Commodity trading strategies and Risk management

Author :
Bui Nguyen Franck

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1 Introduction

1.1 Societe Generale

Societe Generale is a French multinational investment bank and financial services company headquartered in Paris, La Defense. It was created in May 1864(155 years ago), has a revenue of 24 billion euro and has about 200 000 employees worldwide mainly in Paris, London, New York, Hong Kong and Bangalore.

Societe Generale Corporate & Investment Banking's activity, like most corporate and investment banks, consists of advising and helping entrepreneurs, large companies, financial institutions, governments and investors to establish links on the capital markets (ex: financial markets) and provide them with optimal investment and risk management solutions. Because of its banking activity Societe Generale undertakes positions on the market which puts the firm at risk. As an exemple in January 2008, Societe Generale lost 4.9Billion over three days due to fraudulent trade by Jerome Kerviel as he was speculating for a decreased on the market due to the early sign of financial crisis.

The regulatory authorities have since realized the importance of risk management in these institutions considered to be "systemic" (if it goes bankrupt, it can damage the whole market by spillover effect). Hence the creation of dedicated departments which are commonly called Risk Department (RISQ at SGCIB) and the implementation of restrictive measures on the part of the prudential authorities.

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2 Focus on comodities

Commodities can be split into two types: hard and soft commodities. Hard commodities are typically natural resources that must be mined or extracted such as gold and oil, whereas soft commodities are agricultural products or livestock such as corn, wheat, coffee, sugar.

There are several type of commodities:
-Precious Metals market:
For ages, Humans have used gold as a benchmark for trading/barging items. In the middle ages, monetary power of a country can be measured by Weighting the amount of gold crafted in the coin.
In emerging countries, gold has been used to hedge against inflation, for long time, people would store their money in gold(which is still used by emerging country as they fear that their money would lose power).
Now the precious market trades several underlying for example Gold(XAU)/Silver(XAG)/Platinum(XPT) and Palladium(XPD) are traded.
Usually when market volatility is high, a classic safe heaven is to invest in gold.

-Base metal Market:
Base metals are common metals that tarnish, oxidize, or corrode relatively quickly when exposed to air or moisture. They are widely used in commercial and industrial applications, such as construction and manufacturing.
They are often more abundant in nature and sometimes easier to mine making base metals far less expensive for use in manufacturing than precious metals. Some base metals are Copper(CU), Aluminium(AL), Nickel(NI), zinc(ZN).

There are 2 different types of market where investors can take action in.

2.0.1 Listed market

Exchange-traded options, also known as 'listed options', provide many benefits that distinguish them from over-the-counter (OTC) options. Because exchange-traded options have standardized strike prices and expiration dates and more liquidity, they attract larger numbers of traders. OTC options usually tend to have customized provisions.

2.0.2 Over-The-Counter(OTC) market

An over-the-counter (OTC) market is a decentralized market in which market participants trade stocks, commodities, currencies or other instruments directly between two parties and without a central exchange or broker. Over-the-counter markets do not have physical locations; instead, trading is conducted electronically.

2.1 London Metal Exchange(LME)

The LME was formally founded in 1877, its origins trace back to the reign of queen elizabeth I in 1571, traders formed the Royal Exchange in London to trade physical metals for the domestic market but Britain soon became a leading exporter of metals.

The London Metal Exchange is the futures exchange with the world's largest market in options and futures contracts on base and precious metals(about 3/4 of the world industrial metal is dealt at the LME). In early 19th, as the LME become the most important metal market, traders soon created the concept of the Ring. A merchant would draw a circle. Traders would then gather around the circle and call out bids and offers. The Ring formed the basis for the open outcry trading floor on the LME.
This is a tradition that has lasted till today, although the sawdust has been replaced with a circle of red sofas on which traders must sit if they wish to take part in the trade.

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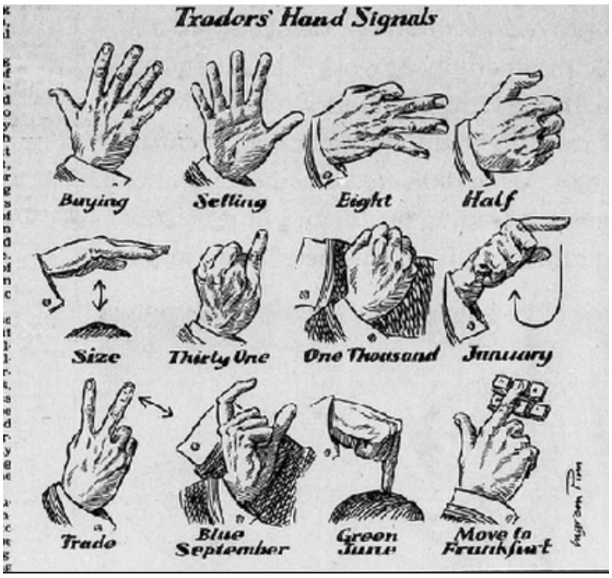
The ring is the open outcry physical trading floor.Each metal is traded in highly liquid five-minute open outcry trading session. Each round is for a specific underlying.

During each 5 intense minutes of trading, hand signals represent a unique system of communication that effectively conveys the basic information needed to conduct business on the trading floor.
The signals let traders and other floor employees know how much is being bid and asked, how many contracts are at stake and what are the expiration months.



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3 Instruments/Models/Strategies

There are mainly 3 types of market participants on LME :

- Hedger : Usually a producer of the commodity or a company that regularly needs to purchase the commodity and don't want to bother with the future price. A hedger might be a producer or consumer and seeks a position in a future or options contract to protect from future price moves in the metals market.
- Speculator : Usually individual or firm that accepts risk in order to make a profit by taking directional position in the market
- Arbitrageur : Arbitrageurs exploit price inefficiencies(market incoherence) by making simultaneous trades that offset each other to capture risk-free profits.

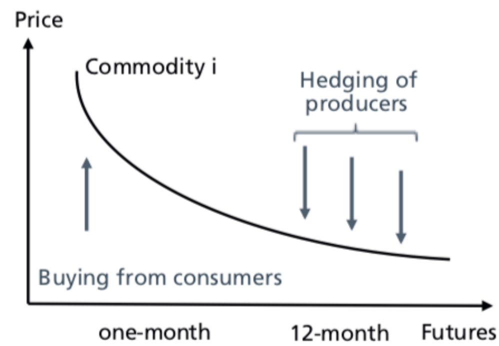
On the other hand, traders and speculators buy or sell metals futures or options to profit from short-term price moves by *arbitrage positions.

*Arbitrage is the simultaneous purchase and sale of an asset to profit from an imbalance in the price. It is a trade that profits by exploiting the price differences of identical or similar financial instruments on different markets or in different forms.

For example, in the old days, metals buyers had no way of knowing the future price when goods arrive in British ports. Metals sellers feared prices might drop by the time their shipment arrived. To solve this issue, merchants and buyers began transacting futures contracts to lock in prices for future deliveries.
Traders would buy futures based on the estimated time of arrival(3months usually) when producers sell long-dated contracts to hedge against a price drop.

Commodity producers sell long-dated contracts at a discount in order to hedge their output, whereas consumers often buy short-dated contracts at a premium in order to secure near-time consumption.
By buying from producers and selling to consumers, investors can capture an 'insurance risk premium' in the form of the roll yield that we will see further.

Illustration of the curve premia



There are several important notions to cover within the commodity market that are all relating from storage notion and pricing.

- Cost of Carry
- Cash and Carry
- Convenience yield
- Roll Yield

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3.0.1 Cost of Carry

Cost of carry refers to costs associated with the carrying value of an investment. These costs in commodities are usually any storage costs involved in holding a physical asset or maintenance such as livestock.

Cost of carry may also include opportunity costs associated with taking one position over another. In the derivatives markets, cost of carry is an important factor for consideration when generating values associated with an asset's future price.

3.0.2 Cash and Carry

Cash and carry trade is an arbitrage strategy which involves buying the underlying asset of a futures contract at the spot market and carrying it for the duration of the arbitrage. Traders use this strategy to take advantage of the difference between the price of the underlying security and its corresponding futures price. The trade in this strategy will be profitable as long as the purchase price plus the cost of carry is less than the money received by selling the futures contract before it expires.

3.0.3 Convenience Yields

Basic economic principles of supply and demand typically drive the commodities markets. **A convenience yield is the benefit or premium associated with holding an underlying product or physical good**, rather than the associated derivative security or contract(future for example). It connects current and expected market conditions in the future and thus determines storage decisions.

There are different motives of keeping inventory:
-Routine production demand instant access without frequent ordering and waiting
-Insurance against unexpected demand or supply shocks to avoid dissatisfying regular customers
-Speculation for capital gains. Additional storage will be carried over time if prices are expected to increase more than carrying cost.

Sometimes, as the result of irregular market movements such as an inverted market, the holding of an underlying good or security may become more profitable than owning the contract or derivative instrument due to its relative scarcity versus high demand. The spot price or front month is priced higher than the future on back month.

3.1 Derivatives tools

Commodity market can include physical trading, derivatives trading using spot prices, forwards, futures. These tools are mostly used for risk management.
Futures contracts are the oldest way of investing in commodities and the most used derivative that I have encountered during my research and will be what I will mostly focus on.

3.1.1 Future/Forward

A future contract is the obligation to sell or buy an asset at a later date, expiration date T at an agreed-upon price. The difference between a future and a contract is that one is standardised(future)used in listed market and the other one is not(forward) and used in Over-the-Counter.
It can be price by using a cash and carry strategy:

Cash and carry Strategy exibition

Position at t	Cashflow at t	Cashflow at T
Sell forward	-	$+F_0$
Borrow S_0	S_0	$-S_0e^{rT}$
Buy S_0	$-S_0$	-
Net Cashflow	-	$F_0 - S_0e^{rT}$

By arbitrage free condition, we must have:

$$F_0 = S_0e^{rT}$$

More generally the future price at time t with maturity T can be written as follows.

$$F_{t,T} = S_te^{r(T-t)}$$

with:

- T Maturity of the future
- $F_{t,T}$ future price at time t with maturity T
- S_t spot price at time t
- r risk free rate

3.2 Basis

At the expiration date, a futures contract that calls for immediate settlement, should have a futures price equal to the spot price. Before settlement, futures and spot prices need not be the same. The difference between the prices is called the basis of the futures contract. It converges to zero as the contract approaches maturity. To understand how futures prices are established requires understanding the behavior of the basis.

