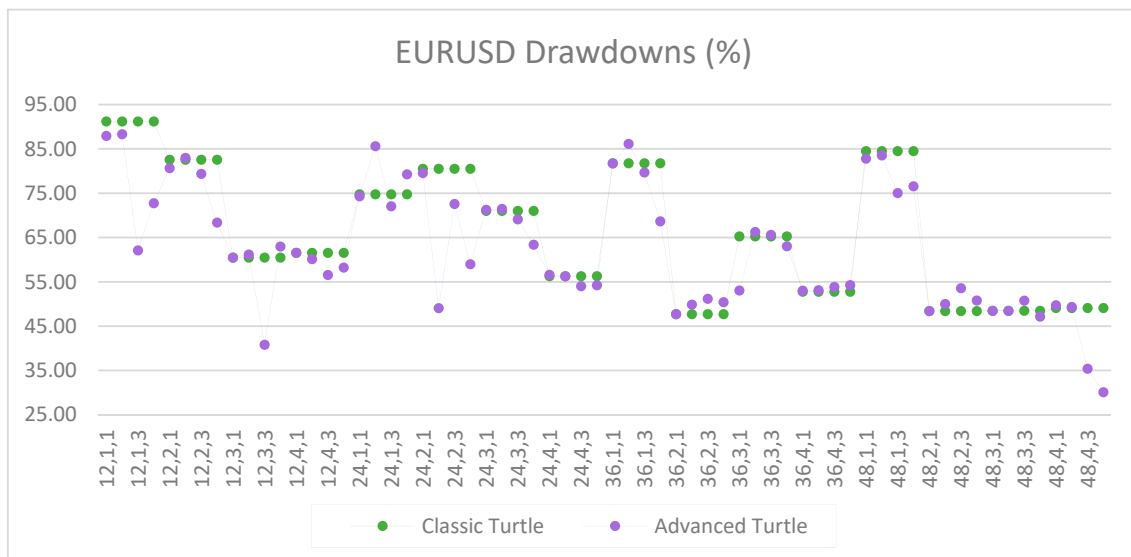


Figure A20. Drawdowns of EURUSD as percentage of equity between the classic and the advanced Turtle systems for every combination of N, X, Y for the medium parameters (40, 80).

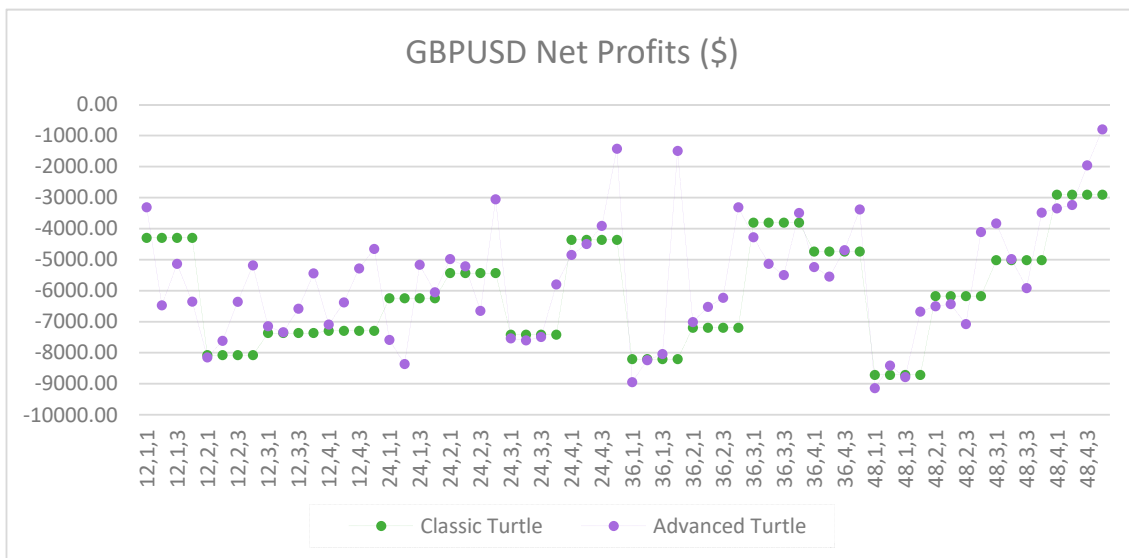


Figure A21. Net profits of GBPUSD between the classic and the advanced Turtle systems for every combination of N, X, Y for the medium parameters (40, 80).

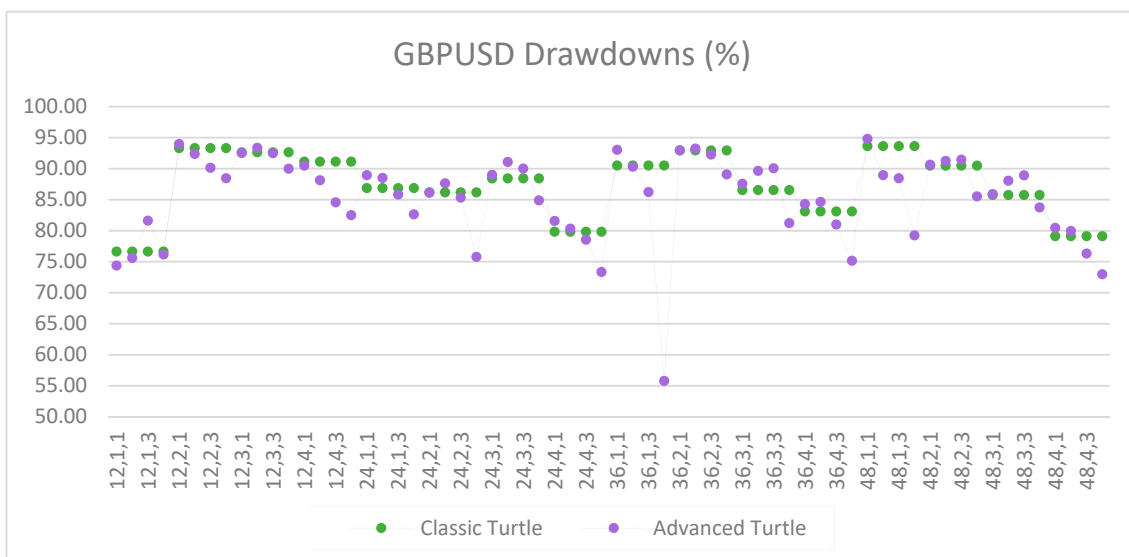


Figure A22. Drawdowns of GBPUSD as percentage of equity between the classic and the advanced Turtle systems for every combination of N, X, Y for the medium parameters (40, 80).

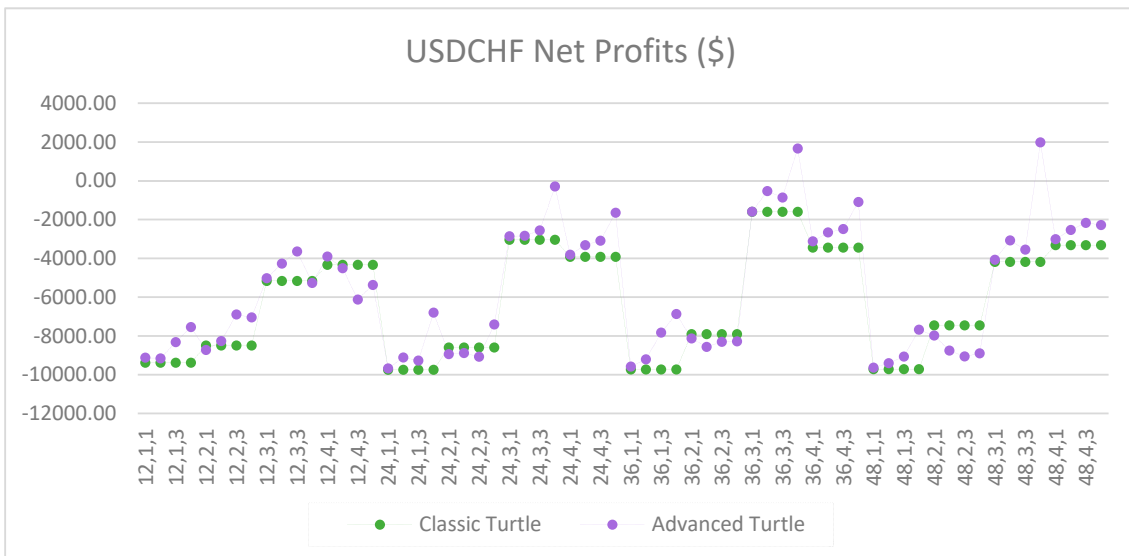


Figure A23. Net profits of USDCHF between the classic and the advanced Turtle systems for every combination of N, X, Y for the medium parameters (40, 80).

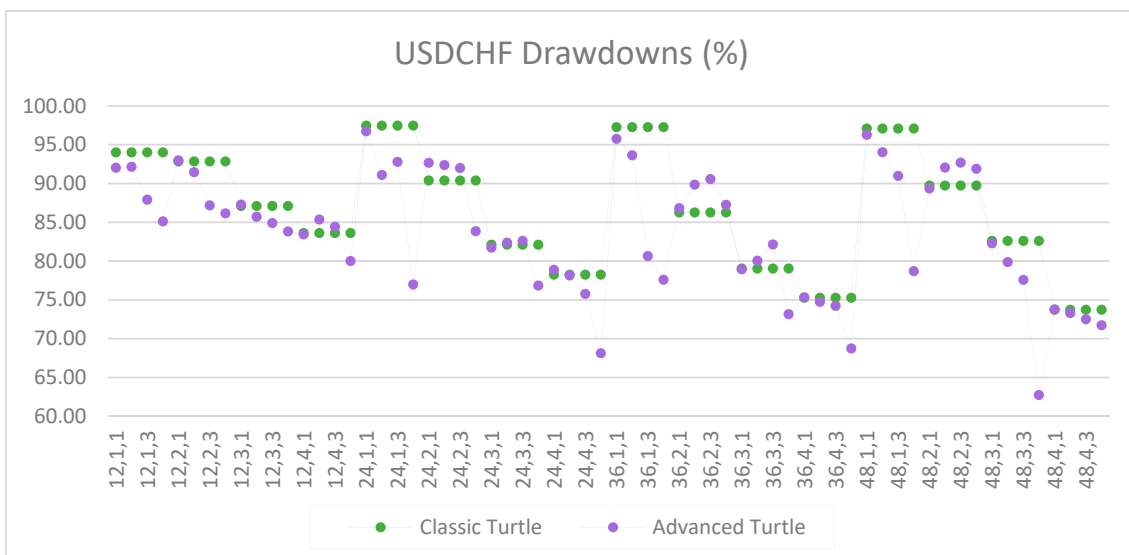


Figure A24. Drawdowns of USDCHF as percentage of equity between the classic and the advanced Turtle systems for every combination of N, X, Y for the medium parameters (40, 80).

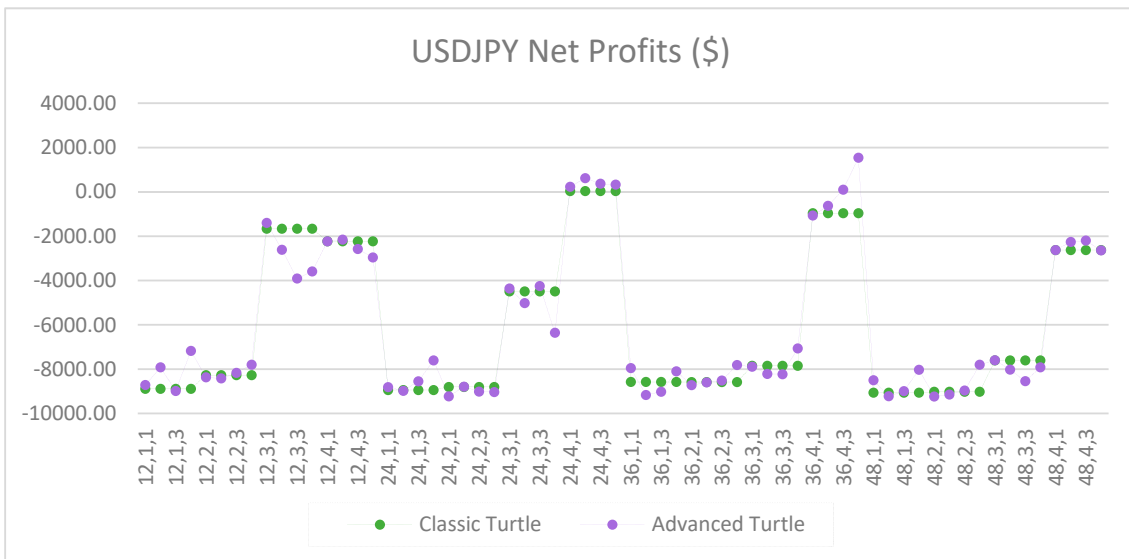


Figure A25. Net profits of USDJPY between the classic and the advanced Turtle systems for every combination of N, X, Y for the medium parameters (40, 80).

