(Almost) Everything You Wanted To Know About FX Volatility Smile (Part II) —Exotic Options, Vol Dynamic, and Everything in Between.

Harel Jacobson · Follow

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86 1

We continue our journey into the FX derivatives jungle exactly where we left off (if you are just joining, feel free to read Part I). So far, we have mapped the FX market landscape, got to know the different players (and the nature of their flow), learned about quoting conventions, and did basic implied volatility modeling using liquid (quoted) volatility points (ATM, RR, BF).

In Part II of this write-up, we will understand why dealers choose to quote/trade specific strategies (namely Risk-Reversal and Butterfly), how the volatility smile reflects market implied skew and convexity, and how the evolution of exotic derivatives greeks affects dealers trading in vega and gamma space.

So let's dive in…

Underneath The Surface

By now, we know that the implied volatility surface in FX space is constructed off ATM, RR, and BF (which struck at 25-delta and 10-delta strikes), but we never answered a simple question (to begin with) — "why is it conventional to quote these specific strategies and specific delta-strikes?". When I was a junior analyst learning vol modeling for the first time, I was curious about that as it didn't seem trivial that this is how implied volatility is modeled. Luckily, a senior quant at the firm that worked at was kind enough to explain to me how options dealers approach surface modeling in FX, so here it goes…

Before we touch on surface modeling, we will take a small pause and do a short premier about exotic derivatives in the FX space (you will see later how it all comes together, I promise…)

Since the FX space is traded almost exclusively in the OTC market (hence, it can be tailored to clients' specifications), it's highly common to trade exotic options/structures (both by hedgers and speculative investors).

We can distinguish between five main types of exotic options:

1. **Barrier Options** -these options are vanilla options with contingency (which makes them highly path-dependent). Knock-Out (KO) option will act as a plain vanilla option as long as the KO level is not touched, while Knock-In (KI) option **ONLY** becomes a vanilla option if the KI level is touched. There are further modifications we can apply (like how frequently the barrier is monitored), but the basics are the same.

2. **Payout Options (cash-or-nothing) —** these options pay a predefined/fixed payout contingent on the condition (trigger) being met. Among these options, we can find One-Touch (OT) / No-Touch (NT), and digital options. The main difference between digital options and touch options is that digital options are European style options (i.e., the trigger is observed once, at expiry), while touch options are American style options (continuous monitoring of the trigger level). Like 1st-generation exotics, we can add conditions to increase the leverage (cheapen the option price). For example, we can add triggers (so instead of a No-Touch, we can trade Double No-Touch, which increases the chances of the option being knocked out)

3. **Strikeless volatility contracts —** unlike vanilla-type options that have fixed strikes, strikeless volatility products allow investors to gain the purest exposure to realized/implied volatility. Products like Volatility Swaps and Correlation Swaps have constant gamma/vega exposure and pay/receive the difference between realized vol/correlation and a fixed vol/corr strike. Among these products, we can also find FVA (forward-vol agreement), which allows investors to gain exposure to the volatility term