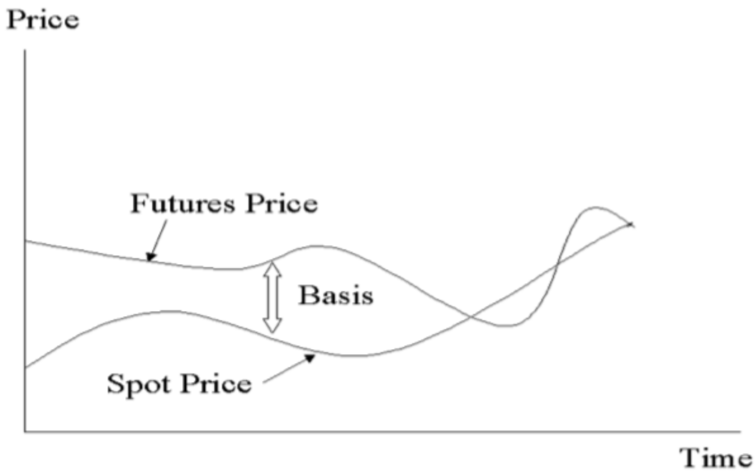
The basis is defined as the difference between the spot and futures price. Let $b_{t,T}$ represent the size of the basis for a futures contract at t that settles at date T. Basis reflects the cumulative storage costs and other cost related to holding the physical asset all the way to the futures expiration date. In commodities, the basis is named Exchange For Physical(EFP) and is often positive.

$$F_{t,T} = S_t + b_{t,T} \tag{1}$$

Futures price must converge to spot price upon expiration of the futures contract. As such, basis tends to weaken as expiration approaches, it is in fact a deceasing function of time to maturity.

$$\lim{}_{t \to T} S_t e^{(r_t + c_t)(T-t)} = S_T \implies \lim{}_{t \to T} b_t = 0 \tag{2}$$

Exhibit 1: Possible Dynamics of the Basis for a Futures Contract



3.3 Future curve shape

In commodities market, curve shape is a direct function of physical stock evolution and gives us valuable information about the market. Contango and backwardation are curve structures seen in futures markets based on several factors.

Contango

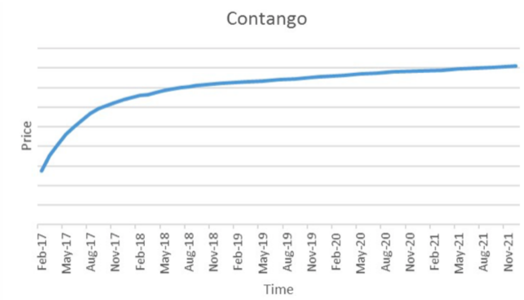
When supplies are abundant and increasing, it means that the physical market is in excedent(Offer greater than demand). The market wishes to push the underlying in the future while offering a greater remuneration for longer expiry which is a contango future curve shape. A contangoed future curve represent a preference for future price instead of spot price.

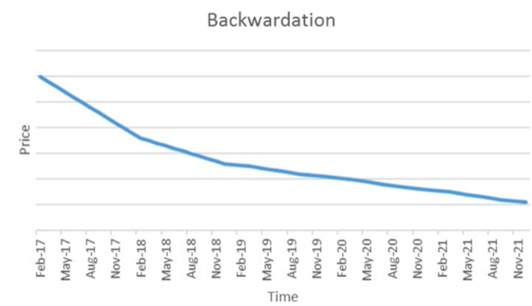
Backwardation

On the opposite when supplies are low, it means that the physical market is in deficit or a shortage in the underlying(Demand higher than offer). The market "offers" a prime for spot price instead of future which is a backwardation future curve shape. A backwardated curve penalise underlying storage by making it immediately available.

Definition of Contango and backwardation future/forward curve:

$$\begin{cases} F_{t,T} > S_t & \text{Contango} \\ F_{t,T} < S_t & \text{Backwardation} \end{cases} \tag{3}$$





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3.4 Storage theory

Inventory plays a fundamental role in the formation of a commodity price as holding stocks can be economically beneficial.
The storage theory tries to link future price and current supply. Period of relative scarcity of the commodity are related to high convenience yields but ample storage implies low convenience yield. We deduce that the slope of the convenience yield curve can therefore predict changes in inventories.

There are two major economic effects based on storage theory:
1. The time value of holding a commodity. The inventory enables holders to store the commodity when its price is low and sell it on the market when the price goes high. It also avoids the disruption of manufacturing.
2. The holding cost. Holding cost is also called carry cost or cost of storage. It includes the land and facility to store the commodity, as well as the operation management cost and maintenance.

Storage theory models of future

$$F_{t,T} = S_t e^{(r_t + c_t - y_t)(T-t)} = S_t e^{(r_t + c_t - y_t)\tau} \tag{4}$$

The storage theory models gives us a new definition of contango and backwardation as a function of rates, storage cost and convenience yield :

$$\begin{cases} r_t + c_t - y_t > 0 \rightarrow F_{t,T} > S_t & \text{Contango} \\ r_t + c_t - y_t < 0 \rightarrow F_{t,T} < S_t & \text{Backwardation} \end{cases} \tag{5}$$

The storage theory gives us a new model that now permits the modelisation of contango and backwardation depending on the sign of $r_t + c_t - y_t$ which was not possible before. If the rate and/or the storage goes up, then the future price goes up. However in scarce period, the convenience yield becomes higher than the cost of carry, dragging down the future price below spot price making backwardation observable.

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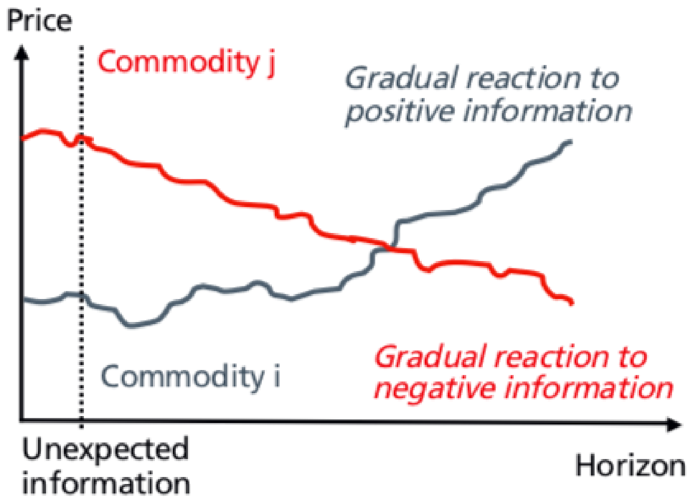
3.5 Samuelson effect

The following chapter on Samuelson effect has not been part of my research. However following my talking to Francois BEUZELIN a senior commodity trader in base metals, I had the chance to talk to him regarding this subject. I cannot go deeply within the subject but this will be an interesting part to ask for the resting months.

Commodities market is the most volatile market as it can be severely impacted by weather, political, decease and more.
Within the different the different actor of a commodity market there are 2 types :

- Short term actor
- Long term actor



Long term investor are usually producer that wants to hedge against future drop however on the closer term, money maker wants to profit of market incoherence.
The current futures price reflects current information about the spot price at delivery time. As information is revealed, futures prices varies making money maker more sensible of information making money maker front month volatility maker as well. Future's volatility of prices is the greatest in time periods in which information dissemination on the underlying commodity is the most rapid.
Volatility of price changes is clearly related to the quality and quantity of information revealed over time and it is in fact a decreasing function of time to maturity.

3.6 Riding the yield curve

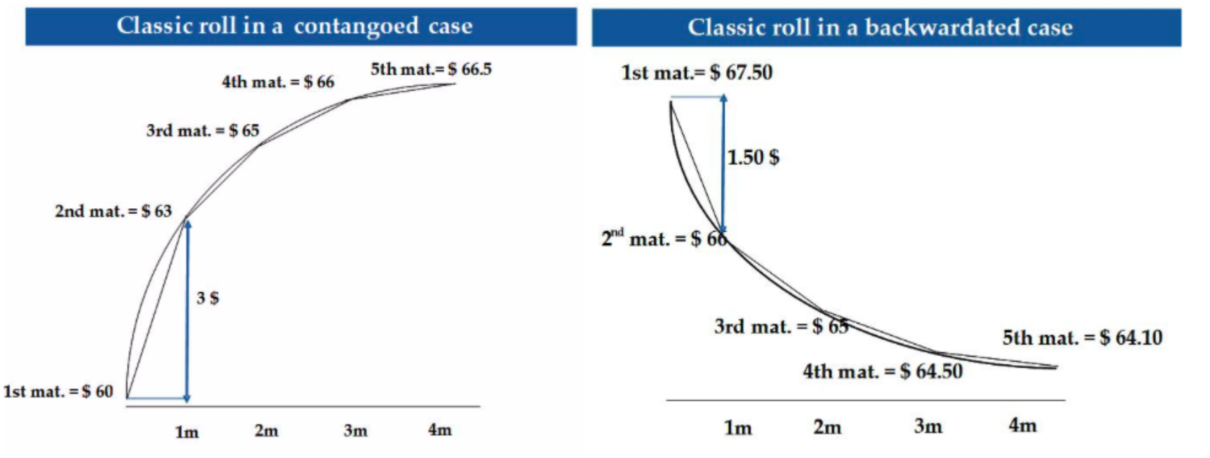
Roll forward refers to extending the expiration of futures/forward contract by closing the initial contract and opening a new longer-term contract for the same underlying asset at the current market price. A roll forward enables the trader to maintain the position beyond the initial expiration of the contract without taking on expiry which means delivery of physical goods and storage cost.
The storage represents a cost, which includes the cost of storage, insurance and financing(cost of carry). The convenience yield is the premium associated with holding the commodity for immediate or short-term usage. This is having an impact on the performance of commodity indices through the roll mechanism.

3.6.1 Roll Yield

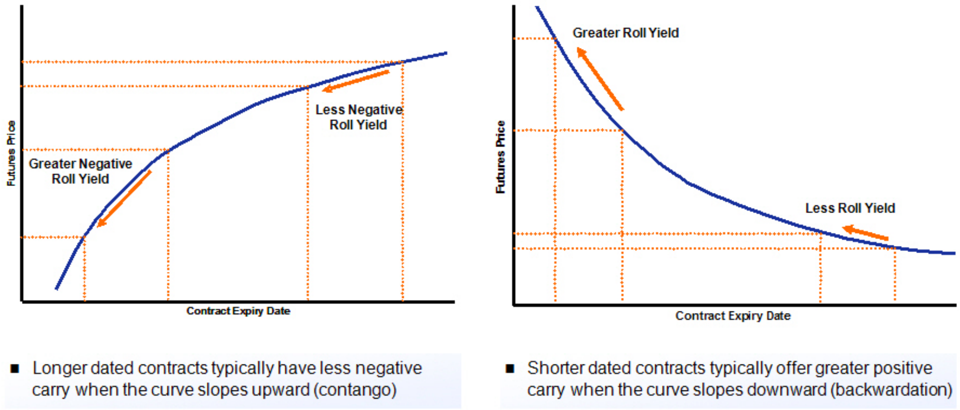
The roll mechanism (holding a contract until it approaches expiry and selling it to buy the next one) generates a positive or negative performance called the roll yield. For a given commodity, the sign of the roll yield comes from the shape of that commodity's future curve.

$$RollYield = F_{t,T} - F_{T-\epsilon,T} = \begin{cases} \underbrace{b_{t,T} - b_{T-\epsilon,T} < 0}_{Contango} & \text{Negative return strategy} \\ \underbrace{b_{t,T} - b_{T-\epsilon,T} > 0}_{Backwardation} & \text{Positive return strategy} \end{cases}$$

The roll yield is the return that futures investor captures as their long position in a futures contract converges to the spot price(Basis converges to 0). For instance, holding a commodity while its future curve is in contango represents a cost as the nearby contract's positive spread to the spot price(Future>Spot) converges to 0 as time approaches expiry. The opposite is also true: in a bakwardated curve, the contract's price tends to move higher(Future<Spot) as it gets closer to delivery. This positive or negative yield is realized when the contract is sold, i.e. when it is rolled into the new one.