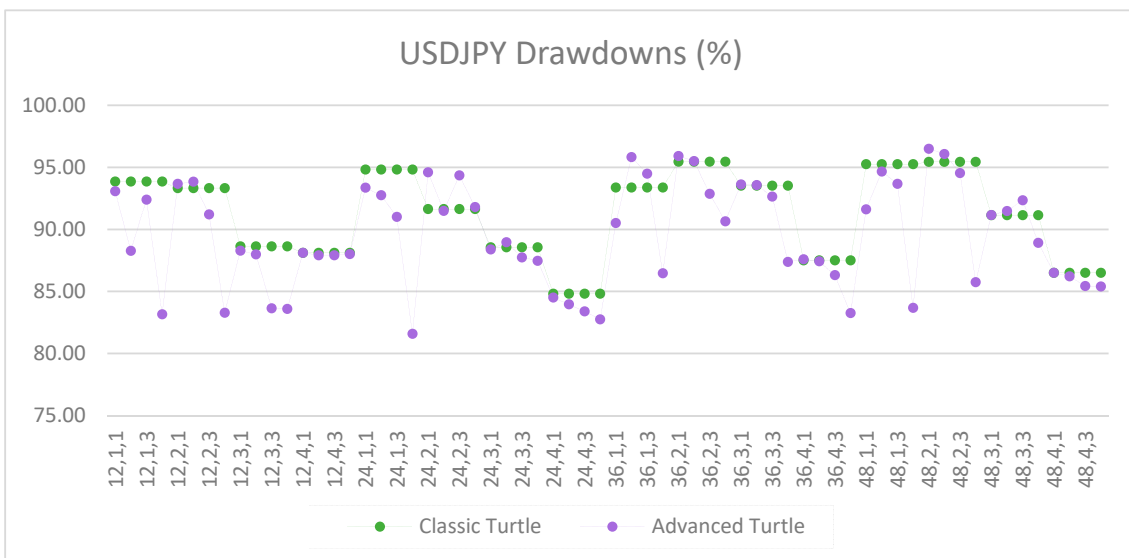


Figure A26. Drawdowns of USDJPY as percentage of equity between the classic and the advanced Turtle systems for every combination of N, X, Y for the medium parameters (40, 80).

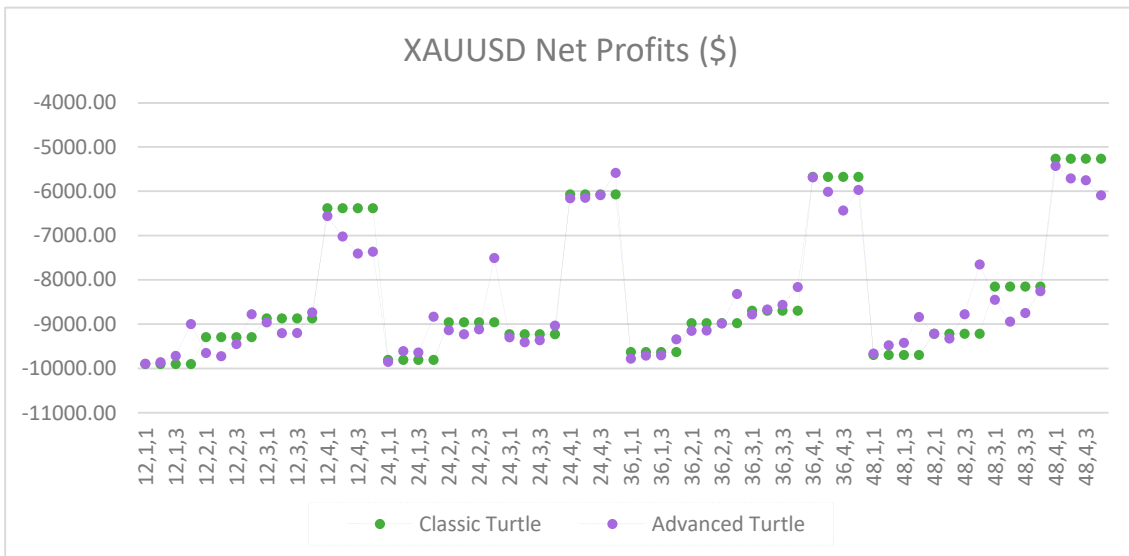


Figure A27. Net profits of XAUUSD between the classic and the advanced Turtle systems for every combination of N, X, Y for the medium parameters (40, 80).

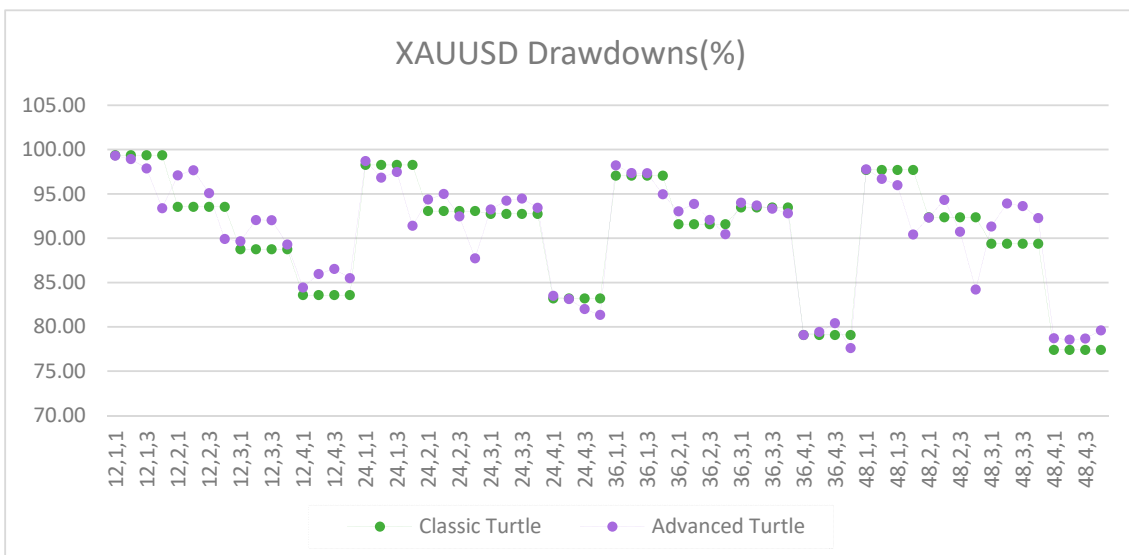


Figure A28. Drawdowns of XAUUSD as percentage of equity between the classic and the advanced Turtle systems for every combination of N, X, Y for the medium parameters (40, 80).

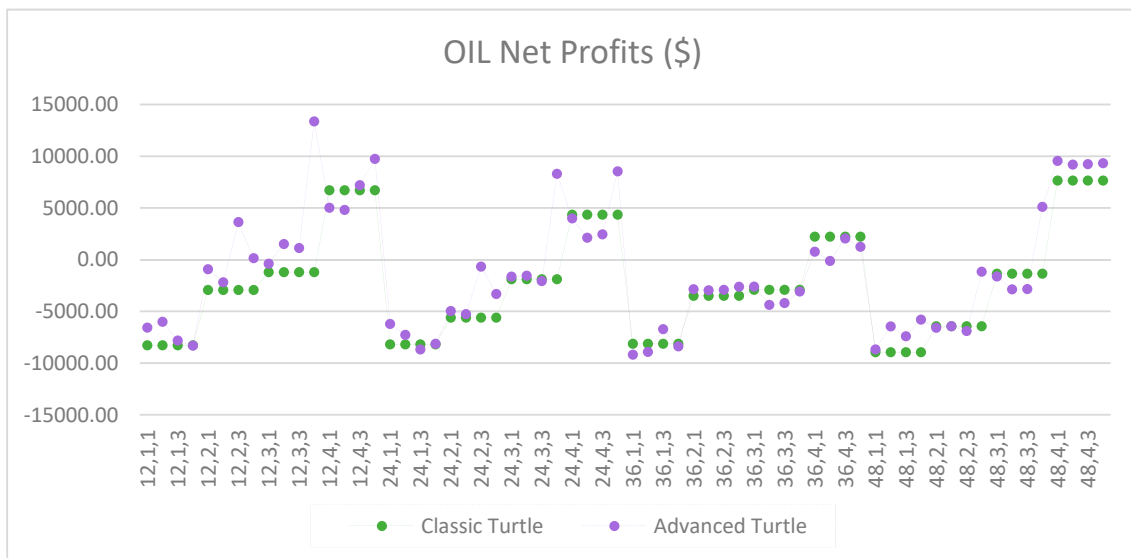


Figure A29. Net profits of OIL between the classic and the advanced Turtle systems for every combination of N, X, Y for the medium parameters (40, 80).

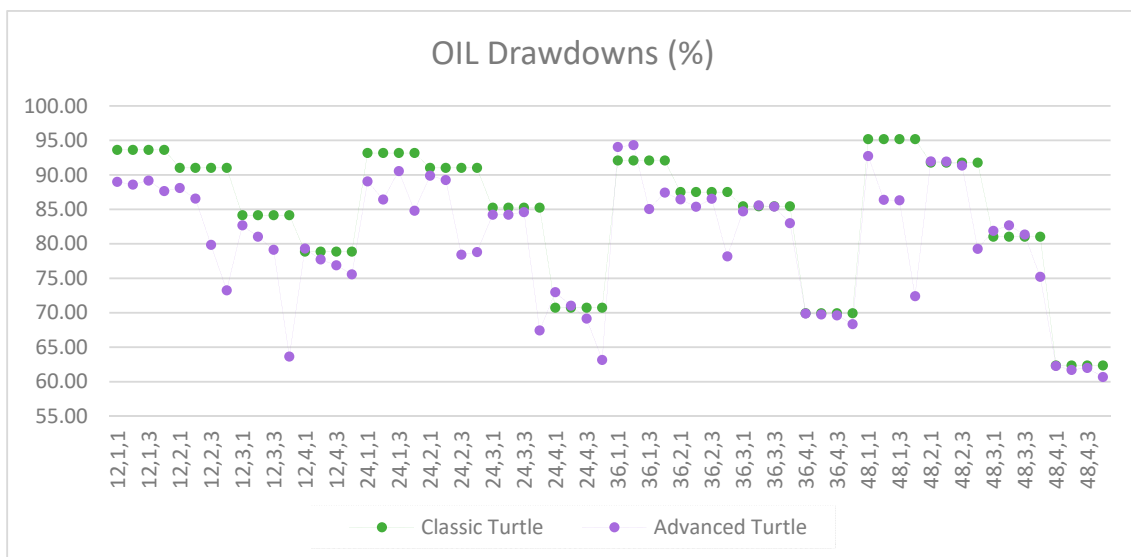


Figure A30. Drawdowns of OIL as percentage of equity between the classic and the advanced Turtle systems for every combination of N, X, Y for the medium parameters (40, 80).