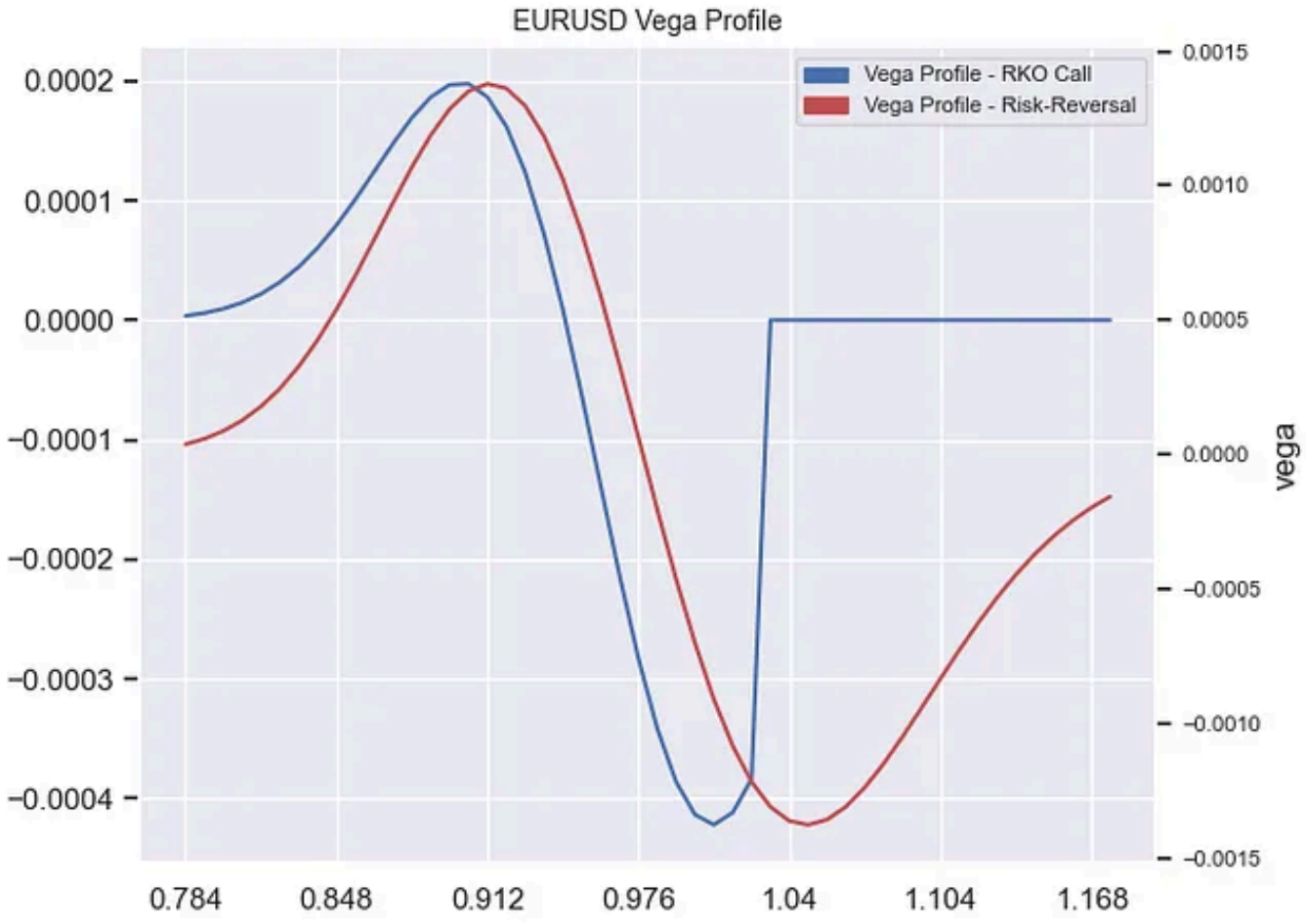
structure and forward volatility in a strikeless manner (unlike calendar spread).

4. **Forward Structures** — Forward structures are essentially strips of forwards with embedded optionality that allow the holder of the structure to pay/receive a stream of cashflows at a predefined rate. Used mostly by corporates to hedge payables/receivables, these products usually gain popularity when uncertainty grows in the market (or in periods of steep appreciation/depreciation of the local currency). As they are used to hedge future cashflows (usually with long duration), these products are traded further out on the term structure.
5. **Hybrid/Correlation products** — The correlation-based exotics are probably the poster child of financial innovation and quantitative finance. These products, which include structures like basket options (and "best-of"/"worst-of" baskets), dual currency binary options, and cross-asset structures, try to benefit from mispriced correlation to provide leverage to these products. It goes without saying that modeling them is highly difficult and requires "rocket-science" level quantitative models.