Contango ➔ Negative Roll Return (= -3/60$ = -5%) Backwardation ➔ Positive Roll Return (= 1.5/67.50$ = 2.2%)



3.6.2 Roll Down Yield

The roll forward curve strategy earns positive gain during inverted market and losses during "normal" future market.
I will introduce the roll down yield strategy which is the same idea as the roll down but for the contangoed market.
We know from the basis that future price will converge certainly to the future spot price. By short selling a future and carrying over to maturity, we are able to capture the yield profit of a contagoed market.

$$RollDownYield = -F_{t,T} + F_{T-\epsilon,T} = \begin{cases} \underbrace{b_{t,T} - b_{T-\epsilon,T} > 0}_{Contango} & \text{Positive return strategy} \\ \underbrace{b_{t,T} - b_{T-\epsilon,T} < 0}_{Backwardation} & \text{Negative return strategy} \end{cases}$$

For a contangoed future curve the strategy to adopt is a short sale.
By selling a 2nd maturity future, waiting to be close to expiry and buying another future down the curve, we are able to capture the difference.

3.7 Long/Short strategy

Long/short strategy is an investing strategy that takes long positions in commodities that are expected to increase and short positions in commodities that are expected to decline. A long/short strategy seeks to minimize market exposure while profiting from gains in the long positions, along with price declines in the short positions.
This is a popular strategy in equity and one example is buying one share of SG and sell one share of BNP. If the market decline both companies will most likely to behave similarly and the strategy is a hedge against market exposure or spot movement. The strategy captures the spread between SG and BNP.

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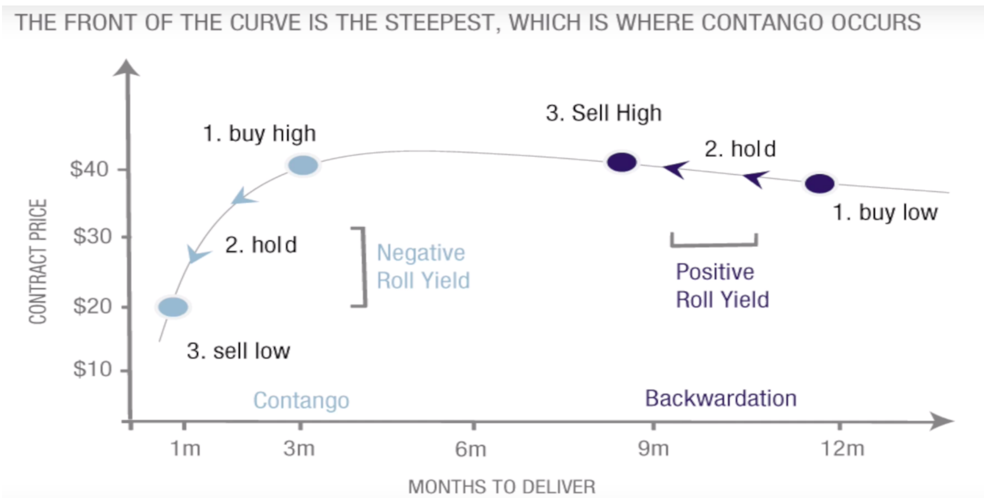
3.8 Roll yield spread

The roll yield spread strategy is the return of a combination of riding the yield curve and between 2 long/short future of different maturities.
There are 4 different shape within the future market:

- Concave contango (most dominant curve shape in commodities)
- Convex contango
- Concave backwardation (likely seen as a seasonal pattern)
- Convex backwardation

The front month future is always more volatile meaning that the probability for the curve regime to switch between concave and convex is much more important than the back month. By taking only a long position or short position, investors expose themselves to market exposure for example curve regime switch from concave to convex or even contago to backwardation due to unpredicted disease.



The main notion to understand is the steepness difference between concave and convex. By using a long short strategy, investors are able to profit of curve shape steepness while hedging against potential curve regime switch and profit from the steepness of a front month concave contangoed curve.
As commodities metals future market is often in concave contango, by selling a 3month future and buying a 12m, carrying the future to expiry and selling/buying respectively, the strategy captures the steepness of front month concave contago while loosing on the back month.

This strategy earns less profit than the roll yield. However, it is a hedge against volatility. Indeed we know from the Samuelson effect that the front month price is more volatile than the back month. By taking both long/short position we are hedging against spot price movement on the front month.

$$RollYieldSpread = -F_{t,T_1} + F_{T_1-\epsilon,T_1} + F_{t,T_4} - F_{T_4-\epsilon,T_4} = \underbrace{-b_{t,1} + b_{t,0}}_{FMvolatility} + \underbrace{b_{t,4} - b_{t,3}}_{BMvolatility}$$

4 Greeks

The Greeks refer to the various dimensions of risk that an options position entails. Greeks are used by options traders and portfolio managers to hedge risk and understand how their pl will behave as prices move.

Delta $= \frac{\partial P}{\partial S} = \begin{cases} e^{-qt}N(d_1) & \text{Call} \\ e^{-qt}N(d_1 - 1) & \text{Put} \end{cases}$

Delta represents the rate of change between the option's price and a \$1 change in the underlying asset's price. It is the speed of the price for a movement of spot.

Gamma $= \Gamma = \frac{\partial^2 P}{\partial S^2} = \frac{N'(d_1)}{S\sigma\sqrt{T}}$

Gamma indicates the amount the delta would change given a \$1 move in the underlying security. It is the acceleration of the price for a movement of spot.

Vega $= \nu = \frac{\partial P}{\partial \sigma} = S\sqrt{T}N'(d_1)$

Vega indicates the amount an option's price changes given a 1% change in the volatility.

Theta $= \Theta = \frac{\partial P}{\partial t} = \begin{cases} \frac{SN'(d_1)\sigma}{2\sqrt{T}} - rKe^{-rT}N(d_2) & \text{Call} \\ -\frac{SN'(d_1)\sigma}{2\sqrt{T}} + rKe^{-rT}N(-d_2) & \text{Put} \end{cases}$

Theta represents the rate of change between the option price and time, or time sensitivity. It indicates the amount an option's price would decrease as the time to expiry decrease.

Rho $= \rho = \frac{\partial P}{\partial r} = \begin{cases} KTe^{-rT}N(d_2) & \text{Call} \\ -KTe^{-rT}N(-d_2) & \text{Put} \end{cases}$

It represents the sensibility of the price with respect to the rate

5 Black Scholes model

The Black Scholes model, also known as the Black-Scholes-Merton (BSM) model, is a mathematical model for pricing an options contract. In particular, the model estimates the variation over time of financial instruments such as stocks.

It suppose that the underlying follows :

$$\frac{dS_t}{S_t} = \mu dt + \sigma dW_t \tag{6}$$

The underlying follows

$$S_t = S_0 e^{(\mu - \frac{\sigma^2}{2})dt + \sigma dW_t}$$

Proof:

By applying Ito's theorem to $S_t = S(t, W_t)$

$$dS_t = df(t, W_t) = \frac{\partial S}{\partial t}dt + \frac{\partial S}{\partial W_t}dW_t + \frac{1}{2}\frac{\partial^2 S}{\partial W_t^2}d < W_t >^2$$

$$dS_t = \mu S_t dt + \sigma S_t dW_t$$

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As we are mainly focused on futures, futures can be described with the call put parity.

Let $f(t, S_t)$ the price of an option.
By using Ito's formula:

$$df = \frac{\partial f}{\partial S} dS_t + \frac{\partial f}{\partial t} dt + \frac{1}{2} \frac{\partial^2 f}{\partial S^2} \sigma^2 S_t^2 dt$$

By replacing dS_t

$$df = (\frac{\partial f}{\partial S} \mu S_t + \frac{\partial f}{\partial t} + \frac{1}{2} \frac{\partial^2}{\partial S^2} \sigma^2 S^2) dt + \frac{\partial f}{\partial S} \sigma S_t dW_t \tag{7}$$

By replacing the value for the greeks:

$$df = (\Delta_t + \Theta + \Gamma \sigma^2 S_t^2) dt + \Delta \sigma S_t dW_t$$

By using an autofinancing portfolio with r risk free rate and f value of the portfolio, black scholes PDE becomes:

Consider the following delta neutral portfolio Π:
-Sell an option f on S
-Buy $\frac{f}{dS}$ underlying
Which gives us

$$\Pi = \frac{df}{dS} S_t - f$$

Then

$$d\Pi = \frac{\partial f}{\partial S} dS_t - df = (-\frac{df}{dt} - \frac{1}{2} \frac{d^2}{dS^2} \sigma^2 S_t^2) dt$$

As the Wiener process disapeared, the portoflio is thus riskless. To satisfy arbitrage free, the riskless portfolio cannot have a higher gain than the riskfree rate.

$$d\Pi = r \Pi dt$$

By combining the last 2 equations

$$-(\Theta + \frac{1}{2} \Gamma \sigma^2 S^2) = r\Pi \tag{8}$$

Mostly known as B&S PDE's.

The main utility for Black-Scholes is that it gives us a closed formula for EU option.

$$\Pi_c(T, S_T) = (S_T - K)_+, \Pi_p(T, S_T) = (K - S_T)_+$$

$$\begin{cases} S_t N(d_1) - K e^{-r(T-t)} N(d_2) & \text{Call} \\ -S_t N(-d_1) + K e^{-r(T-t)} N(-d_2) & \text{Put} \end{cases}$$

With $d_1 = \frac{1}{\sigma\sqrt{T}} (ln(\frac{S_0}{K}) + (r + \frac{1}{2}\sigma^2) T$ and $d_2 = d_1 - \sigma\sqrt{T}$

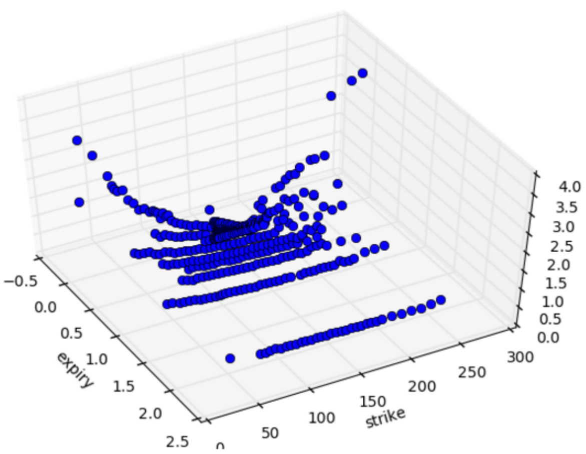
5.1 Volatility investing

The following chapter on volatility has not been part of my research. However following Joaquim GONCALVES, the precious metals traders who is an equity option trader, I had the chance to ask him few question on this subject. I cannot go deeply within the subject but this will be an interesting part to ask for the resting months.

