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Commodity market risk: derivatives hedging for the aluminium market

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INTRODUCTION

The following text will treat carefully the market risk and explains how to offset it through the use of derivatives, options in particular.

We will focus our attention on the commodity markets and then in the aluminium market, pointing out its characteristics.

The first chapter will be about the risk in general. It will be given a definition of it according to the main volumes and dictionaries and it will be split in several categories, in order to better understand its nature and its features.

The first part will include an explanation of forwards, futures and options market, how these derivatives work and how can be used for hedging purposes. Different strategies and strategies combinations will be shown.

The combinations will be divided for categories and it will be pointed out if they use the same kind of option or if, on the contrary, they need to use either call option and put option.

The first steps concern a more theoretical approach through which it is proper to get closer to the real subject of this whole text: the aluminium market and the practical use of derivatives.

Indeed, the second part of the thesis is going to present a brief history of the aluminium market, which is its relationship with the other metals, how it was discovered and why it has become so common nowadays.

Furthermore, it will be done a detailed description of the aluminium production and price trends, highlighting its main drivers and variables. In the last two centuries, since it was discovered, the use of aluminium and its popularity has changed a lot, along with its price trends.

In this sense, another milestone has been the creation of the LME index in 1978 at the London Stock Exchange.

Since that moment the price drivers started to affect the trend and volatility of the aluminium in a very different way.

At the end of the third chapter, an outlook for the next year will be given just to point out at which point we are now, what are the aluminium characteristics that in the near future can keep its use at a mass distribution level, and what can be its application in terms of sectors and geographically too.

The last part of this text will be entirely dedicated to the practical application of the option derivatives to two types of companies operating in the aluminium market.

Company A and Company B will be our protagonist, the former, a company which buys aluminium to sell a finite product, the latter, an aluminium producer which sells it directly on the market.

The strategies that will be seen in detail are five, and all their characteristics will be pointed.

In particular, it is interesting to understand how they work which are their differences and in which cases one its preferable to the others. In doing so, real data of the aluminium market will be applied covering a time span of 33 months.

This method is applied in order to make the presentation and the understanding as close as possible to a real application in the commodity market.

I THE DIFFERENT TYPOLOGIES AND DEFINITIONS OF RISK

1.1. A broad definition of risk and its main classifications

The definition of risk, according to the Cambridge Dictionary, is the probability that something bad happens. In order to have a wider frame to describe risk we may divide it into two main classes: static risk and dynamic risk.

The static risk is that type of risk that can be predicted almost with certainty for what concerns the relative probabilities but we don't know beforehand who will be the subject of that risk or who will suffer the adverse event[1]. For instance, all the games that involve probabilistic models and the insurances programmes computations are based on static risk. You can calculate for each and every agent the probability of a bad event to build up an insurance plan, you know that it is going to happen to someone, but you can't forecast who will suffer it. For the same reason, we know that someone who's gambling it is going to win or to lose the lottery with a certain probability but we don't know aprioristically who is the subject to win or lose.

Definitely, an intrinsic property of the static risk is that the fact in question is expected with certainty, property that in general can be found in the field of mathematical computation; it is also important to point out that the uniqueness of risk holds in this field: the greater is the number of the observable agents, the greater is the probability to construct a precise model which represents the reality's outcome.

The dynamic risks, on the other hand, are all those risks that cannot be forecast with reasonable precision because usually they are measured as the events occur. These risks can be those concerning the economic events like the trend of the GDP or the price of a stock, the unemployment, the demographical trend, the population' statistics, the atmospheric forecasts, both meteorologic and climatic previsions, and are divided in temporary risks and long-term risks. Those are indices that, despite being measured in the past as well, present no certainty for what concerns the future, and thus we can only run a rough forecast. Dynamic risks have three main properties:

[1] "Definition of risk", Treccani, *https://www.treccani.it/enciclopedia/rischio_%28Enciclopedia-Italiana%29/*