Now that we know the different types of exotic derivatives let's see how they affect the smile construction…

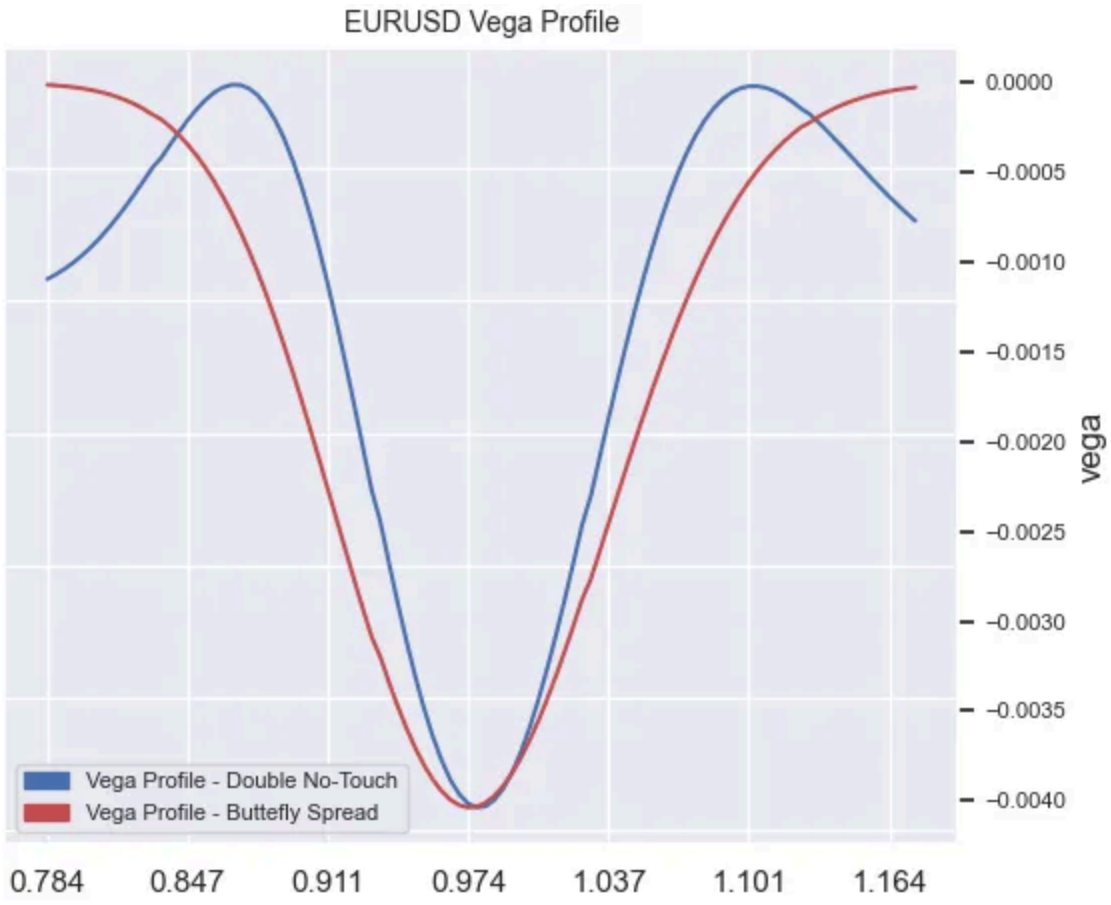
Generally speaking, barrier options are as popular as vanilla options in the FX derivatives space (with their bid/ask spread quoted almost as tight as vanilla options). Both sell-side and buy-side like them as a way to cheapen an option strategy (compared to the equivalent vanilla price), and therefore dealers tend to run a fairly large exotic derivatives book of KO/KI (and reverse KO/KI, where the barrier struck in-the-money). The problem with managing the risk of exotic options is the fact that their risk is discontinuous

around the barrier level (and towards the barrier, to some extent). Ideally, one would want to use "static replication" to hedge that risk, that is, create a portfolio of vanilla options that generate the same exposure (payoff) to offset the risk. The problem is that due to the path-dependent nature of these products, it's very hard to achieve such replication. What dealers usually do is hedge the associated "vega" risk (sensitivity to change in implied volatility). Because these options have multiple strike levels (i.e., vanilla strike and barrier strike), they are also exposed to the shape of the volatility smile or, in other words, the skew. Being that dealers inherit a significant ∂Vega∂Spot ("Vanna" — change in vega w.r.t spot), they mitigate that risk using risk-reversal strategies, as it has a very similar vega risk profile (and if we think about it, a KO option is just another form of skew trade, with a limited downside).