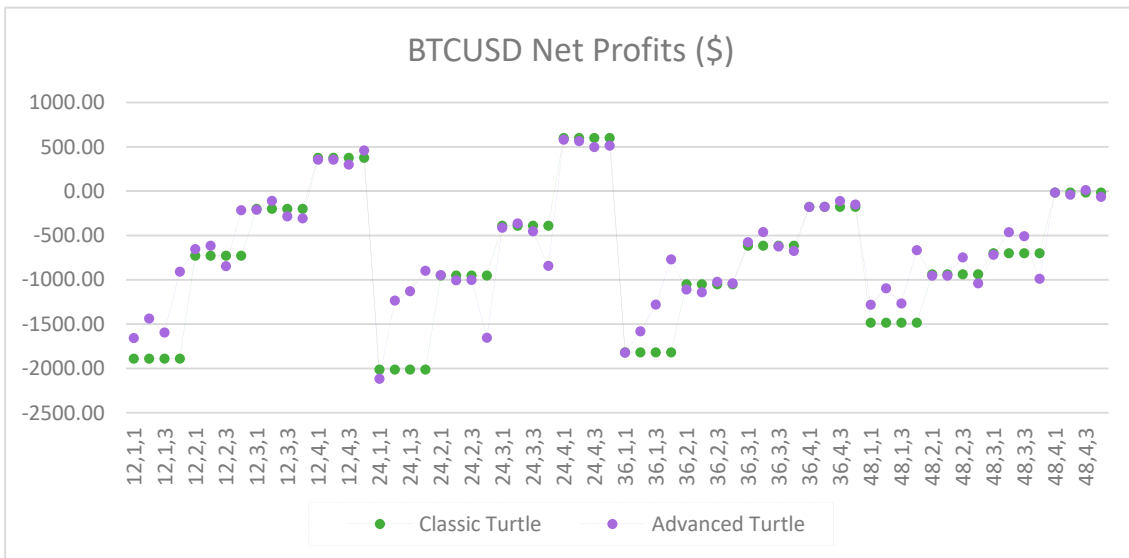


Figure A31. Net profits of BTCUSD between the classic and the advanced Turtle systems for every combination of N, X, Y for the medium parameters (40, 80).

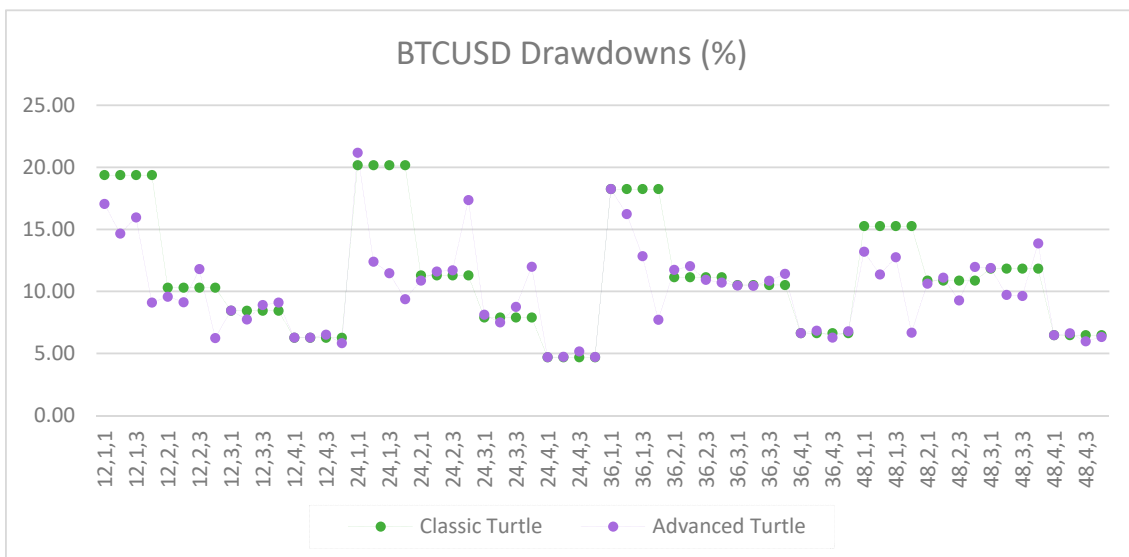


Figure A32. Drawdowns of BTCUSD as percentage of equity between the classic and the advanced Turtle systems for every combination of N, X, Y for the medium parameters (40, 80).

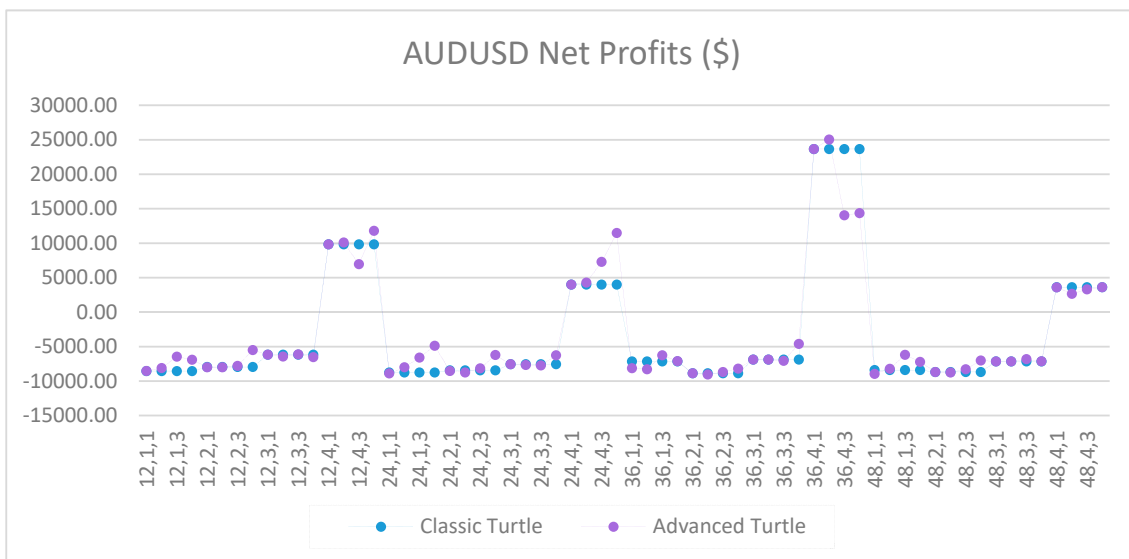


Figure A33. Net profits of AUDUSD between the classic and the advanced Turtle systems for every combination of N, X, Y for the slow parameters (80, 160).

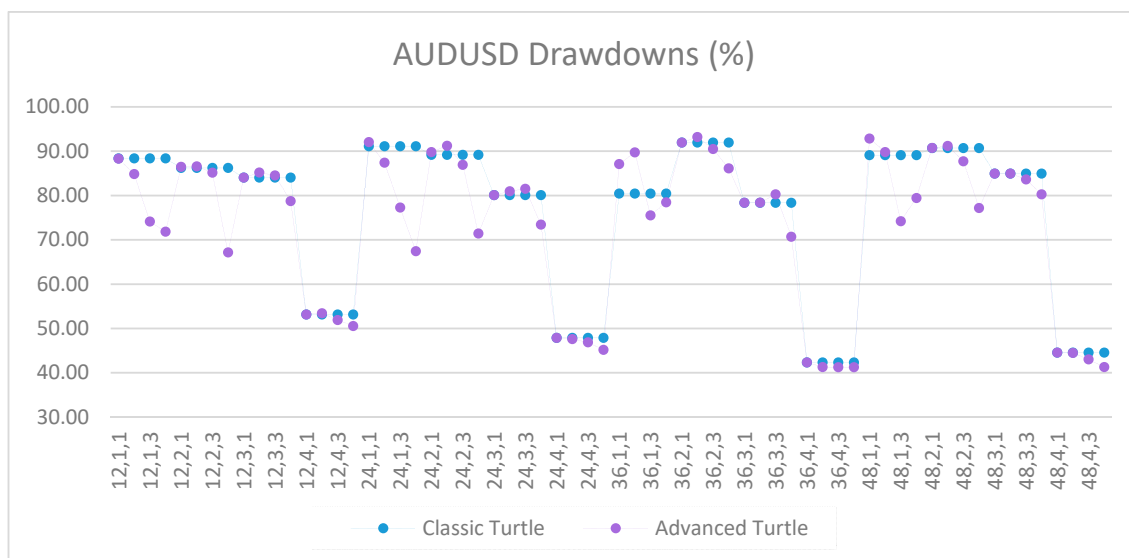


Figure A34. Drawdowns of AUDUSD as percentage of equity between the classic and the advanced Turtle systems for every combination of N, X, Y for the slow parameters (80, 160).

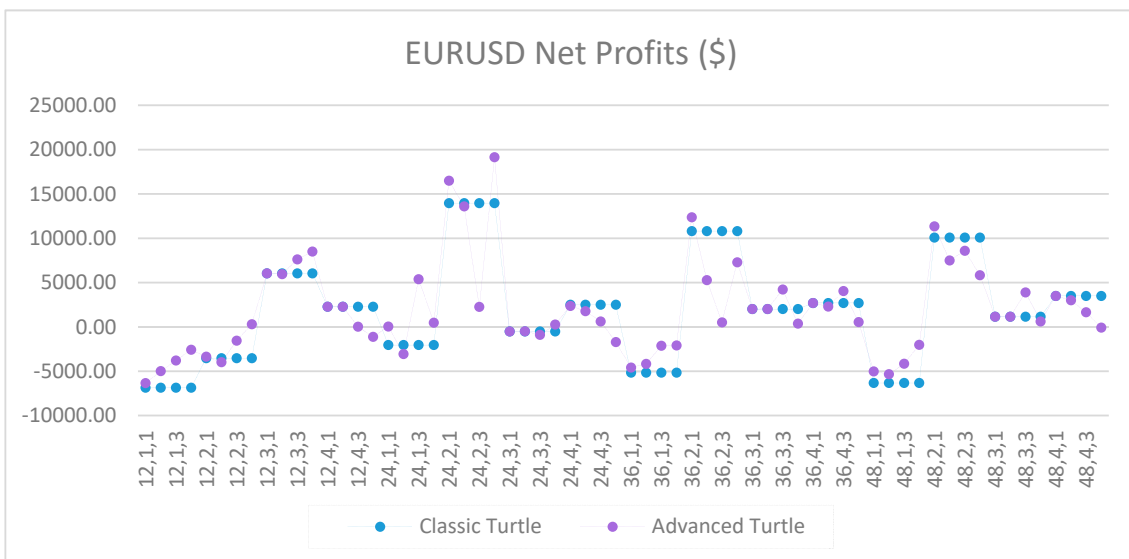


Figure A35. Net profits of EURUSD between the classic and the advanced Turtle systems for every combination of N, X, Y for the slow parameters (80, 160).

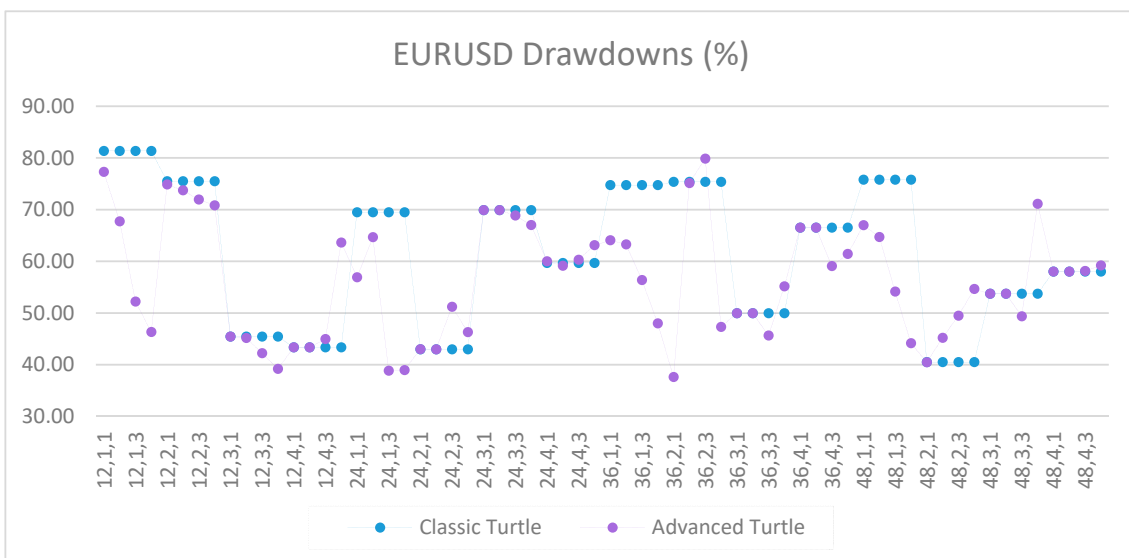


Figure A36. Drawdowns of EURUSD as percentage of equity between the classic and the advanced Turtle systems for every combination of N, X, Y for the slow parameters (80, 160).