- The first is that if an agent invests or bets on a bunch of entities diversifies the risk and as a consequence of that, reduces it with respect to a situation where all the people invest only in an entity;
- Then, the way in which we cope with the dynamic risks is determined by and change with the progress: this means that for example new technologies or models, or even political frames can improve the way in which an individual lives determined adverse situations. If for instance the unemployment rate turns to be higher than forecasted, an inclusive and plural society may find a better model to resolve or at least ease the particular situation.
- Finally, it is true for dynamic risks that if someone faces economical losses as an outcome of a specific event, someone else is going to gain in a way that the two forces compensate each other.

There are then several ways to assess the risk categories and so we can classify it as traditional risk, statistical-financial risk, managerial risk, purely mathematical risk.[2]

The traditional approach to define risk is referred to the likelihood that a future adverse event or an accident caused by human actions can occur. It takes the point of view of an insurance company and can be therefore called also insurance-traditional approach. This trend to point out the negative possible outcome has its origin in the analysis process. Usually, this approach is used when an agent or a company may face a huge loss but with a very small probability. This means that if we take into account the expected value of the losses, a priori, the outcome value (namely p * E(X), where p stands for the probability and E(X) stands for the expected value of the loss) would be in any way so close to 0 that it seems to be non-relevant.

On the other hand, if the negative event occurs, the actual loss is huge and so this is the value that must be taken into consideration when considering problematic and unexpected losses.

The statistical-financial approach is quite the opposite with respect to the previous one, in the sense that in order to value a risk, takes into consideration the expected value of it and so it is more "rational" from this point of view. Why? It gives immediately the

[2] Floreani, A. (2004), *Enterprise risk management,* I.S.U. Università Cattolica, Milano

sense of the loss and the danger that you would deal with in case the event occurs; furthermore, it considers the statistical variation to the expected value of an event or a consequence of an action.
Beside the statistical-financial approach we have the managerial approach that is similar but it evaluates the risk of an event, not according to the expectancy but according to the objectives that a firm or an economic agent has previously set. It is important to underline this approach because although it doesn't appear straightforward, evaluating for instance two different products without considering all the opportunities they can give to the company could be misleading. Let's see the reason why.
Let's consider an enterprise that can undertake two different actions to face a problem: if the approach is the traditional one, it tends to consider only few cases. We can get the following table just to give a better idea of what we are talking about:

Outcome	**Probability**	**Action 1**	**Action 2**
Success		+20'000	+10'000
Partial success	25%	+1'000	+500
Low performance	15%	-8'000	-10'000
Totally negative outcome	5%	-12'000	-15'000

Tab.1

Considering the two actions, Action 1 and Action 2, from the point of view up above, would apparently give a crystal-clear result.
No matter what is the weight of the probabilities, if we consider all the worst possible situations against the only one that can satisfy our objectives, we get the result that the action 1 is completely dominant for every scenario. Indeed, if action 1 is undertaken, in case of success the payoff would be 20'000, and 10'000 on average if action 2 is chosen, in case of success too.
Otherwise, if the performance is low the loss amounts at 8'000 with the first action, while choosing action 2 will bring to a negative result of -10'000.
The less likely scenario of a totally negative outcome sees as a result -12'000 with the first action and -15'000 with the second one, which in this case confirms the rule.
So, why shouldn't we rely completely in this analysis, given that we have already considered the worst possibilities?
The possible answers are two:

1) We don't know which is the expected value of every action until we get the probability of success, and so looking only at some events and state the probability doesn't seem to be enough.

2) We are considering only some events, and we are not taking into consideration for example the cases in which the result is better than the objective we have fixed.

Indeed, let's take a look at the same situation of two different and alternative actions to undertake, in order to improve the economic outcome of a company or simply the improvement of a machinery.