Vega Profile of RKO Call and 25-delta Risk Reversal

The other types of highly popular exotic derivatives are the payout options (cash-or-nothing). Options like touch (or double touch) options and digital options are regularly traded and are often used as a way to buy/sell volatility with a limited downside (payout is fixed) and, therefore, often don't require dynamic/delta hedging. Very much like 1st-generation exotics, it's very difficult to statically replicate these options, and dealers tend to hedge their associated "vega" risk. Unlike barrier options, payout options are, for the most part, sensitive to the change in implied vol and inherit a significant ∂Vega∂Vol ("Volga" — change in vega w.r.t implied vol). The way this risk is hedged, in most cases, is by using a butterfly strategy.



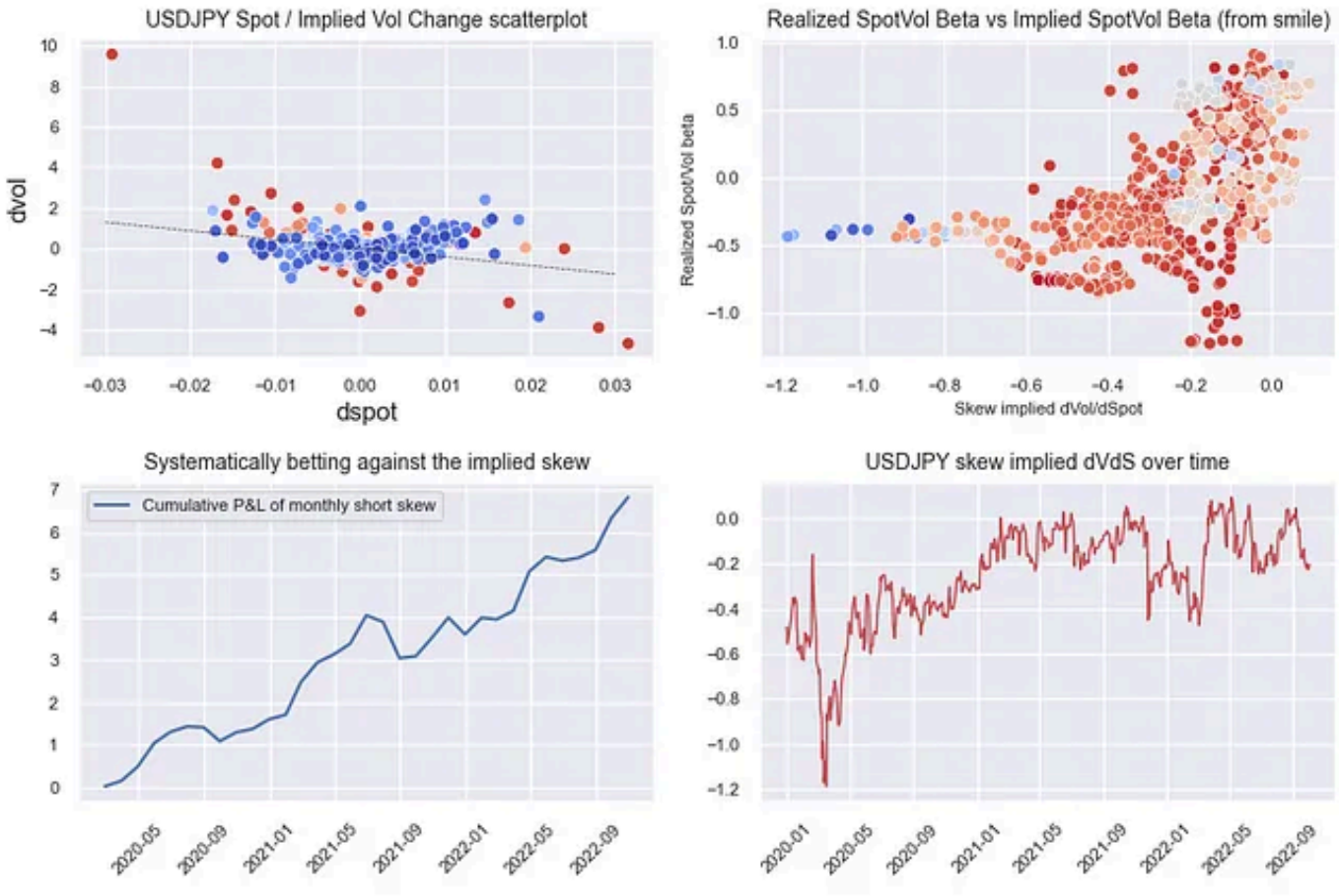
Vega Profile of Double No-Touch and a Butterfly Spread