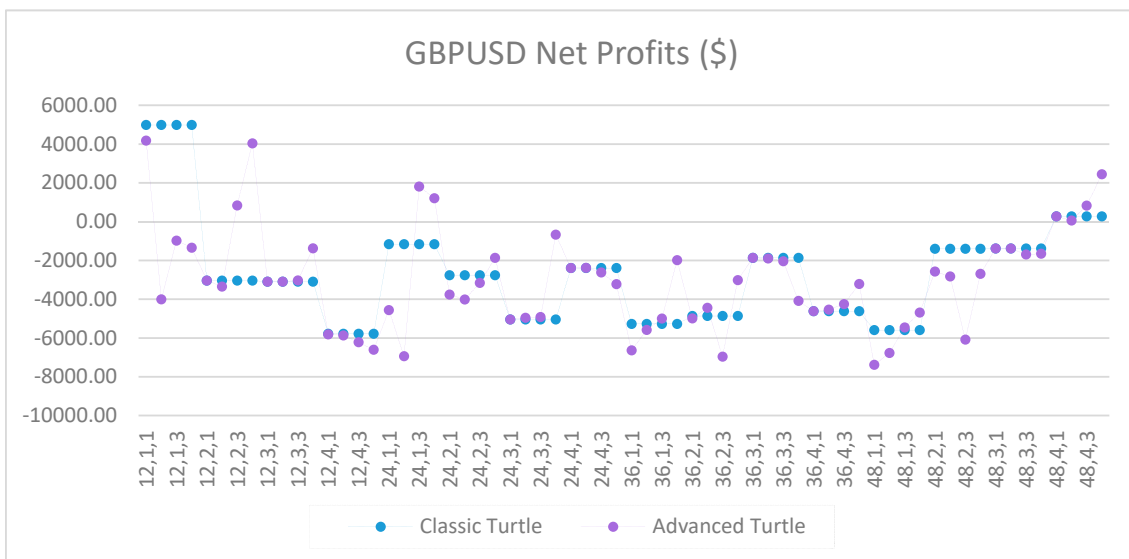


Figure A37. Net profits of GBPUSD between the classic and the advanced Turtle systems for every combination of N, X, Y for the slow parameters (80, 160).

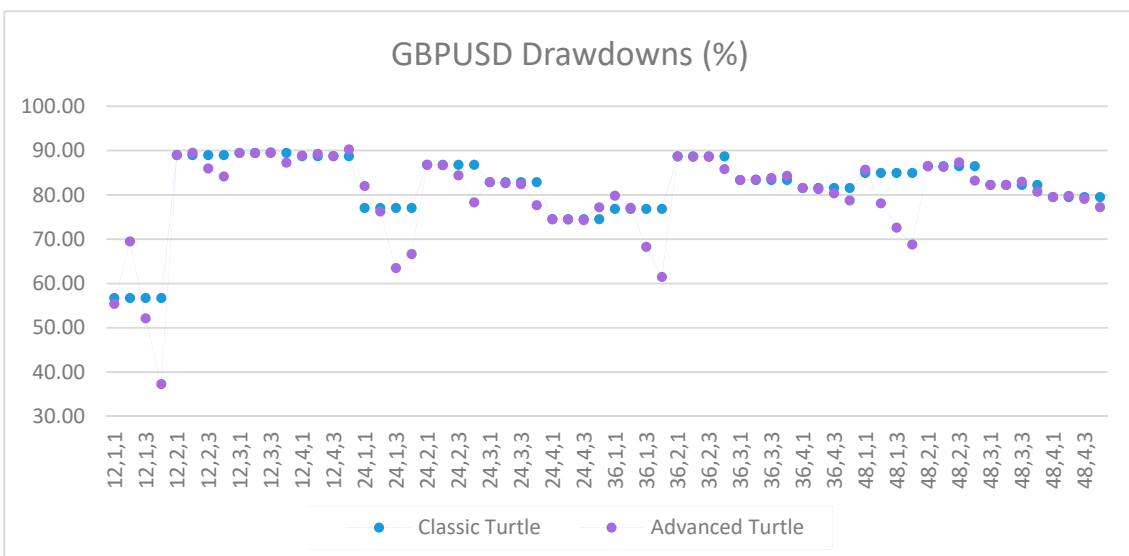


Figure A38. Drawdowns of GBPUSD as percentage of equity between the classic and the advanced Turtle systems for every combination of N, X, Y for the slow parameters (80, 160).

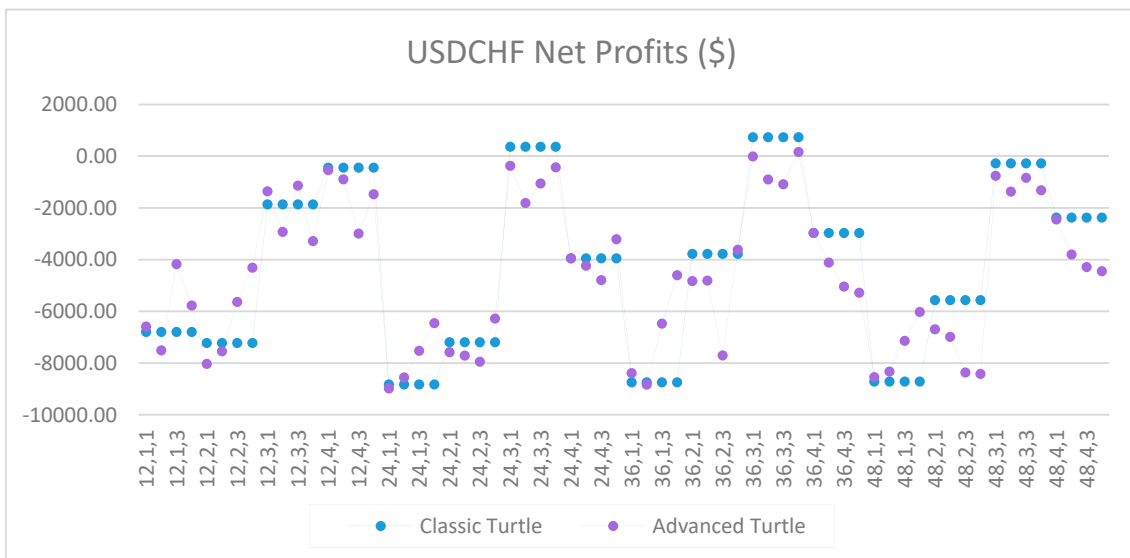


Figure A39. Net profits of USDCHF between the classic and the advanced Turtle systems for every combination of N, X, Y for the slow parameters (80, 160).

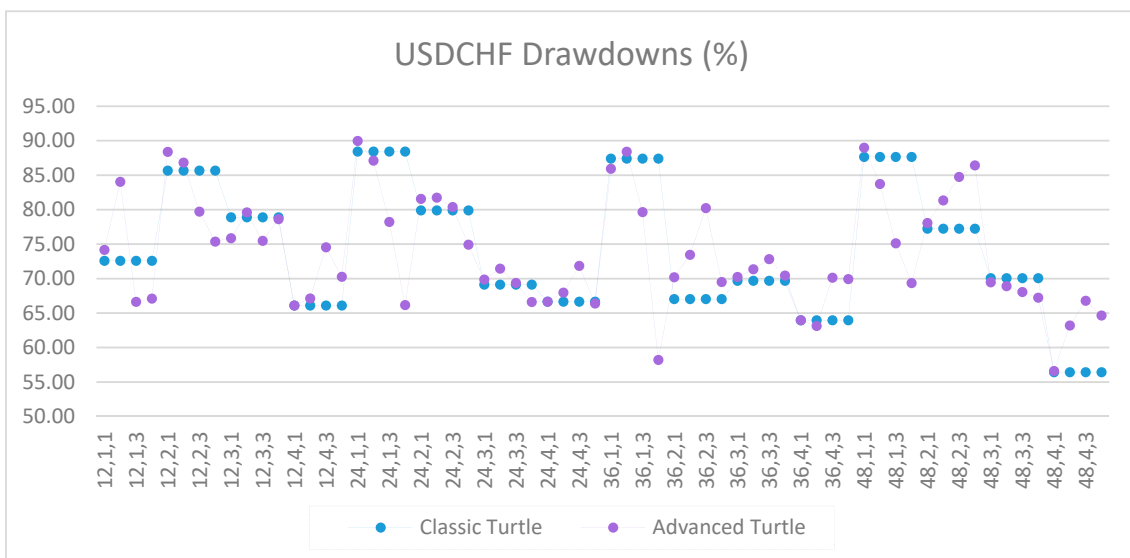


Figure A40. Drawdowns of USDCHF as percentage of equity between the classic and the advanced Turtle systems for every combination of N, X, Y for the slow parameters (80, 160).

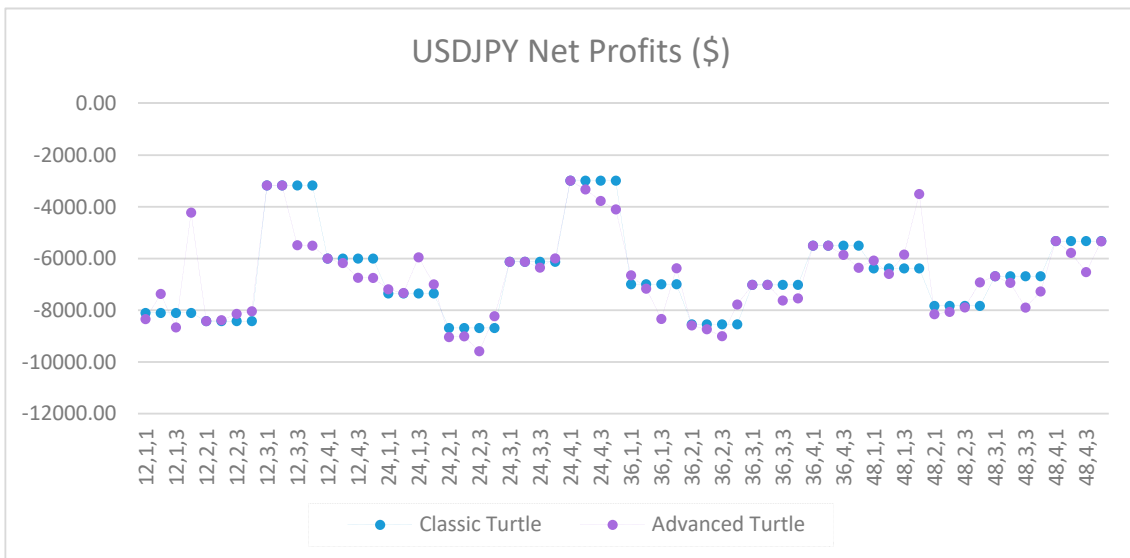


Figure A41. Net profits of USDJPY between the classic and the advanced Turtle systems for every combination of N, X, Y for the slow parameters (80, 160).

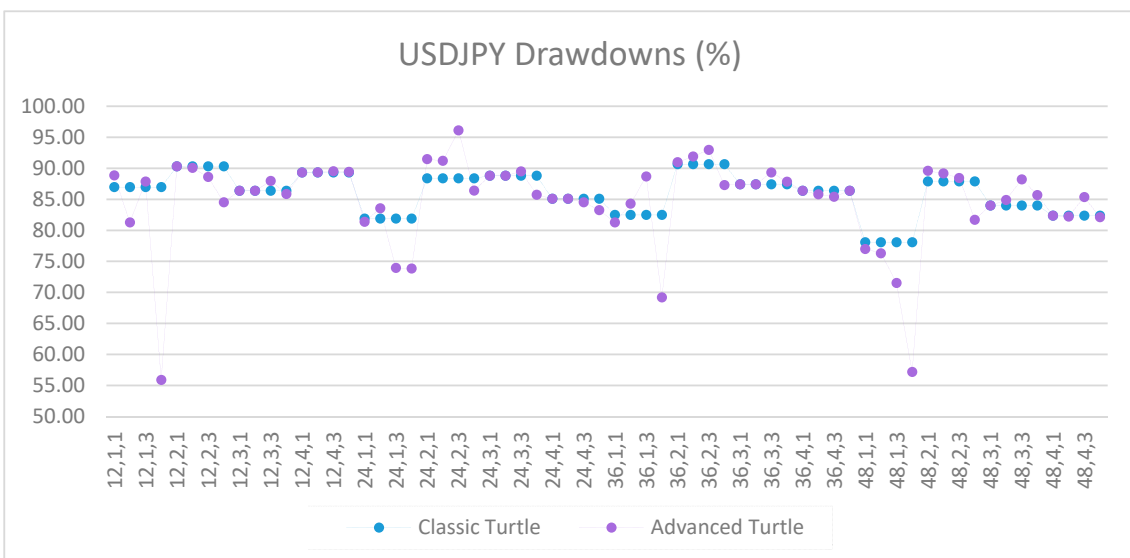


Figure A42. Drawdowns of USDJPY as percentage of equity between the classic and the advanced Turtle systems for every combination of N, X, Y for the slow parameters (80, 160).