5.2 Implied volatility

Given a spot price, strike, risk free rate,Maturity, standard deviation of the log returns the Black-Scholes formula gives the appropriate price for an European call/put option.
One main assumption from the BSM is that the volatility is **constant**.
Implied volatility is given a strike, a spot, a risk free rate and a maturity, it is the volatility that replicates market price with all the information given. It means that for each strike and maturity, we have a different volatility. Because it is implied, traders can't use past performance as an indicator of future performance. Instead, they have to estimate the potential of the option in the market. volatility$\sigma_{implied} = \sigma_{implied}(T, K)$

Volatility surface by maturity and strike



The figure shows the volatility surface and if we look closely to volatility with respect to the strike, the smile can be seen.
The advantage of BSM is that it gives us a close formula for option pricing and it is fearly computable in term of time computation. Actually there is always the question of should I go for precision but a longer time computation or less precision but much quickier. Within SG, BSM is very popular and we will see that even for variance methods, we do not use the other as it takes to many time to compute.

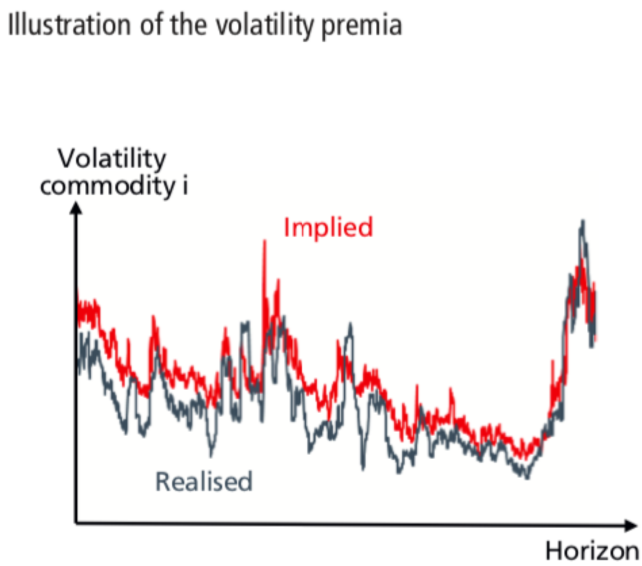
5.3 Historical volatility

Historical volatility gauges the fluctuations of underlying securities by measuring price changes over predetermined periods of time.

5.4 Volatility trading

This part is again not in my research, it is only the curiosity, and opportunity to have an option trader close by. It is also an opportunity to introduce Black-Scholes formula and translate to what drives datas from the PnL that I certify.

By ploting implied volatility and historical volatility with respect to maturity, we can see that they are not equal. Traders can utilise this difference by trading on the difference of volatilty by taking positions with options.
This is the volatility arbitrage which is a trading strategy under a delta neutral portfolio of an option and its underlying. The objective is to take advantage of differences between the implied volatility of the option, and a forecast of future realized volatility of the option's underlying.



A trader looks for options where the implied volatility, $=\sigma_{Implied}$ is either significantly lower than or higher than the forecast realized volatility for the underlying for example gold. In the first case, the trader buys the option and hedges with the underlying to make a delta neutral portfolio. In the second case, the trader sells the option and then hedges the position. (As proved above, it gives us a delta neutral portfolio).

I have not dug deeper in this subject but for the remaining month it will surely be a very interesting subject that I will work on and try to implement.

6 Risk Management

6.1 Risk measure

When an entity makes an investment decision, it exposes itself to a number of financial risks. For example, traders seek positions on the market in order to satisfy their client or taking advantage, market inconsistency, hedge their book against market parameter movement.
My main missions is to quantify the exposure of front office and report it. I needed first to understand where the data come from, understand the main lines of front office strategy presented above in order to have a critical point of vue of what I am reporting.

First, lets define what is a coherent risk measure ρ.
Let$(\Omega,\mathcal{F},P)$ be a probability space and $L^\infty(\Omega,\mathcal{F},P)$ by L^∞.
Let V_{t+1} be the value of the portfolio at the end of the time period and $X = \Delta V_{t+1} = V_{t+1} - V_t$ be the profit and loss(P&L). The loss is defined as $L_{t+1} = -\Delta V_{t+1}$. The distribution of L_{t+1} is termed the loss distribution.
Then $\Omega = \Omega_1 \cup \Omega_2$ with $\Omega_1 = \{L \leq VaR_\alpha\}$ and $\Omega_2 = \{L > VaR_\alpha\}$.
The application ρ is a coherent risk mesure if it satistifes the following conditions:

- Homogeneity: ρ is homogeneous if for all loss variables L and $h \geq 0$
$$\rho(hL) = g\rho(L)$$
- Translaction invariance: ρ is translation invariant if for all loss variables L and $a \in R$
$$\rho(L + a) = \rho(L) - a$$
- Monotonicity: ρ is monotonic if for all variables L_1 and L_2 it holds that
$$L_1 \leq L_2 \rightarrow \rho(L_1) \leq \rho(L_2)$$
- Subadditivity: ρ is subadditive if for all loss variables L_1 and L_2
$$\rho(L_1 + L_2) \leq \rho(L_1) + \rho(L_2)$$

Homogeneity : the amount of risk depends on the size of the position, if we double the position then the risk will be as well
Translation invariance : when adding cash, the risk is reduced by the same amount. Suppose we are adding the amount $\rho(X)$, then

$$\rho(L + \rho(L)) = \rho(L) - \rho(L) = 0$$

Monotonicity : the risk asset X_2 is worth more than the asset X_1, then the risk of X_1 is always greater than the risk of X_2
Subadditivity : the risk of two assets are less or equal to the risk of the two separate assets. It is less risky to have a diversified portfolio
Subadditivity is a desirable property for a risk measure as it consistent with the diversification principle of modern portfolio theory, a subadditive measure should generate lower

measured risk for a diversified portfolio than a non-diversified portfolio.
Proposition : Any risk measure that possess property 2 and 3 is convex

Proof
let $\alpha \in (0,1)$ and ρ that satisfies 1 and 4, then

$$\rho(\alpha X_1 + (1-\alpha)X_2) \leq \rho(\alpha X_1) + \rho((1-\alpha)X_2) = \alpha\rho(X_1) + (1-\alpha)\rho(X_2)$$

6.1.1 VaR

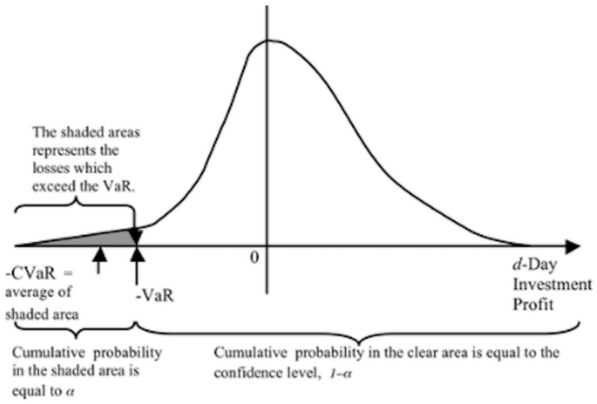
What is the most traders can lose? This is a question that almost every investor when taking position in a risky asset.
VaR is a measure of market risk, it provides an estimate, under a given degree of confidence α, of the size of a loss from a portfolio over a given time period T.
The Value at risk at level $\alpha \in (0,1)$ is the smallest value l such that the probability that the loss $L := -X$ does not exceed $1-\alpha$ given a time horizon. Another definition $VaR_\alpha(X)$ is the $(1-\alpha)$-quantile of X Value at Risk can have several meaning :

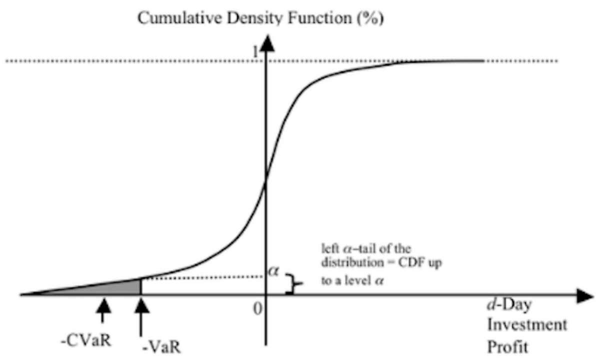
- VaR_α is the minimum loss that will not exceed with probability α
- VaR_α is the α-quantile of the distribution of X
- VaR_α, if $X \in \Omega_1$, it is the greatest lost
- VaR_α, if $X \in \Omega_2$, it is the smallest lost

Definition : We define $VaR_\alpha : L^\infty \to R, \alpha \in (0,1)$ by

$$VaR_\alpha(X) = -inf\{x \in R : F_X(x) > \alpha\} = F^{-1}(X) \tag{9}$$

with
F_X the cumulative distribution function of X.





For example if a daily VaR is £100,000 to a 95% level of confidence($\alpha = 0.05$), this means that during the day there is a only a 5% chance that the loss the next day will be greater than £100,000.

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There are several methods to approximate the Value at Risk for example :

- Historical VaR
- Variance covariance VaR
- Monte Carlo VaR
- Linear Model
- Quadratic model

I will only cover the historical VaR and variance/covariance methods.

6.2 Historical Value at Risk

Societe Generale uses a daily 99%($\alpha = 1\%$) Value at risk.
The fundamental assumption of the Historical Simulation is that you base your results on the past performance of the portfolio and the past will surely repeat itself in the future.

There are 260 days, meaning that 1% of 260 is 2.6

- Calculate the price change of all assets in the portfolio each day for the last year
- Apply the price changes calculated to the current value of the assets and re value the portfolio
- Sort the 260 hypothetical PnL from the lowest to the highest value $[PnL_1, ...PnL_{260}]$
- Return $VaR(X)_\alpha = mean(PnL_2, PnL_3)$

The advantage of this method is that it is fairly easy to calculate compared to the others and that is mainly why SG uses this method. The drawback is that we are using only past data to predict the future and history has proved us that historical data only cannot predict the future.