As we can see, both RR and BF are regularly traded in the market as dealers use them to manage their exotic books and their associated risks. The

volatility smile is, therefore, derived from the additional hedging costs associated with managing exotic options risk (compared to the "flat volatility" assumption.

Assuming we all made this far through the write-up without getting completely confused, we shall take the level of complexity another notch higher…

When we talk about implied volatility smile (and throw in the air occasionally terms like "skew", "convexity", and "high-order moments"), we generally talk about the way the market perceives the way volatility evolves (and we know from derivatives class 101 that volatility itself follows some process, usually stochastic process like Brownian motion). When we think about it, volatility skew describes the "current" $\partial \text{Vol} \partial \text{Spot}$ (or, geometrically speaking, the slope of our spot/vol plot). Let's say we have no opinion about future implied vol, we can use the skew as a scenario analysis measure (sort of a "what if.." when testing different spot levels/changes). Now, it's important to note that, in some cases (if not most) the implied skew can be very different than the realized one (mostly because the implied skew incorporates some risk-premium (remember equity index skew and leveraged effect?). To emphasize that bias let's look at the below analysis of USDJPY 1-month implied (and realized) skew



As we can see above, skew, in most cases, largely overprices spot/vol beta (mostly due to hedging flows and protection buying). There is another level of complexity that I will not touch on in this write-up which is related to the "stickiness" of the smile (if you want to read about it, I wrote about that idea in one of my previous write-ups). To sum, the implied volatility smile gives us a current snapshot of the market expectations regarding the level of future (and future realized?) volatility, the spot/vol beta, and the volatility of volatility.

Now we can take everything we know so far about the FX volatility smile and take a seat at our desk workstation at Goldman Stanely.

A Trip Down Exotics Lane

derivatives so common in the FX space, and why the different players prefer them over simple vanilla strategies?"

To answer these questions we need to consider both the motivation on the buy-side and the sell-side to trade these products.

Let's start with the buy-side. Clearly, a buy-side practitioner is driven by cost and benefit (or risk-reward). Adding path-dependency is a contingency to a vanilla trade is equivalent to selling an option to your counterpart, so exotic options are, in a way, a limited-downside way to sell high-order risk. For example, when we buy a KO option (whether this is KO or RKO) we essentially sell a very leveraged call/put at the knock-out level, but unlike trading a "straight" risk-reversal, our downside is limited by the premium amount we paid. The usual suspects when we want to get a good discount (relative to plain vanilla) are KO-type options, as they increase the probability of the option expiring OTM (or triggered). These options would usually have a 1:5-1:10 discount over the equivalent vanilla.

Now that we understand why buy-side practitioners like exotics, let's understand why sell-side traders like them. There are usually two reasons why the sell-side is motivated to sell exotic options: 1. wider bid/ask spread than normal vanilla (sales desks literally live on that…), 2. trading desks can buy high-order greeks exposure (namely Vanna and Volga) for cheap (or cheaper than go and trade the outright vanilla strategies).