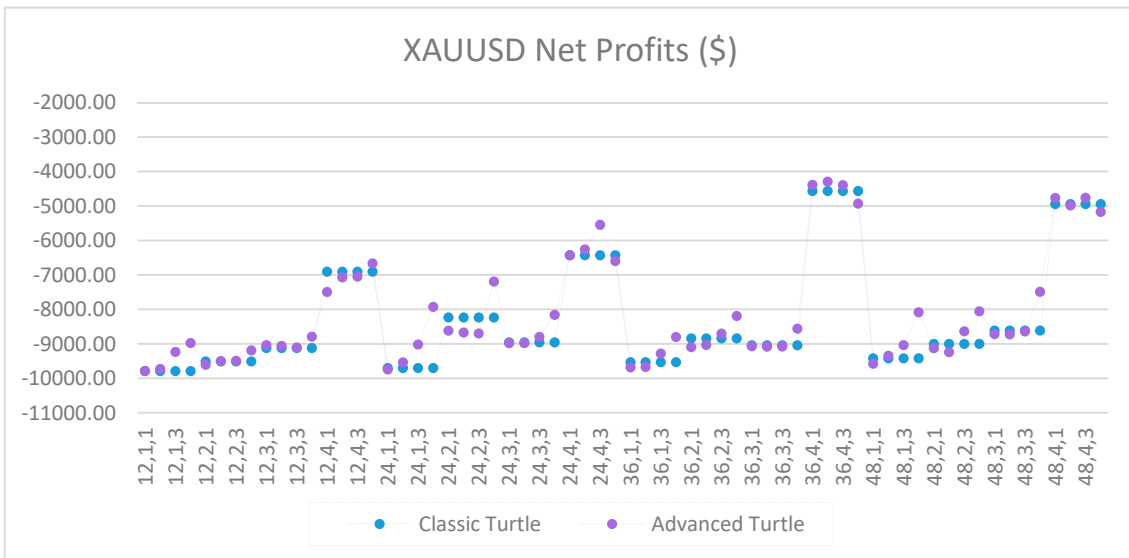


Figure A43. Net profits of XAUUSD between the classic and the advanced Turtle systems for every combination of N, X, Y for the slow parameters (80, 160).

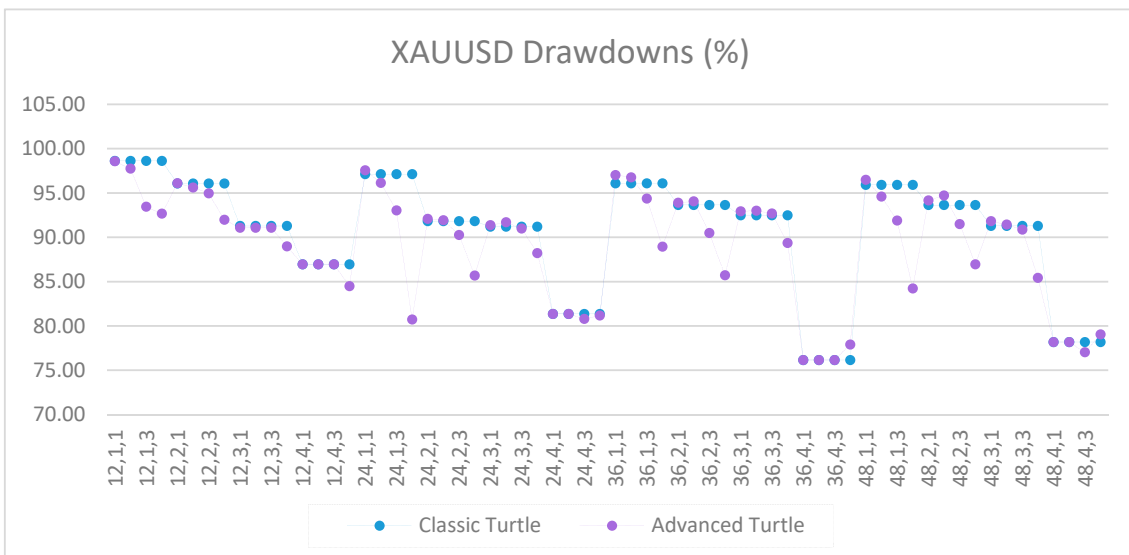


Figure A44. Drawdowns of XAUUSD as percentage of equity between the classic and the advanced Turtle systems for every combination of N, X, Y for the slow parameters (80, 160).

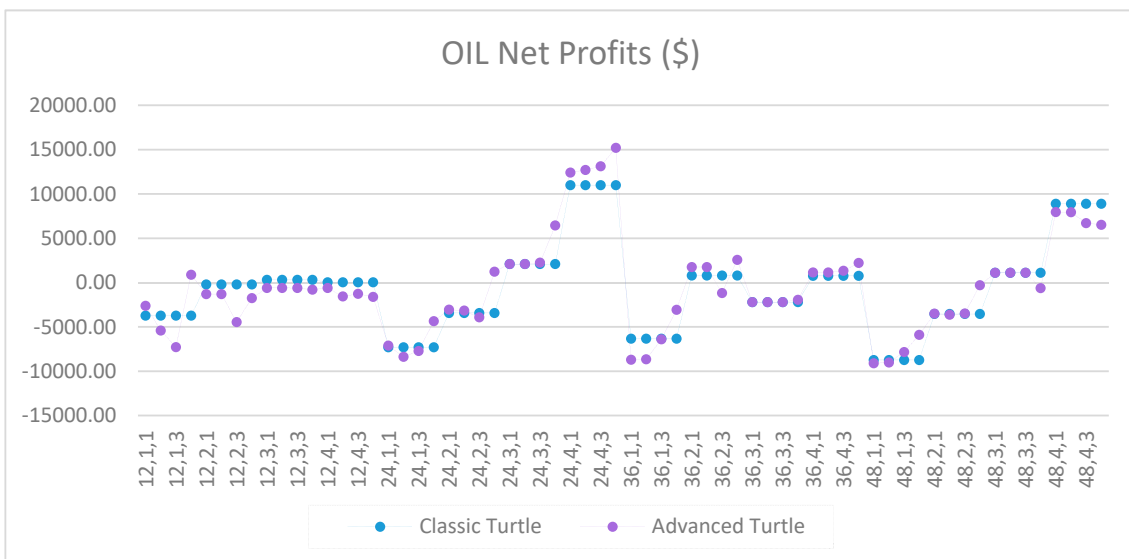


Figure A45. Net profits of OIL between the classic and the advanced Turtle systems for every combination of N, X, Y for the slow parameters (80, 160).

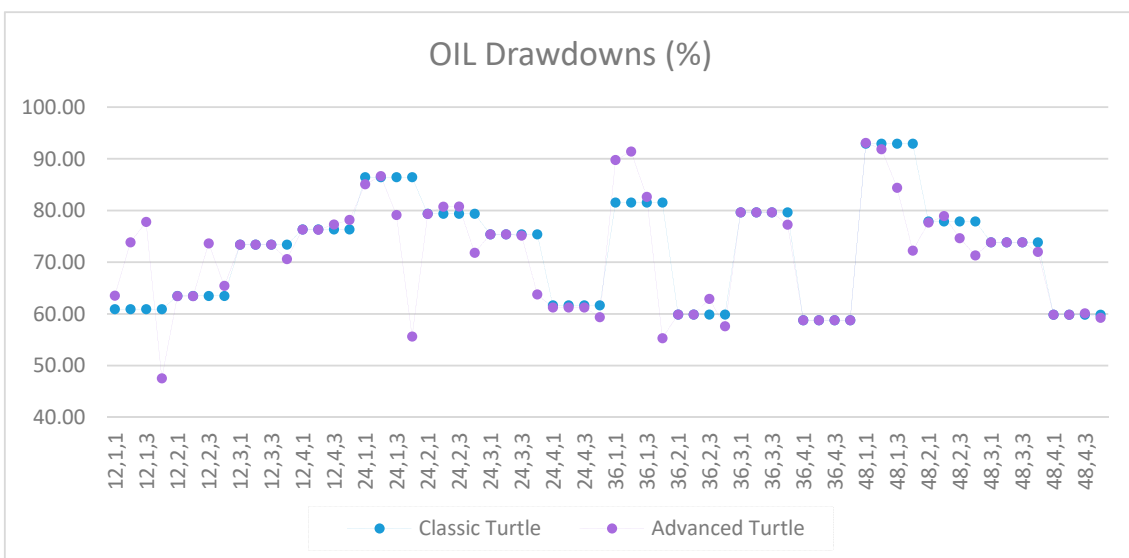


Figure A46. Drawdowns of OIL as percentage of equity between the classic and the advanced Turtle systems for every combination of N, X, Y for the slow parameters (80, 160).

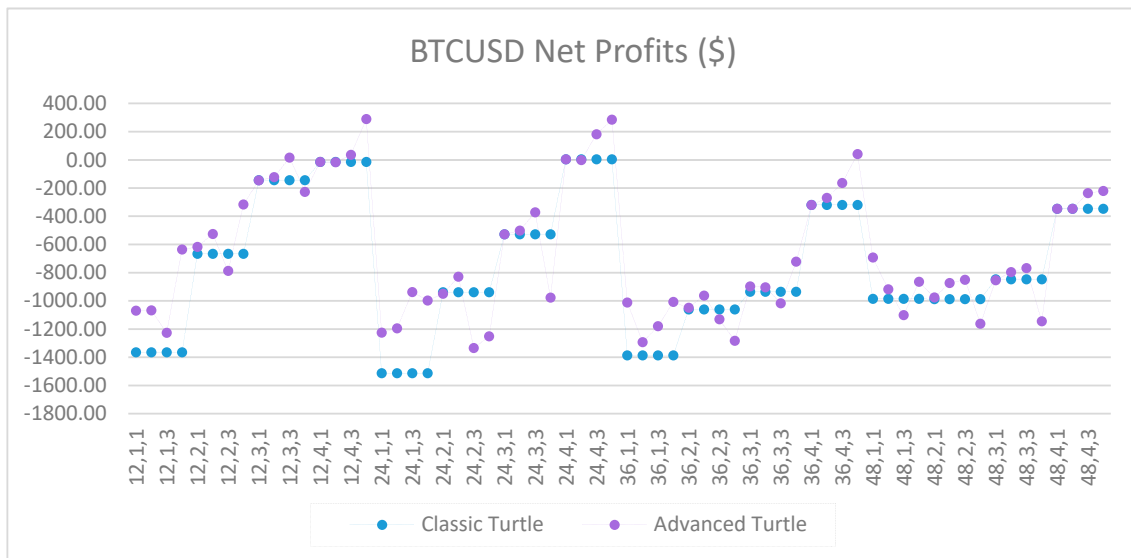


Figure A47. Net profits of BTCUSD between the classic and the advanced Turtle systems for every combination of N, X, Y for the slow parameters (80, 160).