6.3 Variance/Covariance

This method has not been in my research, however I wanted to code a Value at Risk on a portfolio containing commodities Consider a portfolio of P dollars, with a confidence level c
We are considering daily returns, with asset historical standard deviation σ and mean μ.
Then the daily VaR, under the variance-covariance method for a single asset (or strategy) is calculated as:

$$VaR_X(\alpha) = P * (\mu_{Portfolio} - N^{-1}(1-\alpha) * \sigma_{Portfolio}) \tag{10}$$

With N^{-1} is the inverse of the cumulative distribution function of a normal distribution$N(\mu, \sigma^2)$ with mean μ and standard deviation σ.(Find in appendix a table of inverse normal distribution)

Let s have an example, suppose we have a portfolio of 2 underlying(gold and silver) where we have invested 50% in gold and silver. To calculate the parametric VaR, we need to calculate the mean and standard deviation of our portfolio.

$$\mu_{portfolio} = \begin{pmatrix} \mu_{1,1} & \mu_{1,2} & \cdots & \mu_{1,n} \\ \mu_{2,1} & \mu_{2,2} & \cdots & \mu_{2,n} \\ \vdots & \vdots & \ddots & \vdots \\ \mu_{n,1} & \mu_{n,2} & \cdots & \mu_{n,n} \end{pmatrix} \begin{pmatrix} w_1 \\ w_2 \\ . \\ . \\ . \\ w_n \end{pmatrix} = \mu w$$

$$\sigma^2_{portfolio} = \begin{pmatrix} w_1 & w_2 & \dots & w_n \end{pmatrix} \begin{pmatrix} \sigma_{1,1} & \sigma_{1,2} & \cdots & \sigma_{1,n} \\ \sigma_{2,1} & \sigma_{2,2} & \cdots & \sigma_{2,n} \\ \vdots & \vdots & \ddots & \vdots \\ \sigma_{n,1} & \sigma_{n,2} & \cdots & \sigma_{n,n} \end{pmatrix} \begin{pmatrix} w_1 \\ w_2 \\ . \\ . \\ . \\ w_n \end{pmatrix} = w^{'}\Sigma w$$

with

- w is the vector of the weights of the n assets.
- $w^{'}$ is the transpose of w
- Σ is the covariance matrix of the n assets
- μ is the esperance matrix of the n assets

Using the method explained, I wanted to code by myself a variance covariance approach during my research to deepen my understanding of risk management. If our budget is $P = 100000$,the confidence interval is $c = 99\%$ and taking price values for copper and nickel for the last year the 99% annual VaR is :(Find variance/covariance code in Appendix)

```
Annual Value-at-Risk portfolio (0.5:0.5) Copper/Nickel $15800.80
```

There are several drawback of the VaR methods, first it takes historical data, it fails to capture tail risk and most importantly is its lack of subadditivity, does not support portfolio diversification(Proof in append). To correct these problem, risk managers have invented the CVaR. Second it supposed that the PnL follows a normal distribution and we know from that it is a wrong.

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6.4 CVaR/ Expected shortfall

The VaR specifies the value that the loss will be exceeding in a bad day, but it does not specify by how much the loss will be exceeding the VaR

We have seen the case when $L \in \Omega_1$, the profit and loss random variables is less that the VaR. What if $L \in \Omega_2$ with $(P(L \in \Omega_2)) = \alpha$, meaning that $L \in (VaR(L); +\infty)$.

One of the main purpose of the CVaR is to estimate where in the distribution tail the PnL is, second we will see after that the CVaR is a coherent risk measure in contrast to the VaR

Let L represent the PnL, let $X = -L$ and $q_\alpha$represent the $1-\alpha$ percentile VaR.

$$ES_\alpha(X) = CVaR_\alpha(X) = \mathrm{E}[X|X \geq VaR_\alpha] = \frac{1}{\alpha}\int_0^\alpha VaR_s(X)ds \tag{11}$$

Proof:

$$\begin{aligned} CVaR_\alpha = E[X|X \geq q_\alpha] &= \frac{E[X1_{X\geq q_\alpha}]}{P(X \geq q_\alpha)} = \frac{E[(X + q_\alpha - q_\alpha)1_{X\geq q_\alpha}]}{P(X \geq q_\alpha)} \\ = \frac{E[(X - q_\alpha)1_{X\geq q_\alpha}]}{P(X \geq q_\alpha)} &+ q_\alpha \frac{E[1_{x\geq q_\alpha}]}{P(X \geq q_\alpha} = \frac{E[(X - q_\alpha)]^+}{P(X \geq q_\alpha)} + q_\alpha \end{aligned}$$

Moreover:

$$\begin{aligned} E[(X - q_\alpha)]^+ &= \int_{-\infty}^{+\infty} (x - VaR_\alpha(X))^+ dF(x) = \int_{VaR(X)_\alpha}^{+\infty} (x - VaR_\alpha(X))dF(x) \\ &= \int_{1-\alpha}^{1} (F^{-1}(y) - VaR_\alpha(X))dy = \int_{1-\alpha}^{1} (F^{-1}(y))dy - \alpha VaR_\alpha(X) \\ &= \int_{1-\alpha}^{1} (VaR_{1-y}(X))dy - \alpha VaR_\alpha(X) = \int_0^\alpha (VaR_s(X))ds - \alpha VaR_\alpha(X) \end{aligned}$$

$$\boxed{CVaR_\alpha(X) = VaR_\alpha(X) + \frac{1}{\alpha}E[(X - VaR_\alpha(X))^+] = \frac{1}{\alpha}\int_0^\alpha VaR_s(X)ds} \tag{12}$$

CVaR is mainly used in portfolio optimization for effective risk management as it encourage portfolio diversification. The choice between VaR and CVaR is not always clear but generally if an investment has shown stability over time, then the value at risk may be sufficient for risk management in a portfolio containing that investment. While VaR represents a worst case scenario for a time and probability given, CVaR quantifies the expected losses that occur beyond the VaR breakpoint.

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7 Improvement on current Desk tools

I had to mainly work with data and analysing front office PnL. The first questions I asked my-self was, how can we make our daily task more optimised and easier ? I wanted to upgrade the desk tool and explain more properly front office PnL.

7.1 PnL explanation

The daily PnL of a portfolio can be written as the change in portfolio value P. As it is a function of the greeks it can be approximate using taylor's formula:

$$dP(S_t, \sigma, r, t) = \frac{\partial P}{\partial S} dS + \frac{1}{2} \frac{\partial^2 P}{\partial S^2} dS^2 + \frac{\partial P}{\partial \sigma} d\sigma + \frac{\partial P}{\partial t} dt + \frac{\partial P}{\partial r} dr + \epsilon \tag{13}$$

$$dP = \underbrace{\Delta dS}_{PnL_\Delta} + \underbrace{\frac{1}{2}\Gamma dS^2}_{PnL_\Gamma} + \underbrace{\nu d\sigma}_{PnL_\nu} + \underbrace{\Theta dt}_{PnL_\Theta} + \underbrace{\rho dr}_{PnL_\rho} + \underbrace{\epsilon}_{Other}$$

When I first came, front office PnL and greeks breakdown were displayed in an excel Pivot tables. We had to manipulate excel sheets and formula and by the end of the day produce a report for front office. This method is not the more optimized and we can say it is still very manual. I wanted to add my own touch to the team. From my competence earn in python throughout my uni education, I wanted to migrate the current excel/VBA tools into python.

I had to follow these steps:

- Import data from excel
- Store data permanently in an online server
- Create a python library that would re calculate PnL and Metrics.
- Create new automated report that would actualise and send to the Front Office
- Optimise the library
- Apply current knowledge on statistics, time series to find trend within the market

7.2 VBA/python migration project

I am actively working on digitizing the Risk desk with migration of VBA code into python .

Before jumping into coding, I had to understand how the pricer works and response to different request.
First, Meteor Risk Management(MRM) is an SQL server that contains multiple tables for one specific day lets say D. It is often called a "cube".
For a D day, several tables or generated and contains different information regarding the trading day.
There are 2 important tables which I will name them T1 and T2.

T1 contains all quantitative data(Pnl,delta,vega,rates, ...) whereas T2 contains all qualitative data(Portfolio,client,currency,underlying,...).
The size n_{T1} and n_{T2} are the numbers of column in the respected tables which are also dimension of the cube. By adding more column, information regarding the PnL of the D day, we are increasing the cube dimension and the time to get the information.
To recover the "cube" and restore all the information for the D day, I had to join the two tables on on the dealID.

After playing with the data I had to construct an SQL request that gets the table. Each day has a deal ID for a specific tables given by an API. This ID can be retrieve through an API as a JSon.
Having the Deal ID for the D day, the SQL request for the PnL recalculation can be written as :

```sql
SELECT table1.dealID, Portfolio, Underlying, Client,
SUM(PnL), SUM(Delta) AS Delta
FROM [dbo].[table1ID] table1
LEFT JOIN [dbo].[table2ID] table2 ON table1.dealID = table2.
   dealID
GROUP BY table1.dealID, Portfolio, Underlying, Client
```

Listing 1: MRM SQL request

Having now the SQL request, I needed to connect python to our SQL server and store our dataframe. I had to use 2 new python libraries which are pyodbc(SQL connection), pandas(store our data). First to connect python to the server and second to store our data in a dataframe.

```python
import pyodbc
import pandas as pd

req = "SQL request"
conn = pyodbc.connect(driver = "SQL server",
                      server = "server name",
                      database = "database name",
                      uid = "user ID",
                      pwd = "password")

# Create a connection and store the datas in a panda
df = pd.read_sql(req,conn)
```

Listing 2: Python/SQL connection and data storage

7.2.1 Online data storage

The next step is now to store these data in an online database for MMG UK only.
One powerful tool from Societe General is a website called SGLambda. This website allows online data storage and access from every language as an http request(similar to MongoDB).
In order to store our data, we need a new library request that send http request(post and get) in order to store our data. As this part is specific to SG, I cannot disclose further details but to sum up, we send the pandas dataframe into an online server using a post request and to get the bijection we use the get method from request library.

7.2.2 Pricing library

After successfully importing data in an online database, one thing was missing which was an excel cube add-in that would calculate the different metric and PnL and display the result in pivot tables.
Indeed, now having the raw data such as the PnL, greeks and essentially all the breakdown by deal, by client and entity, recreate an excel add in that would map the quantitative data and the qualitative. For example one question from the trader would be how much delta did I have yesterday on gold for client X in my book Y?
The formula given by taylors decomposition proved me that by having the explained PnL by greeks, to get the overall Pnl I had to add them together.

Overall the main purpose was at the end of the day, aggregate front office PnL by group of portfolio, explain to back office and certify where these value come from. The purpose of this library is to do this job on a daily basis and being self sufficient meaning without any human clicking button.