A typical day on my Bloomberg chat would be packed with sales desks trying to pitch some RKO options with a barrier struck 4–5% ITM for about 15–20bp

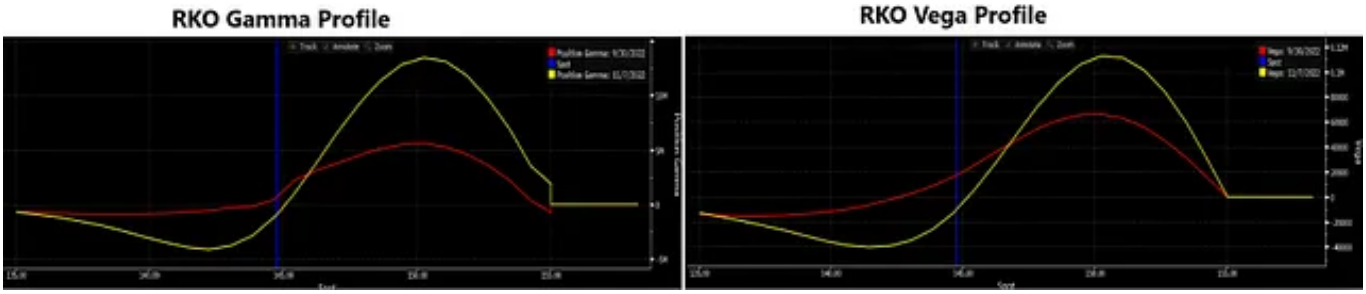
(0.15% — 0.2%) premium. Sometimes they are "axed" to trade them because they need to keep their greeks inventories under a certain threshold, but more often than not it's just like offering candies to sweet-tooth kids.

Breaking The Barriers

By now, we (kind of) have a good understanding of how the FX derivatives market works and the what, why, and hows of exotic derivatives. Now let's analyze how a typical RKO (Reverse Knock-Out) option works. A definition of RKO options is "an option that its chance of being triggered increases as its intrinsic value grows", meaning that the KO barrier is struck ITM.

Now, we are sitting at the JPY options desk at Goldman Stanley and our hedge-fund sales desk just sold a 250mio 2-month USDJPY 148 Call with RKO @ 155. Our initial greeks are as follows:

So we are pretty flat gamma/vega and paying some theta (which is not ideal, but we get theta from our vanilla book, so that's fine). Now let's take a look at the Vega/Gamma profiles over time:



If we run some basic scenario analysis, it seems like we get longer vega and longer gamma as the spot moves up, which kind of make sense, as we are essentially long a barrier (i.e., we would really want that barrier to hit and the option terminated). Here is where things really get interesting…

Usually, exotic options (and barrier options in particular) try to take advantage of the implied volatility smile (i.e., sell the expensive side of the skew), as it really cheapens the option relative to trading outright vanilla (and is perceived as "safer" trade than equivalent risk-reversal), so dealers, on average "get given" the skew (or the expensive side, to be exact). When spot moves towards the barrier they will get longer vega (and will probably need to sell to balance their books), and longer gamma (so they will have to sell delta to balance their directional exposure). This entire dynamic of dealers' exotic options hedging is one of the key drivers of the FX smile dynamic.

In a way, because 1st generation exotics (barrier and payout options) are discontinuous in their nature we can breakdown the dealers hedging strategy into two dynamics (that alternate at/around the barrier/trigger level):

1. as spot moves towards the KO barrier dealers get longer vega (and 2nd order vega derivatives like Vanna and Volga), so they, in theory, should sell the inherit vega coming from these options. Also, dealers get longer

gamma, so as the spot moves up/down they need to sell/buy delta (or take profit on their delta)

2. Once the barrier hits the option ceases to exist, so all the greeks that were traded against that option need to be unwound, which is why we often see a “wash” move at an area with a large cluster of barriers (usually in tandem with increasing implied vol/RR.

Clearly, there is a lot to digest now, as we covered in the write-up so far a lot of ground in the space of FX derivatives. In the closing part of this FX derivatives trilogy, we will look at what I think is the least explored, yet most interesting research area in the market and that is understanding the effect of dealers' positioning and the existence of exotic flows on spot/vol dynamic in the FX space.