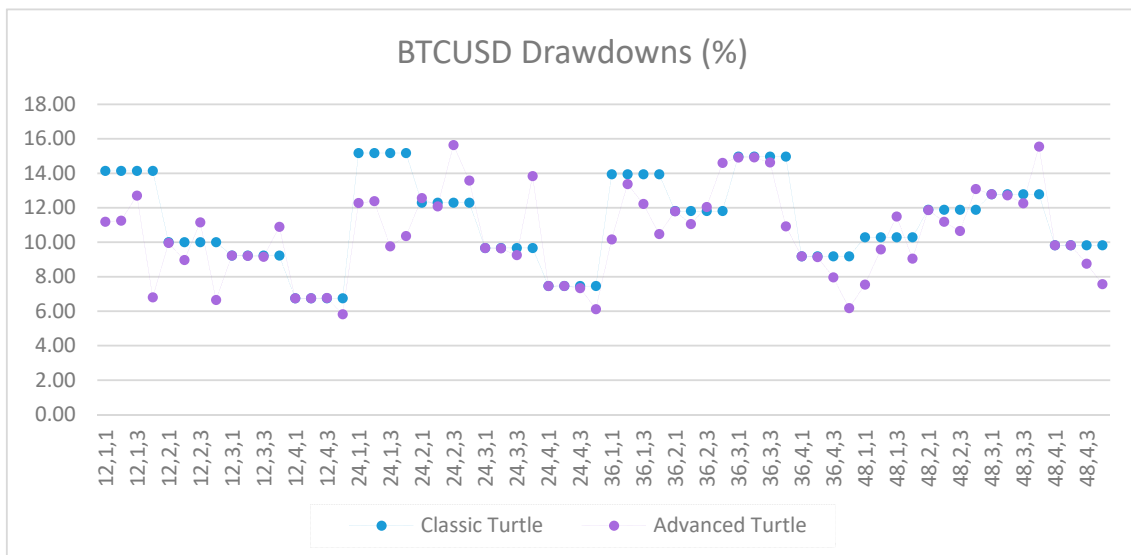


Figure A48. Drawdowns of BTCUSD as percentage of equity between the classic and the advanced Turtle systems for every combination of N, X, Y for the slow parameters (80, 160).

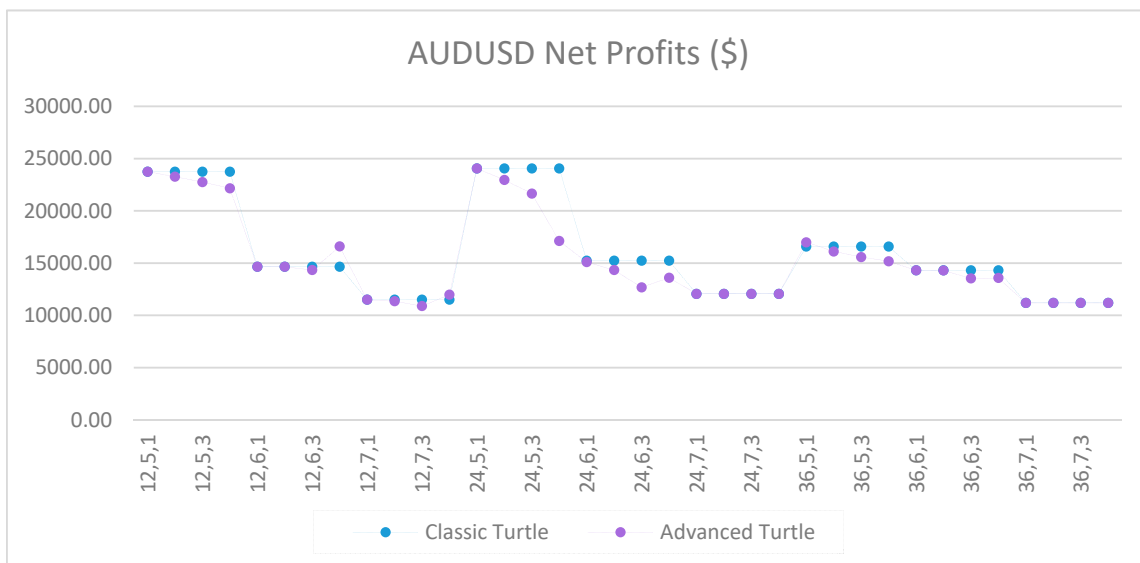


Figure A49. Net profits of BTCUSD between the classic and the advanced Turtle systems for every combination of N, X, Y for the slow parameters (80, 160), where $X \geq 5$.

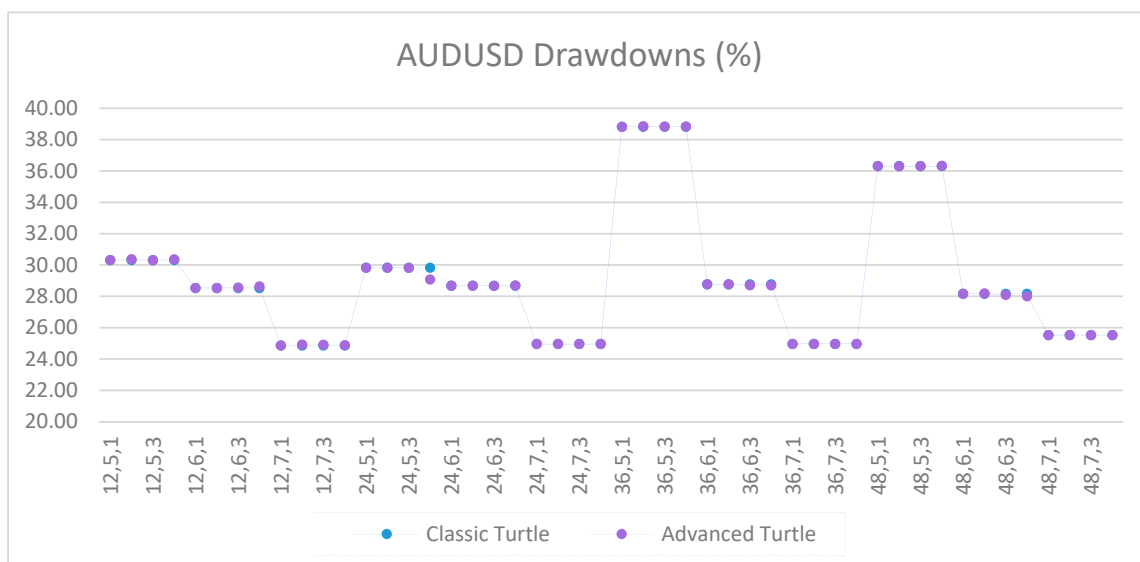


Figure A50. Drawdowns of BTCUSD as percentage of equity between the classic and the advanced Turtle systems for every combination of N, X, Y for the slow parameters (80, 160), where $X \geq 5$.

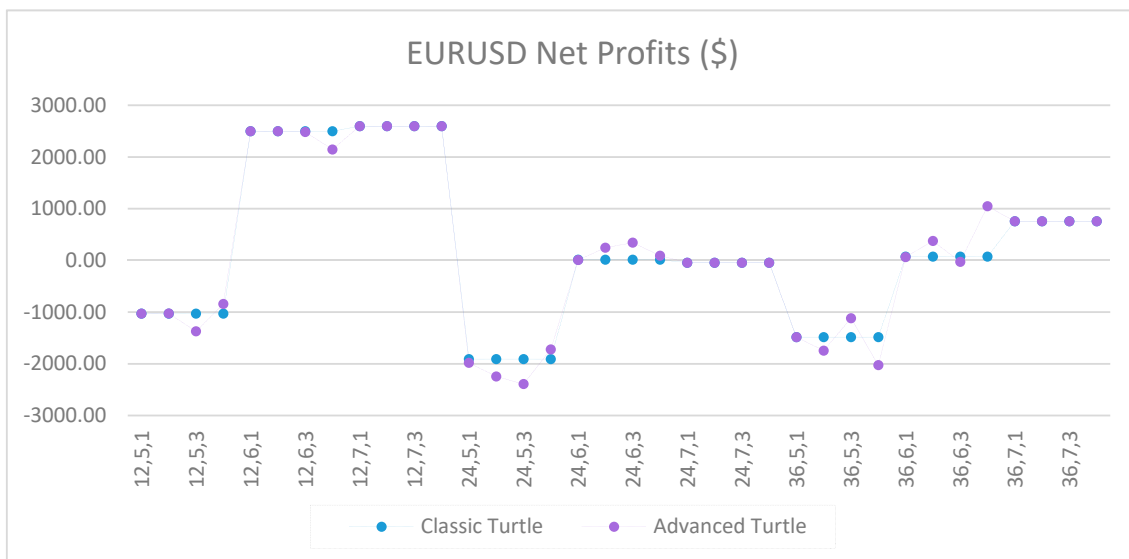


Figure A51. Net profits of EURUSD between the classic and the advanced Turtle systems for every combination of N, X, Y for the slow parameters (80, 160), where $X \geq 5$.

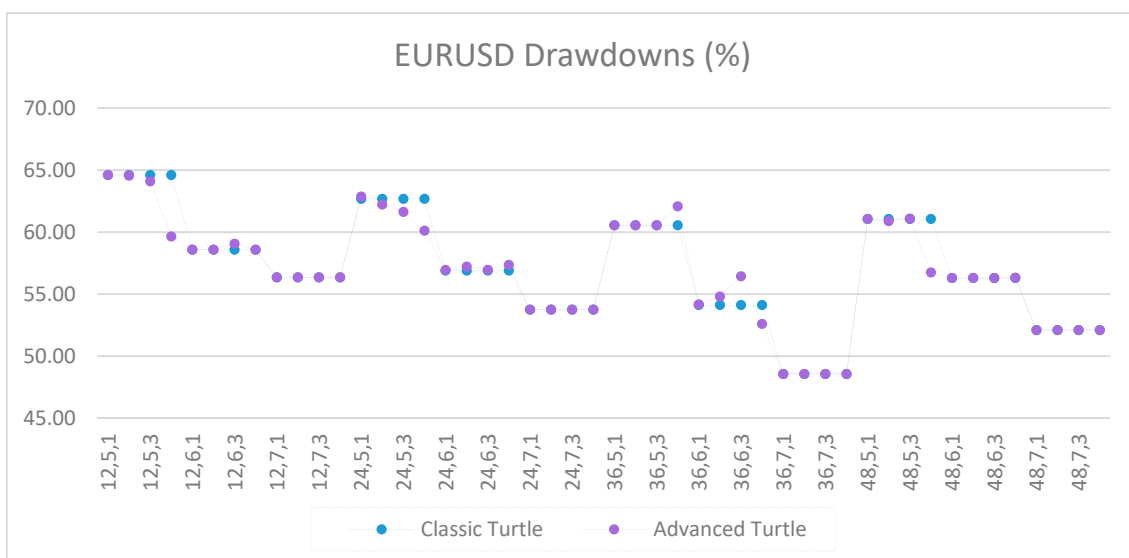


Figure A52. Drawdowns of EURUSD as percentage of equity between the classic and the advanced Turtle systems for every combination of N, X, Y for the slow parameters (80, 160), where $X \geq 5$.

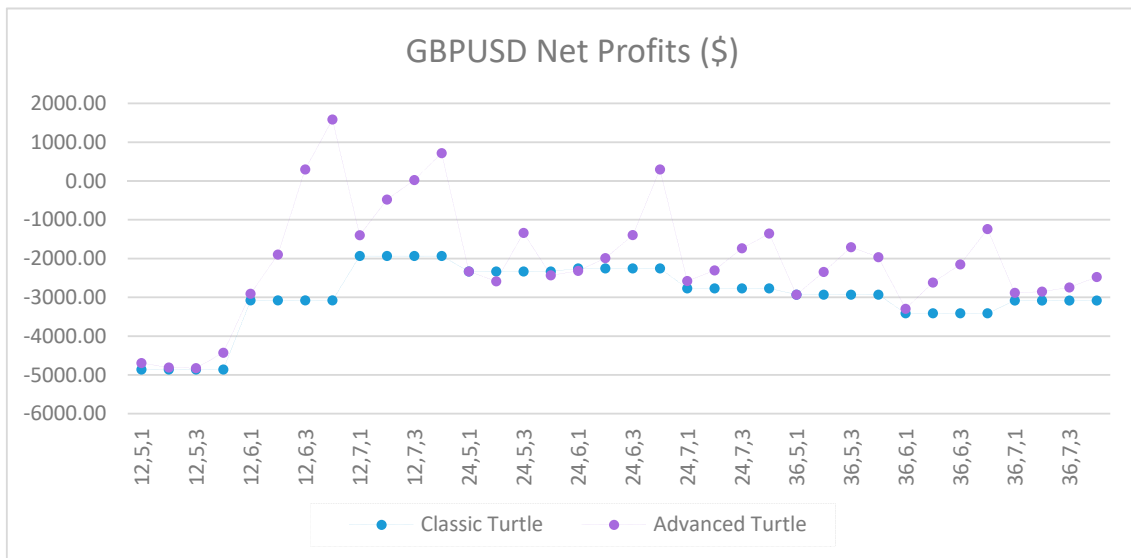


Figure A53. Net profits of GBPUSD between the classic and the advanced Turtle systems for every combination of N, X, Y for the slow parameters (80, 160), where $X \geq 5$.