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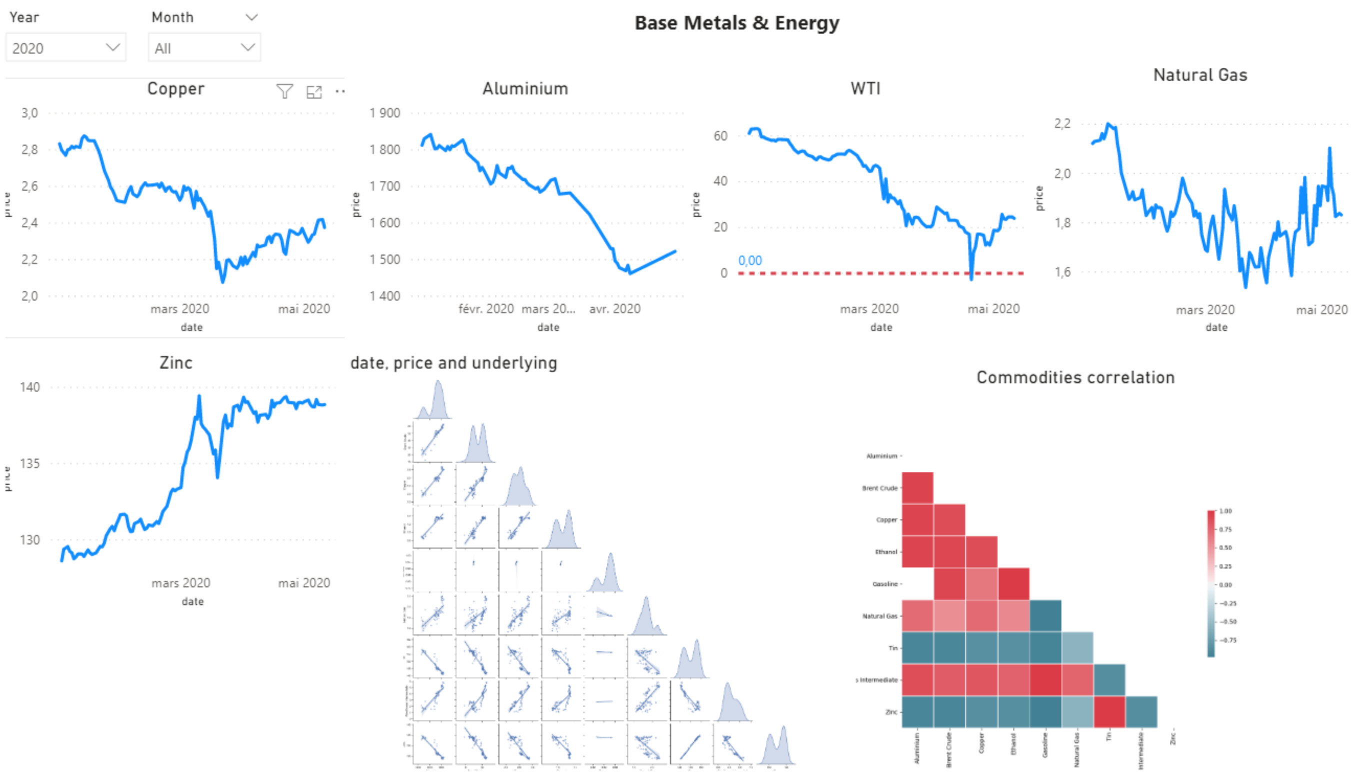
7.2.3 PowerBI reporting

The result was python retrieves data in the background and merge/aggregate in the back while we report daily PnL breakdown, front office activities and show clearly and precisely the amount of risk taken by underlying and by maturity date. These report have been migrated to PowerBI.
Power BI is a business analytics service by Microsoft. It aims to provide interactive visualizations and business intelligence capabilities with an interface simple enough for end users to create their own reports and dashboards. Please Find below 2 screenshots of the finished work I have done so far :



Datas showed in this PowerBI are from Jan 2020 which includes coronavirus. There are significant correlations on industrial metals such as copper, aluminium and energy. Indeed in time of uncertainty, market data becomes more and more correlated. This is the case especially for industrial metals as they are needed in industries such as car, tech.

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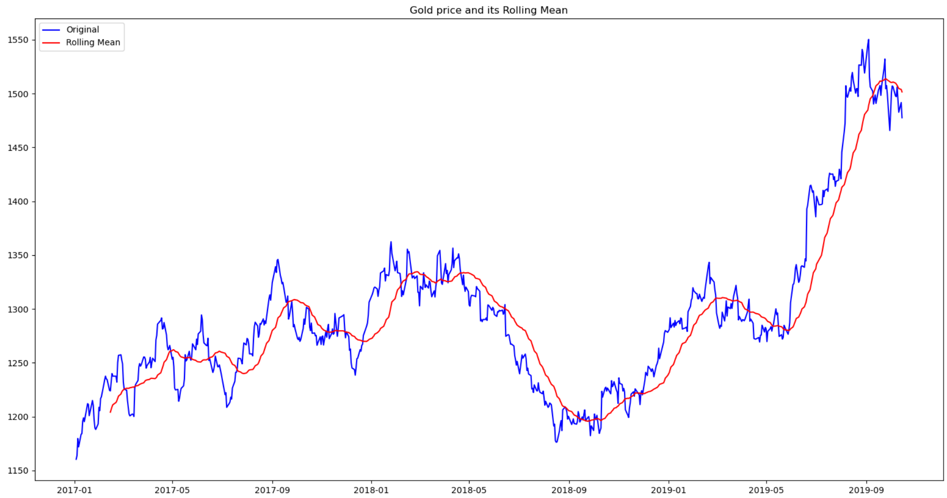
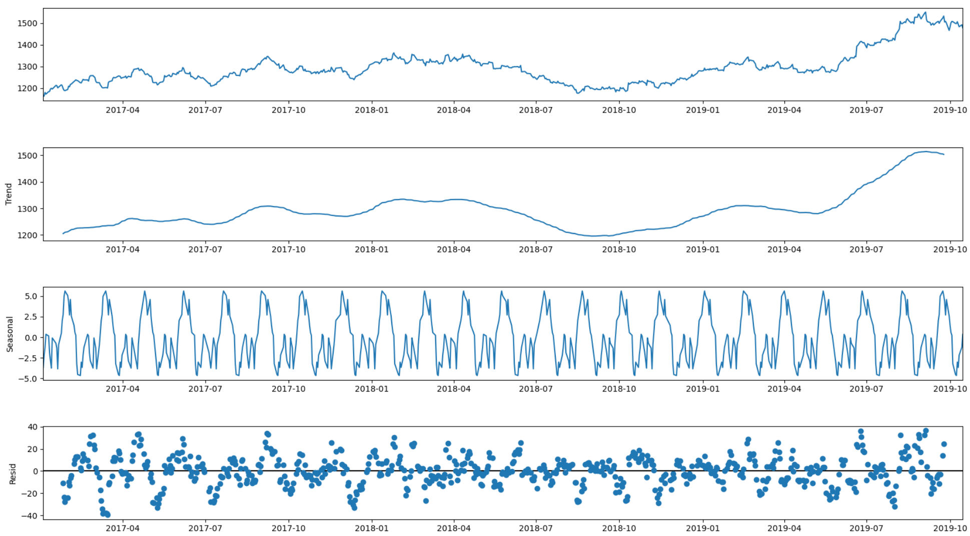
7.3 Time series prediction

Since April 2019, Societe Generale decided to shut down the commodities trading desk. One big question from front office was, is our year to date PnL converging to 0?

I tried to answer this question with the data stored in my database. By taking each daily PnL and appending each day in a unique table, I am able to plot the ytd of front office.
This ytd can be represented as a time series with a trend, a seasonality and residue. As I am not allowed to talk about Société Générale data, I have modelized the price of gold since 2017 and tried to fit a model on it.



The first question to answer before fitting a model is : is the time series stationary ?
If the time series is stationary, it means that values do not depend on time meaning that the current value that we are looking for can eventually repeat in the future.
By looking at the rolling mean, we can see that over the time, gold price has a tendency to increase meaning that the time series is not stationary and we can decompose the gold price as its trend, seasonality and residue.



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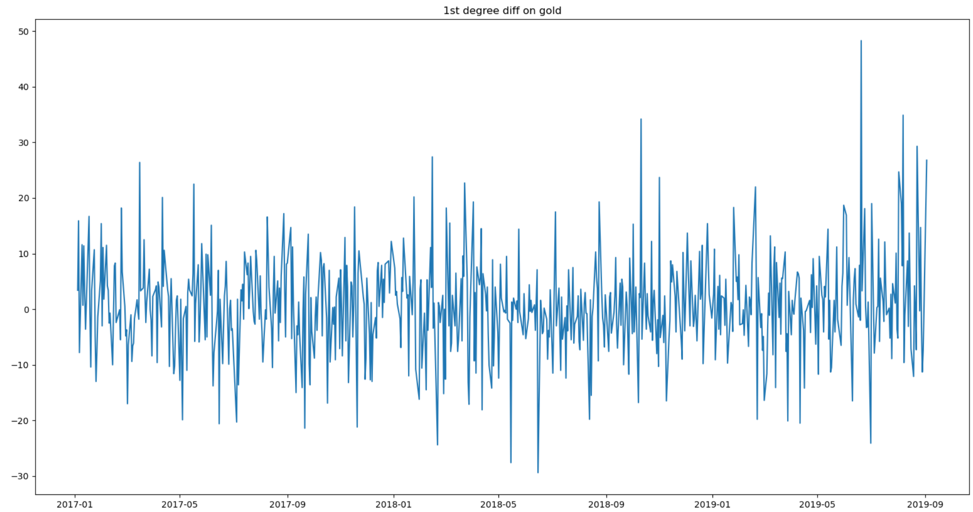
One way to make a time series stationary is by differentiation. The differenced series is the change between consecutive observations in the original series, and can be written as

$$\hat{y}_t = y_t - y_{t-1} \tag{14}$$

By differencing the gold price :



To prove mathematically that the time series is stationary I used an augmented Dickey-Fuller test :

Results of Dickey-Fuller Test:	
Test Statistic	-1.716025e+01
p-value	6.849468e-30
No. Lags Used	1.000000e+00
Number of Observations Used	6.610000e+02
Critical value (1%)	-3.440282e+00
Critical value (5%)	-2.865922e+00
Critical value (10%)	-2.569104e+00

H_0 : Time series is stationnary
H_1 : Time series is not stationnary

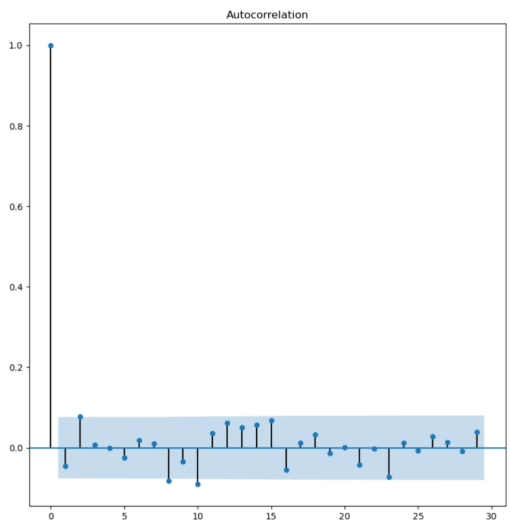
I supposed 2 possible outcomes(which may be false) either the time series is stationary or not. As p value is fairly small I deduced that I can reject H_0 confidently and the time series is stationary because I supposed a binary space which is stationary or not.

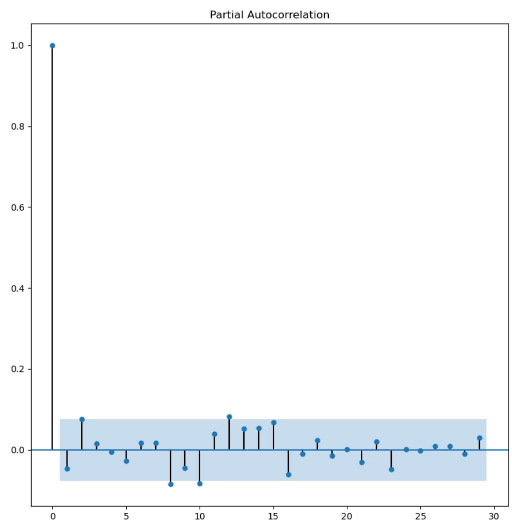
As I am trying to fit an ARIMA(p,d,q)

- AR: Autoregression. A model that uses the dependent relationship between an observation and some number of lagged observations
- I: Integrated. The use of differencing of raw observations (subtracting an observation from an observation at the previous time step) in order to make the time series stationary
- MA: Moving Average. A model that uses the dependency between an observation and a residual error from a moving average model applied to lagged observations

The second task is to look at the correlogram ie Autocorrelation and partial autocorellation in order to find the number of lag the prediction depends on.