Harel.

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Written by Harel Jacobson

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> which is why we often see a “wash” move at an area with a large cluster of barriers

could you please explain me the meaning of "wash'?

A very informative saga of FX volatility smile. All your articles here and the podcast are too good to be true. Kudos to medium platform for bringing your gems to me and thanking you Harel for your time and effort.

1 reply

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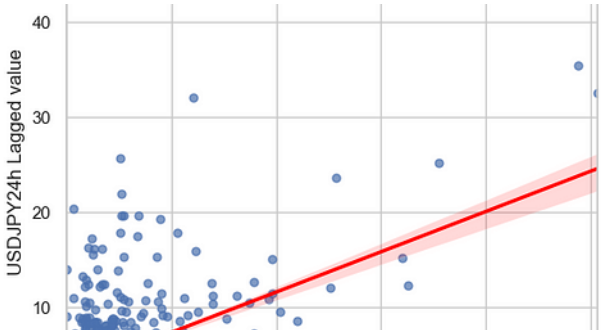

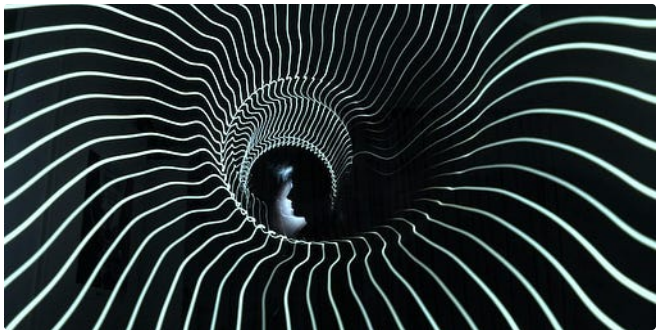

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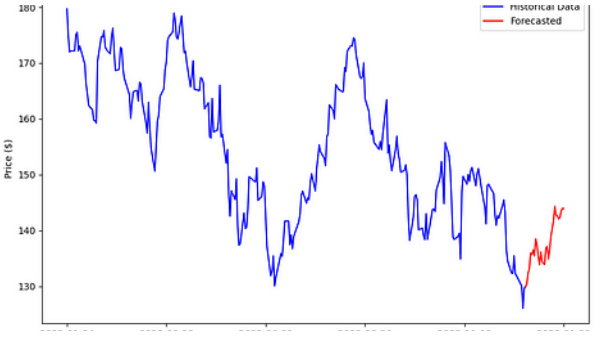

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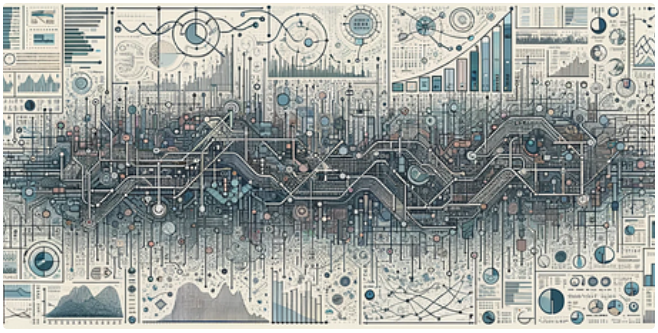

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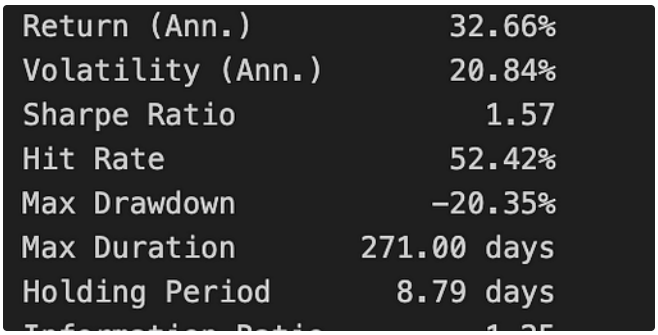

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