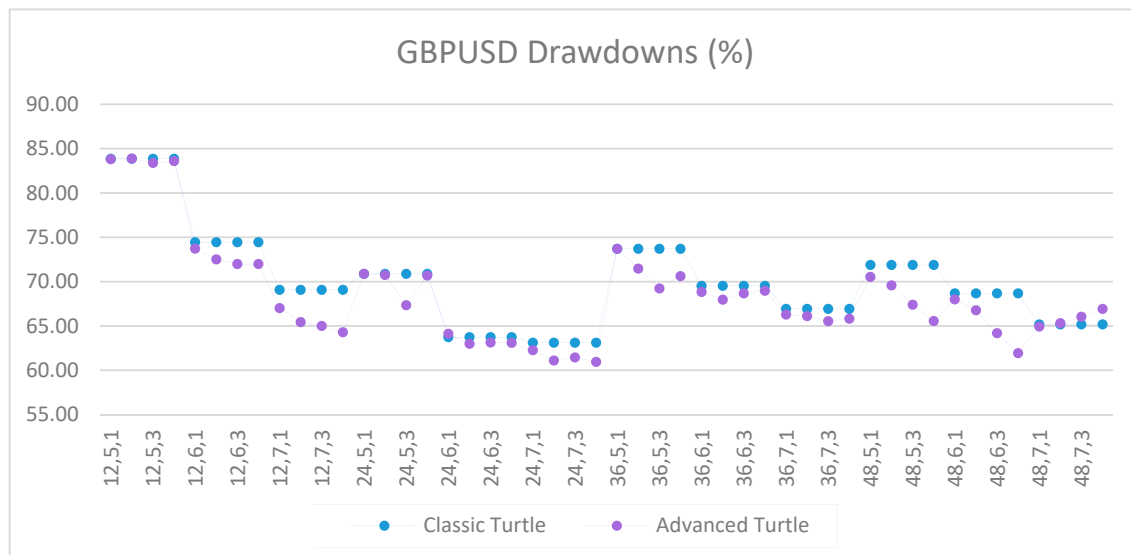


Figure A54. Drawdowns of GBPUSD as percentage of equity between the classic and the advanced Turtle systems for every combination of N, X, Y for the slow parameters (80, 160), where $X \geq 5$.

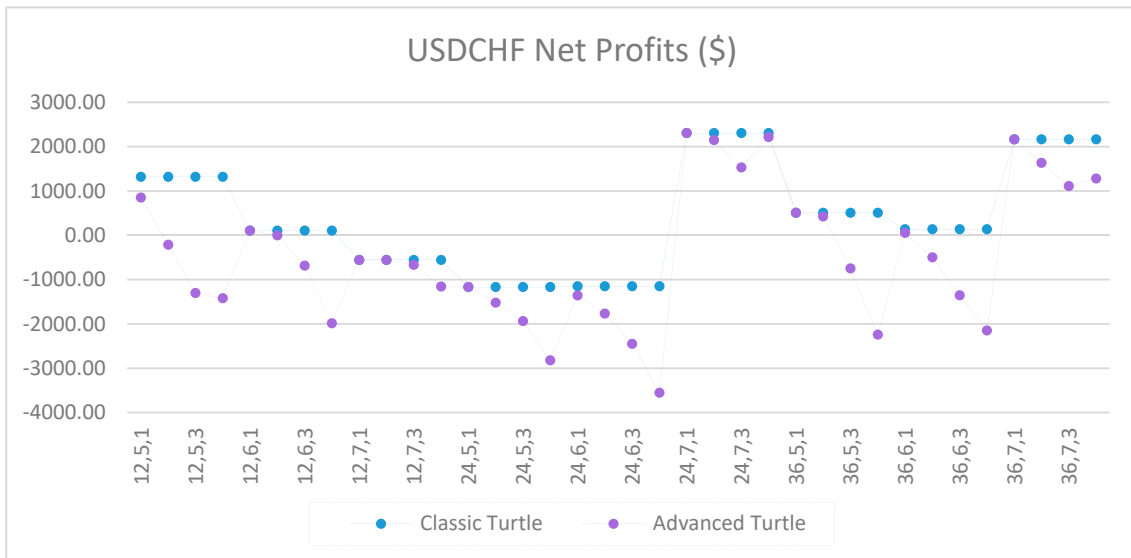


Figure A55. Net profits of USDCHF between the classic and the advanced Turtle systems for every combination of N, X, Y for the slow parameters (80, 160), where $X \geq 5$.

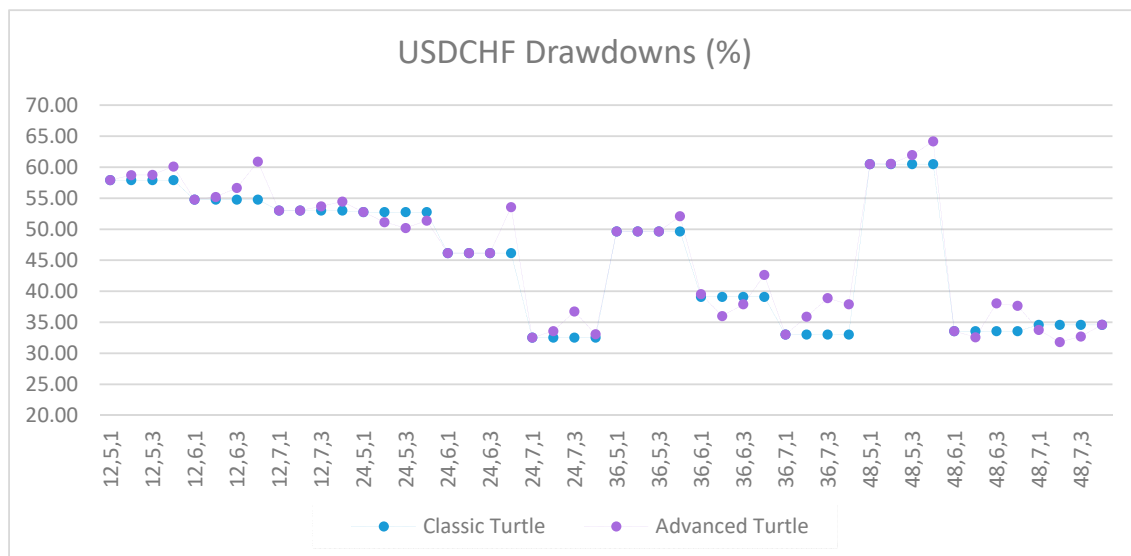


Figure A56. Drawdowns of USDCHF as percentage of equity between the classic and the advanced Turtle systems for every combination of N, X, Y for the slow parameters (80, 160), where $X \geq 5$.

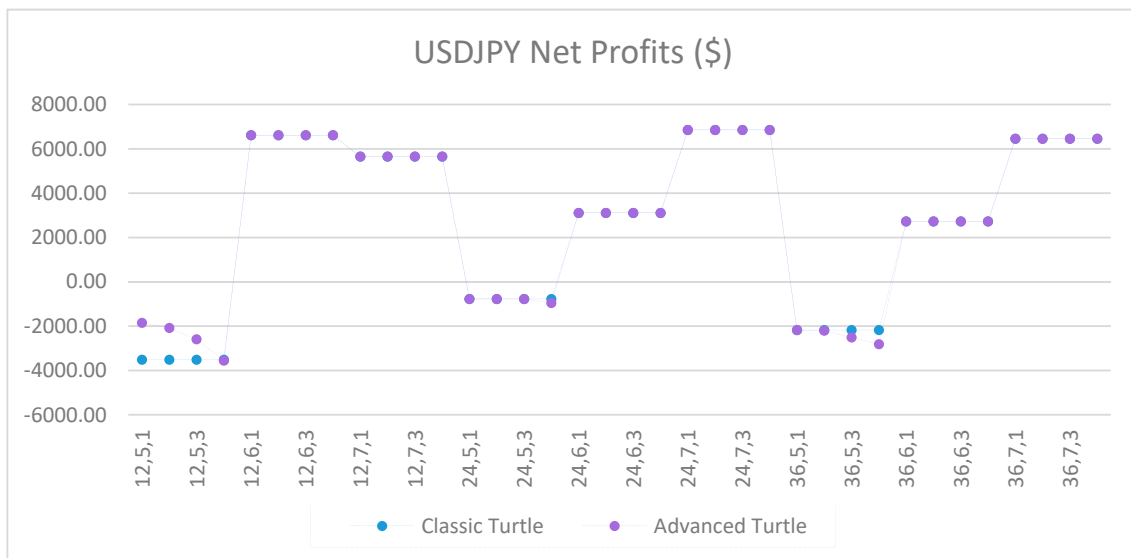


Figure A57. Net profits of USDJPY between the classic and the advanced Turtle systems for every combination of N, X, Y for the slow parameters (80, 160), where $X \geq 5$.

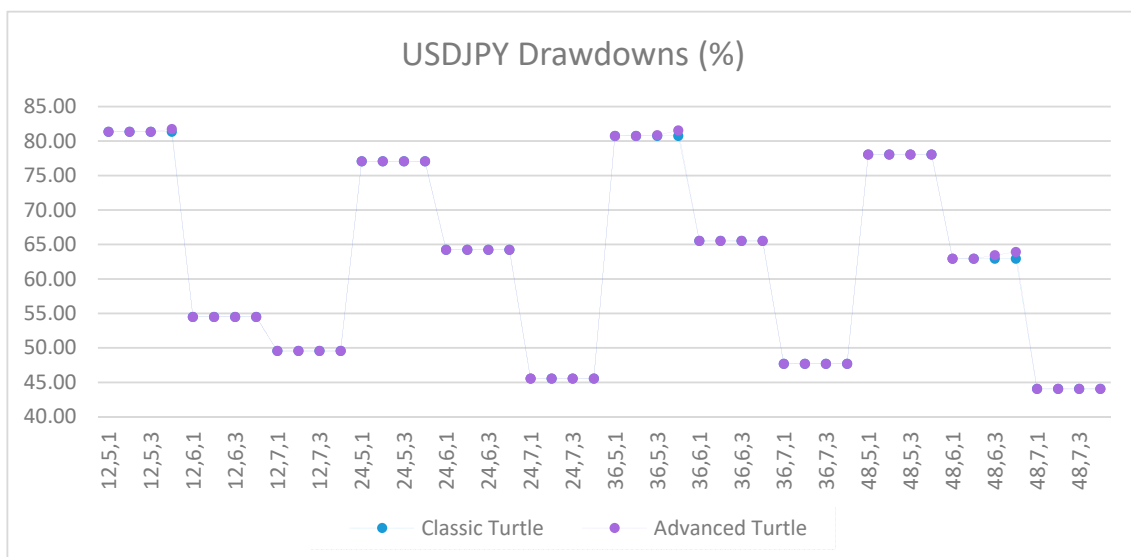


Figure A58. Drawdowns of USDJPY as percentage of equity between the classic and the advanced Turtle systems for every combination of N, X, Y for the slow parameters (80, 160), where $X \geq 5$.