- p: The number of lag observations included in the model, also called the lag order
- d: The number of times that the raw observations are differenced, also called the degree of differencing
- q: The size of the moving average window, also called the order of moving average





Partial autocorellation gives us the number of lag or auto regressive parameter which the predictions depends on (p =2), Autocorellation gives the number of residue or moving average the prediction depends on, (q=2)

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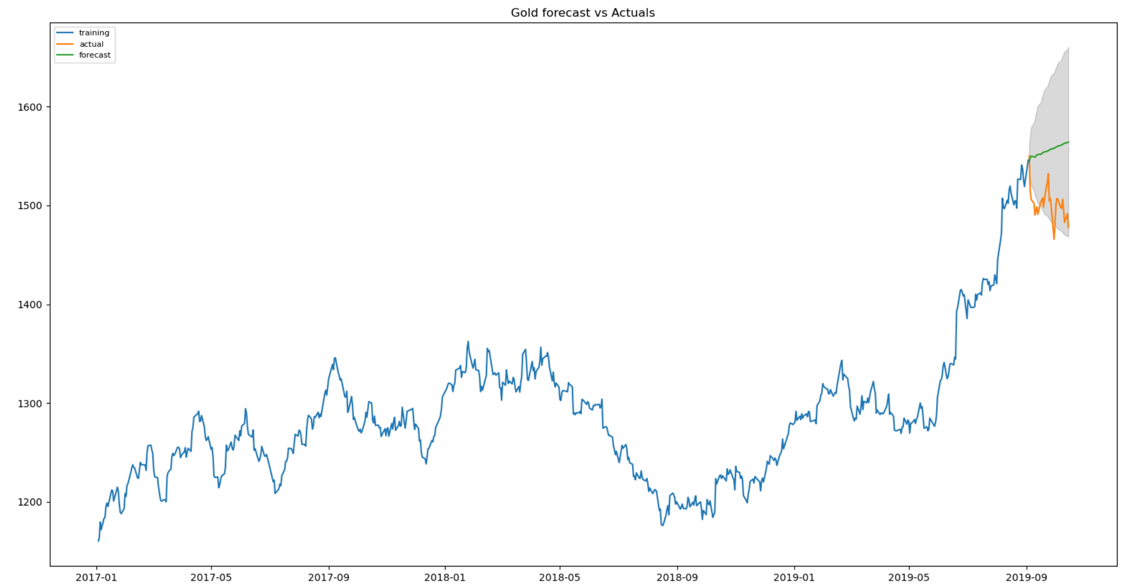
Having all the parameters I have splitted the gold price in 2 dataframe,

- Train : datas from 2017 until sep-2019
- Test : Data on sep-2019

The train data is where I will fit the ARIMA(2,1,2) model on and the test data is where I will compare the model on.



As you can see, my prediction is not very good (RMSE = 54), and the forecast looks like a linear function. What I am suspecting is that it is missing the volatility meaning that ARIMA is not a good fit. Another model to try on is a GARCH model which tests heteroskedasticity of the residue and captures the volatility of the model. Due to time lack I have not tried another model yet but it will be very interesting to fit and calibrate a GARCH model on commodities price.

By doing this method I have tried to predict front office PnL and tried to answer their question if their PnL is converging to 0 or not by first looking at its stationary, second its tendency to decrease towards 0 or not and finally if the standard deviation is a decreasing function of the time.

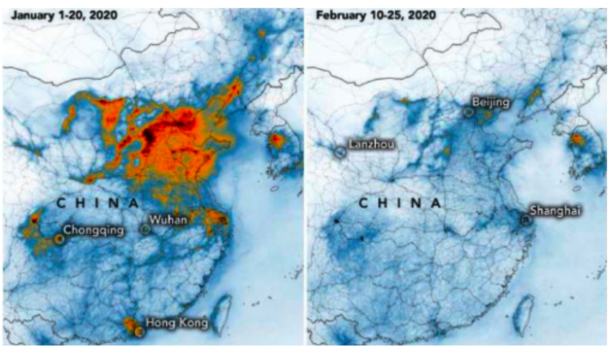
8 Coronavirus economic impact

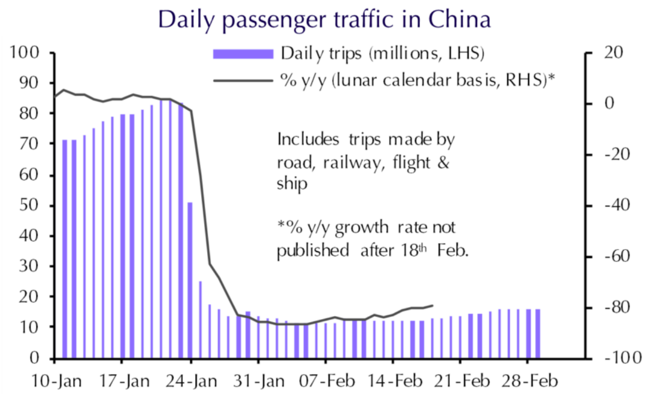
China has become an indispensable part of global business as the world's second-largest economy. It's grown into the world factory driving demand for commodities like oil and copper(consumming half of the world's metals and mining resources) and central to a diverse range of global supply chains and land of all high tech companies.
The country also boasts hundreds of millions of wealthy consumers who spend big on luxury products, tourism and cars. China's economy accounted for roughly 4% of world GDP in 2003; it now makes up 16% of global output.

8.1 Coronavirus impact on China

It all started from the 31th of December 2019 , pneumonia cases have been reported to the World Health Oranization. January 7th 2020, China confirmed that pneumonia cases are from an unkown virus.
January 23rd, Wuhan has been quarantined and all major Chinese new year events have been canceled. January 26, all Chinese tours inside China and outside have been canceled. January 31st, Donald Trump announced that that it will deny entry to foreign nationals who have traveled to China in the last 14 days.

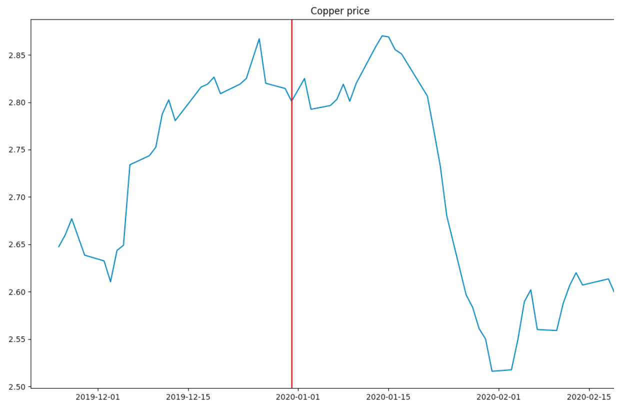
From the above timeline, the most important date to remember is January 23rd as it was the day Chinese government has decided to quarantined Wuhan, industrial city of 11 million inhabitant(5times Paris), and cancelling all lunar new year festivities.

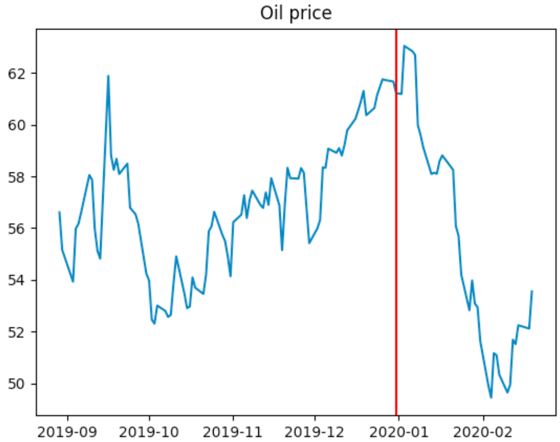




Energy consummation and goods have severely dropped in China as people are more likely to stay home during an outbreak to avoid getting sick, preventing them from traveling, shopping and working. A striking fact from this consequence is the picture above showing the amount of CO_2 before the quarantined and after. Moreover, it happened during Chinese new year which at this time tons of people should have traveled and done activities that would have alimented the world economy.
A comparaison between this year and last year, daily traffics have plunged by almost 90% Car plants across China have been ordered to remain closed following the Lunar New Year holiday(week of Jan-25th), preventing global automakers Volkswagen, Toyota, Renault from their daily production.

8.2 Coronavirus impact on commodities market



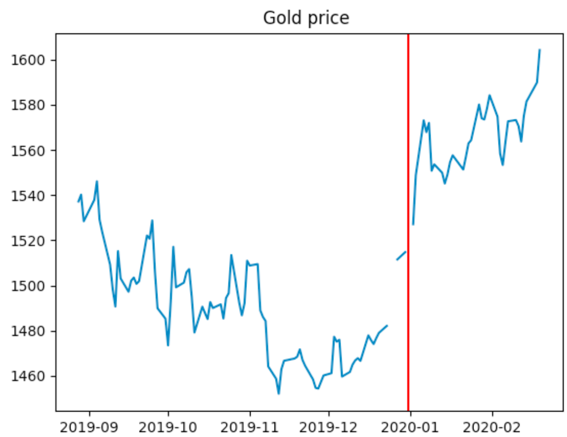


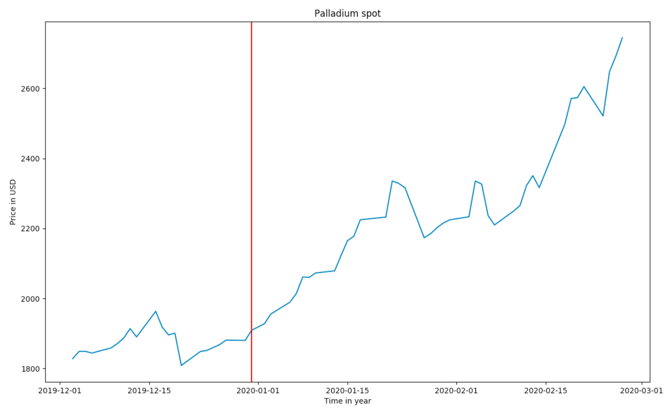
Following the coronavirus outbreak, commodities market has been the first market to be directly impacted. Copper market and Oil market have both plunged by -15% since Chinese government order the quarantine on Wuhan city.

What does it represent for the world economy?

Copper market and oil market have a strong ability to assess overall economic well-being because of the metal's wide-ranging application in industrial production, electrical equipment and the energy supply needed.

The main reason to the decrease in those market is due to an overall fear of short term investors on the world economic growth dragging price in these markets down.





Since the begening of January, gold price has spiked up due to a demand that keeps growing higher and higher. This increase is driven by the fear of economic slowdown and people taking shelter on the gold market when the world economy is unstable especially during this pandemic event.

Indeed for ages and emerging countries, gold has always been a safe heaven for example people from Vietnam always invest in physical gold instead of keeping Vietnamese money. Contrary to US dollars, Vietnamese money is much more exposed to money decreased. Vietnamese people tend to stack up physical gold instead of keeping money at the bank, hedging themselves against forex movement

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8.3 Coronavirus impact on equity

The coronavirus outbreak in China has rattled the global economy, disrupting virtually every major industry, from food, fashion and entertainment to automobiles and technology. Among them, Starbucks and Apple have close.

Starbuck stocks price in USD

Apple stocks price in USD

The major cacao actor on in China is Starbucks. Starbucks has almost 4,300 outlets in China, making it the company's largest market outside the US. Chinese sales account for about 10% of Starbucks' global revenue, making the country its most important global growth engine.

Starbucks has closed more than half of its stores in China and delayed a planned update to its 2020 financial forecast, saying it expects a material but temporary hit.
By looking at Starbucks figures, since the 23rd of Jan it has severely drop(-15%).

Apple has a large sales presence in China and assembles most of its products there. By closing stores and factories, Apple told customers that its suppliers could be disrupted and that traffic to its stores in China had dropped.
China being apple's principal market and being land of most if not all factories where iPhone are produced, by closing 40 stores it has ended several months growth with a drop of about (-15%).

The coronavirus has not only impacted commodities market but also international firms such as Starbucks and Apple by forcing these titans to close store and impact daily production. Another interesting firms to look for would be air traffic and air plane companies. Due to globalisation, people travel often around the world. As the coronavirus has now impacted the world, people are not only careful asian countries but also the rest of the globe. Putting pressure on aircraft companies cancelling flight not only from and in China but also other destination.
Globalisation allows information to travel much faster from each part of the world, but it has also allowed pandemic such as black plague and nowadays the coronavirus to spread even faster.

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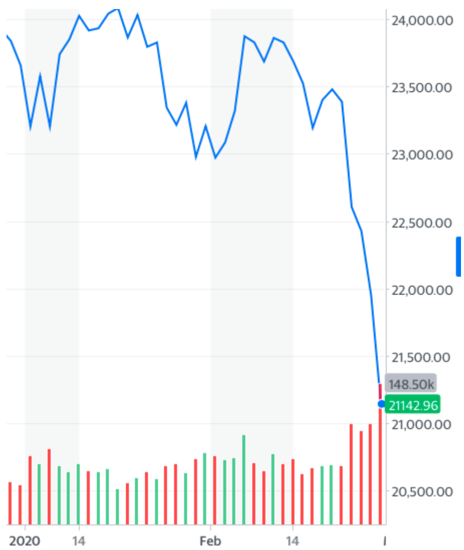
8.4 Coronavirus impact on Japanese economy

Following the exponential growth of the Coronavirus worlwide, the Japanese economy has been severely impacted. as of FEB-28th 2020, the prime minister Shinzo Abe has closed all schools until the begening of April and looking further ahead Olympic games will happen in Tokyo's summer 2020 which is in 5 months time.

Investing in the Japanese market has not been unsecured as now. Indeed by closing all school, it shows to the world that perhaps in future event, Japanese PM can also order quarantine of several Japanese city. Tokyo, capital of Japan, is the most populated megalopolis, 14 millions people. By potentially closing Tokyo,we could see an even sharper drop of industrial commodities.
Moreover, Olympic games are due in 4/5 months time. OG enthusiast, firm, local have already planned trips, infrastructure, transportation and supply facilities. By cancelling the Olympic games it will severely impact people that have already invested. This would be the certain looses.

The eventual possibility of quarantine and OG cancellation has severely impacted the Nikkei 225 falling from more than 1000points. The Tokyo Stock Exchange suffered its biggest one-day loss in 14 months Tuesday, with marine transportation and metal product issues among the hardest hit, while investors fled to the safety of gold market.



To sum up, we can clearly see the impact of the coronavirus for the last 2 months worlwide and on different market. Energy and industrial metals have significantly dropped due to a global economic fear decrease. Investor are now looking for safe haven underlying which price would not drop such as gold. Several international companies have closed shops throughout all China impacting their shares. Several important indexes such as the Nikkei 225 have severely decrease.

We can safely conclude that the Coronavirus has impacted the worlwide economy by pressuring short term investors to flee to safe heaven, leaving industrial metals and energy. More precisely, due to the extreme measure of China's government to completely stop the advance of the coronavirus(23rd of Jan), most commodities market have been impacted.

9 Conclusion

In a nutshell, this research has been an excellent and rewarding first professional working experience. I had the opportunity to work in a fast paced environment of a trading floor within a powerhouse company that is Societe Generale Corporate & Investment banking.

The time calculation of front office PnL was way to long, most tools are in VBA. I wanted to innovate the current desk tools and I had the opportunity to work on a new project which was the migration of VBA tools to python by implementing my own library. This library is mainly meant for PnL calculation, greeks breakdown, historical VaR, automatising of data retrieval and reporting front office PnL in PowerBI. I had the opportunity to develop my quantitative skills in python/SQL/VBA by broadening my library usage such as pandas, seaborn, scikitlearn, pyodbc, tensorflow but mainly in data visualisation.
Moreover, as I created a new library and migrate excel reporting into PowerBI, I had the opportunity to learn about PowerBI language which is DAX (Data Analysis Expression) I had to mainly work with different dataframe by merging, slicing, selecting the right data in order to explain a particular underlying for a particular client.

I had the opportunity to sit behind front office desk, by doing so I learned their way of thinking, the current needs of the market, commodities behavior. They have also asked me small task such as data retrieval, PnL explanation and breakdown by greeks.

For the following months I have several project in mind, as I have been accustomed to SG's tools and increase my data knowledge, I want to work closely with the strategists to develop a neural network to predict short term tendancy on commodities. Indeed I would like to broaden my knowledge in machine learning with the utilisation of Scikitlearn by predicting commodities stock price, clustering each underlying and look for seasonal pattern. I have also been placed in another perimeter which is agriculture and energy, they would like a python script that does the same as I did for metals but more optimised in term of time calculation.

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11 Appendix

11.1 Proof

VaR subbadditivity counter example proof:
Consider two assets X and Y that are normally distributed, but subject to the occasional independent shocks:

$$X = \epsilon + \eta, \epsilon \sim \mathcal{N}(0,1), \eta = \begin{cases} 0 & \text{with proba } 0.991 \\ -10 & \text{with proba } 0.009 \end{cases} \tag{15}$$

The VaR is 1% is 3.1 since the probability that η is -10 is less than 1%. Suppose that Y has the same dsitribution independently from X, and that we formulate an equally weighted portfolio of X and Y. In that case, the 1% portfolio VaR is 9.8% because for $(X+Y)$ the probability of getting the -10 draw for either Xor Y is much hiegher.

$$VaR(X) + VaR(Y) = 3.1 + 3.1 < VaR(X+Y) = 9.8$$

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12 Python Code

All code within my report has been done in python

Variance/Covariance code in python

```
import numpy as np
from pandas_datareader import data as web
from scipy.stats import norm
import quandl
import pandas as pd

def var_cov_var(P, alpha, mu, sigma):#Definition of variance co variance method
    x = norm.ppf(alpha, 0, 1)
    return (mu-x*sigma)*P

poid = np.array([.5,.5])#Weight attribuated to each underlying, here 50/50 for copper and nickel
key = 'X3cPbT9FyDvVeyioftp5'
copper = quandl.get("ODA/PCOPP_USD",api_key = key)[-260:-1]#taking copper price from quandl API for the last year
nickel = gold = quandl.get("ODA/PNICK_USD",api_key = key)[-260:-1]#taking nickel price from quandl API for the last year
data = pd.merge(copper,nickel,how='inner',left_index = True,right_index = True).rename(columns={'Value_x': "copper", 'Value_y': "alluminium"})#

result = data.pct_change().dropna()# Calculate the percentage change between date d-1 and d-2 for copper and nickel and store

P = 100000   #Budjet de: 1,000,000 USD
alpha = 0.01
c = 1- alpha  #Internval de confiance

#Calcul la matrice de covariance
cov = result.cov()

#Calcul la matrice d esperance
mu = result.mean()

#Calcule l esperance du portfolio avec le poid attribue a chaque underlying
port_mean = mu.dot(poid)

#Calcule l ecart type du portfolio avec le poid attribue a chaque underlying
port_std = np.sqrt(poid.T.dot(cov).dot(poid))

var = var_cov_var(P, alpha, port_mean, port_std)#Value at Risk du portefeuille

print("Annual Value-at-Risk portfolio (0.5:0.5) Copper/Nickel $%0.2f" % var)
```


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Stocks data price retrieval via Quandl API

```python
class param:
    def __init__(self):
        #Variables
        self.spotFX = pd.DataFrame.from_dict(req.get('https://api.exchangerate-api.com/v4/latest/EUR').json())
        self.key = 'X3cPbT9FyDvVeyioftp5'

        #Precious Metals
        #Listed
        self.goldListed = quandl.get("LBMA/GOLD",api_key = self.key)
        self.silverListed = quandl.get("LBMA/SILVER",api_key = self.key)
        self.platListed = quandl.get("CHRIS/CME_PL1",api_key = self.key)
        self.paladListed = quandl.get("CHRIS/CME_PA1",api_key = self.key)

        self.goldListed = self.goldListed.drop(self.goldListed.columns[[0, 2, 3, 4, 5]], axis=1).rename(columns={'USD (PM)': 'xauSpotListed'})
        self.silverListed = self.silverListed.drop(self.silverListed.columns[[1,2]], axis=1).rename(columns={'USD': 'xagSpotListed'})
        self.platListed = self.platListed.drop(self.platListed.columns[[0, 1, 2, 3, 4,6,7]], axis=1).rename(columns={'Settle': 'xptSpotListed'})
        self.paladListed = self.paladListed.drop(self.paladListed.columns[[0, 1, 2, 3, 4,6,7]], axis=1).rename(columns={'Settle': 'xpdSpotListed'})

        #OTC
        #self.bulk['xauSpotOTC'] = self.bulk['xauSpotListed']
        #self.bulk['xagSpotOTC'] = self.bulk['xauSpotOTC']

        #Base Metals
        #Listed
        self.aluListed = quandl.get("INSEE/010002041",api_key = self.key)
        self.copperListed = quandl.get("CHRIS/CME_HG1",api_key = self.key)
        self.leadListed = quandl.get("ODA/PLEAD_USD",api_key = self.key)
        self.nickelListed = quandl.get("ODA/PNICK_USD",api_key = self.key)
        self.zincListed = quandl.get("ODA/PZINC_USD",api_key = self.key)

        self.bulk1 = pd.merge(left = self.aluListed, right = self.copperListed, how ='inner',left_on='Date',right_on='Date')
        self.bulk1 = pd.merge(left = self.bulk1, right = self.leadListed, how ='inner', left_index=True, right_index=True)
        self.bulk1 = pd.merge(left = self.bulk1, right = self.nickelListed, how ='inner', left_index=True, right_index=True)
        self.bulk1 = pd.merge(left = self.bulk1, right = self.zincListed, how ='inner', left_index=True, right_index=True)
```


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