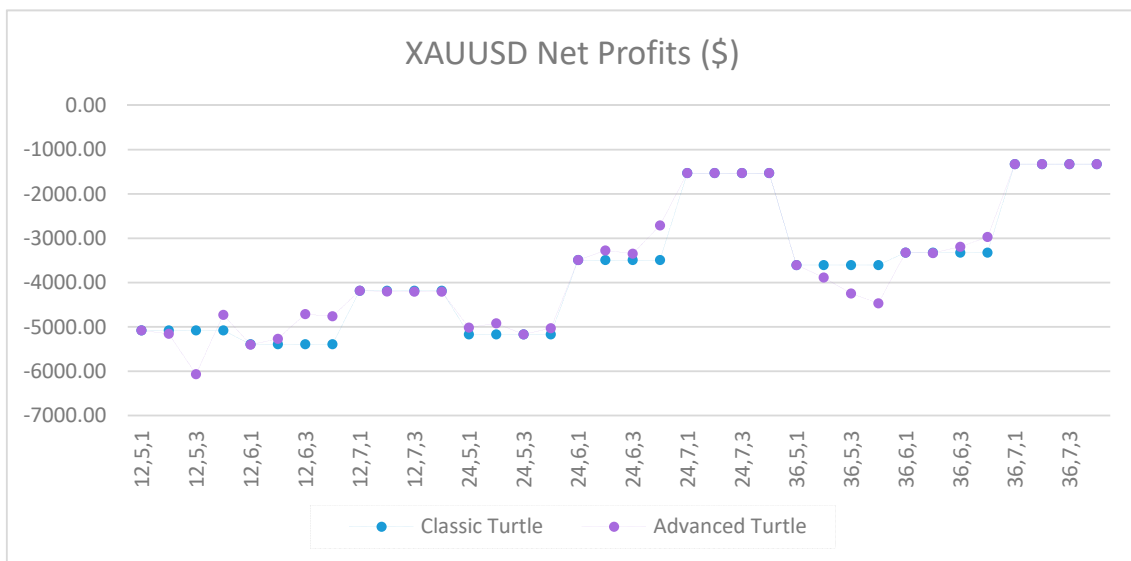


Figure A59. Net profits of XAUUSD between the classic and the advanced Turtle systems for every combination of N, X, Y for the slow parameters (80, 160), where $X \geq 5$.

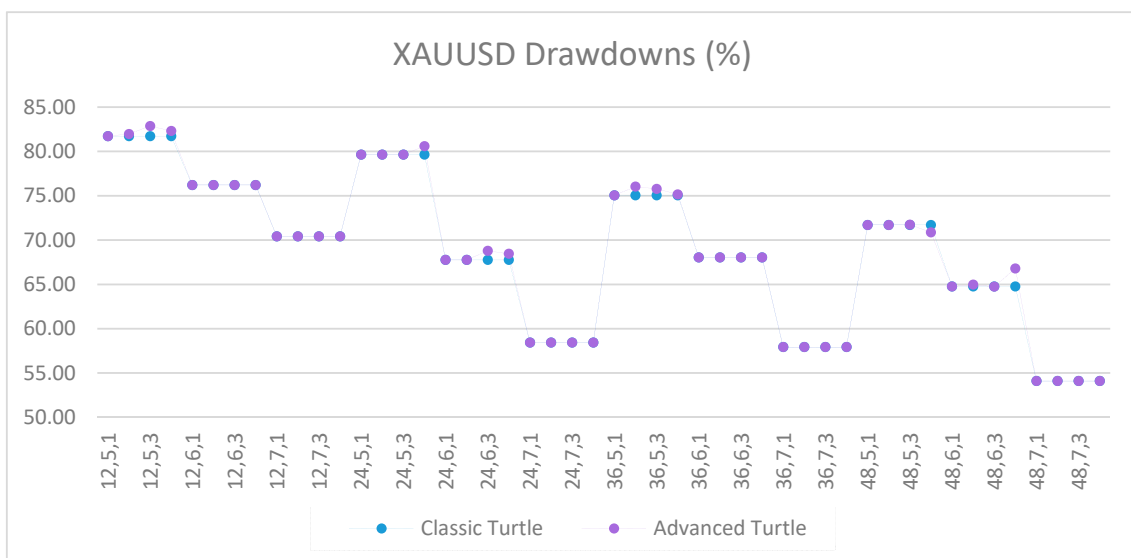


Figure A60. Drawdowns of XAUUSD as percentage of equity between the classic and the advanced Turtle systems for every combination of N, X, Y for the slow parameters (80, 160), where $X \geq 5$.

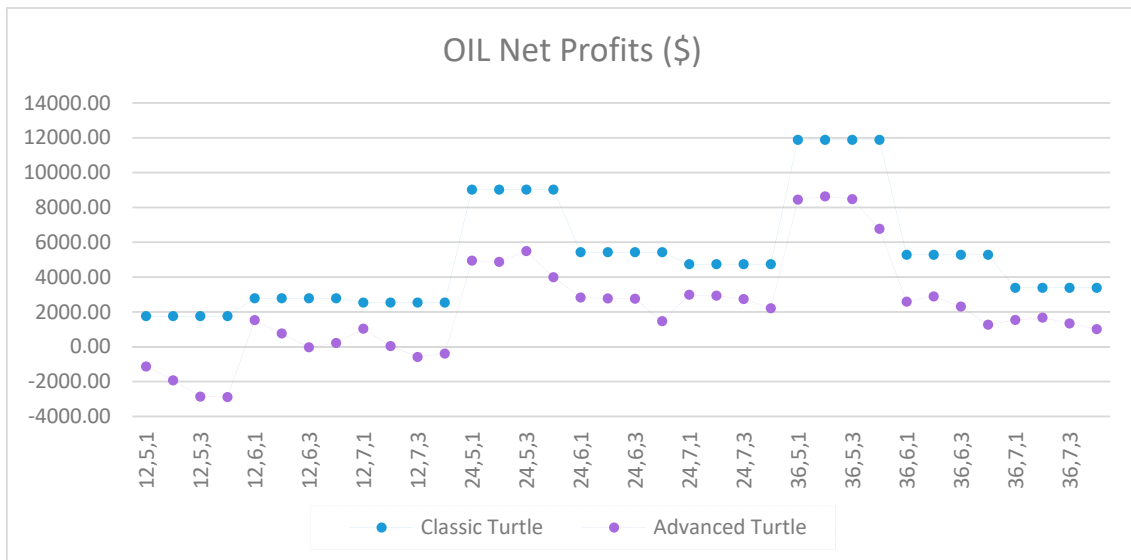


Figure A61. Net profits of OIL between the classic and the advanced Turtle systems for every combination of N, X, Y for the slow parameters (80, 160), where $X \geq 5$.

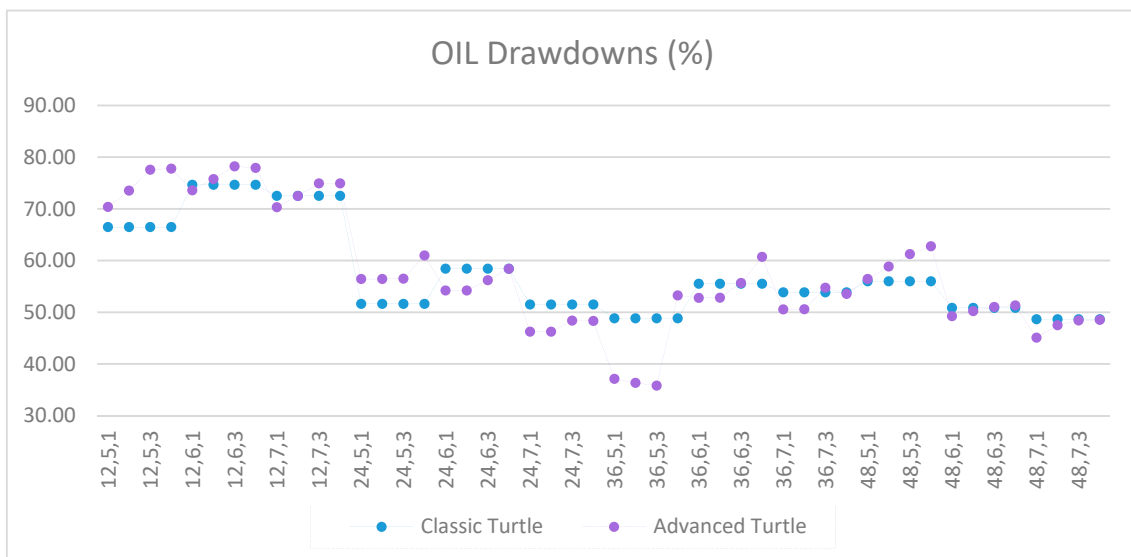


Figure A62. Drawdowns of OIL as percentage of equity between the classic and the advanced Turtle systems for every combination of N, X, Y for the slow parameters (80, 160), where $X \geq 5$.

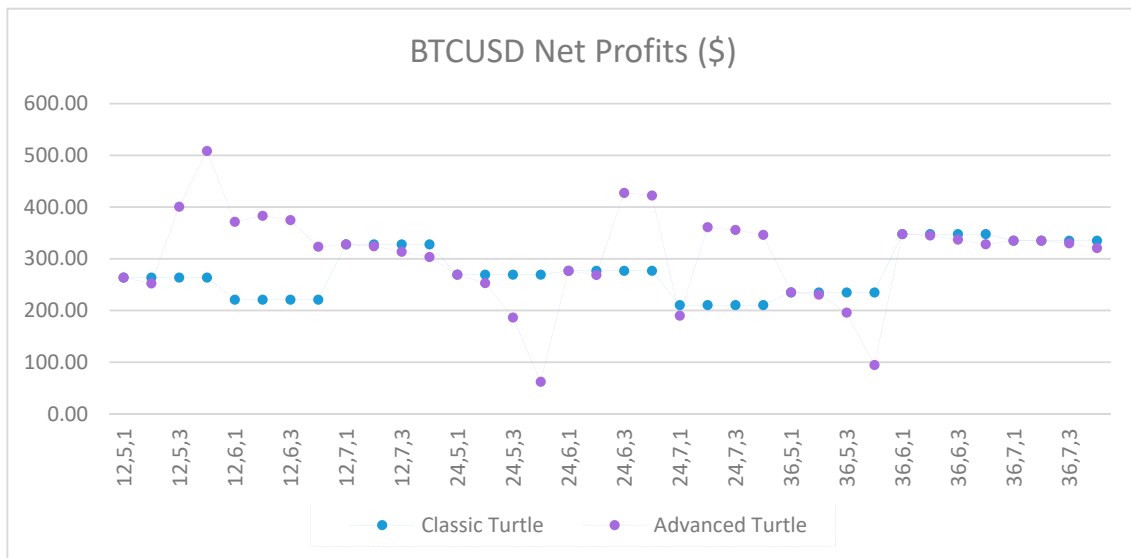


Figure A63. Net profits of BTCUSD between the classic and the advanced Turtle systems for every combination of N, X, Y for the slow parameters (80, 160), where $X \geq 5$.

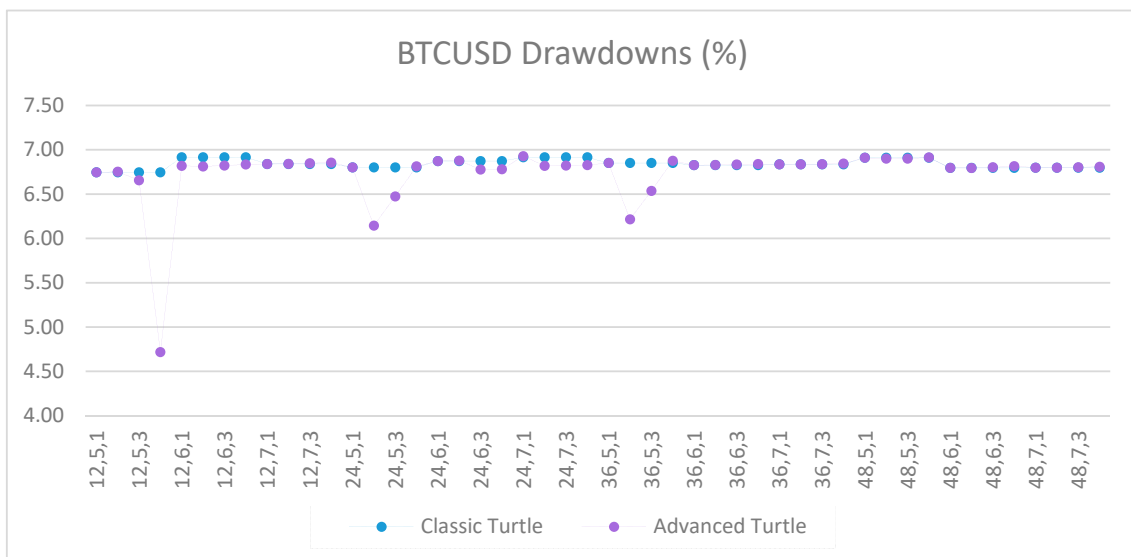


Figure A64. Drawdowns of BTCUSD as percentage of equity between the classic and the advanced Turtle systems for every combination of N, X, Y for the slow parameters (80, 160), where $X \geq 5$.

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