Outcome	**Probability**	**Action 1**	**Action 2**
Perfect result	10%	50'000	100'000
Beyond the expectations	20%	30'000	50'000
Success	25%	20'000	10'000
Partial success	25%	1'000	500
Low performance	15%	-8'000	-10'000
Totally negative outcome	5%	-12'000	-15'000

Tab.2

In this table we have taken the managerial approach, that is, we have considered all the probabilities and mostly, all the possible outcomes with respect to the objectives that we had previously stated, even those which lays above the threshold set to consider our project/action successful.

Then, we try to compute the expected value of each action to see if the change in the approach was worth.

We set the notation E(X1) to represent the expected value of the Action 1 and E(X2) as the expected value of the action 2.

Of course, at every numerical outcome corresponds a probability to which we have to multiply in order to get the result.

$$E(X1) = p1*X1a + p2*X1b + p3*X1c + p4*X1d + p5*X1e + p6*X1f =$$

$$= 0{,}05*(-12'000) + 0{,}15*(-8{,}000) + 0{,}25*1'000 + 0{,}25*20'000 + 0{,}20*30'000 + 0{,}1*50'000$$

$$= +\ 14'450$$ [3]

[3] 'p' stands for the probablity, 'X' stands for the action, '1' and '2' beside X define which action

$$E(X2) = p1*X2a + p2*X2b + p3*X2c + p4*X2d + p5*X2e + p6*X2f =$$

$$= 0{,}05*(-15'000) + 0{,}15*(-10'000) + 0{,}25*500 + 0{,}25*10'000 + 0{,}20*50'000 + 0{,}1*100'000 = + 20'375$$

In this scenario, if we use the managerial approach the computations show off clearly that the convenient action to be undertaken is instead the second one, because if we consider all the possibilities and also the better-than-goal objectives, it comes out a better overall result for Action 2.

This seems to be a more precise way to evaluate the effect of an action in a company but also the effect of several investment opportunities or simply daily life choices.

The last approach that we can list is the mathematical approach. It has the main property of using exact mathematical formulas to evaluate the risk. Thus, different formulas lead to different results.

In using this approach, the credit is that each and every formula leads to a precise result that is not questionable, while the flaw is on the other hand that mathematical approach allows to consider any variable as a potential measure of risk and so it is harder to catch the correct meaning of each one.

Furthermore, a formula or a parameter that can fit every single situation can't exist and as a consequence of that, a formula can bring to a misleading result if it's not proper to the single situation in one case but may fit perfectly in another one.

The expected value, the value at risk, the maximum potential loss are all possible measures but what makes practically the difference is when and in which cases they are practically used: for instance, the mathematical approach is used in a company or in a financial institution when it is time to evaluate the position of a firm regarding its capital or the probability of solvency of a determined loan. In those cases, it is of paramount importance the use of the correct measure and that's the main utility of the mathematical approach.

1.2. Systemic and non-systemic risk

Risk can be classified in many ways: another differentiation that we may underline is the one between internal and external risk.

The external risk comes by definition from sources that are external to the firm like the general business cycle, the sector cycle and other conjunctural macroeconomic features that can affect the whole economy. Then, it has a certain importance also the trend of the interest rates.

An external risk can be also a natural disaster that destroys the harvest for a company working in the primary sector or in the soft commodity sector. The properties that mark an external risk show that it can't be forecast with certainty and can't be influenced by the singular agent or company.

The events that cause a damage are given by chance and can't be handled, but can be reduced.

On the contrary, internal risks arise from the firm itself and they can be due to the production process or from the behaviour of the workers.

For example, the forecast built up internally could differ from the effective result on the balance sheet. Moreover, the internal risk can concern the informatic system of a firm, or the logistic organization: if the operational process is not set up in the correct and more efficient way, it leads to a result that it's not optimal. If the safety measures are not taken as determined by law, a tragic episode can occur sooner or later. If the administration offices are not disposed in a functional way or simply there is someone who don't work as he/she should, the accounting and administrational process takes a step back.

A similar classification of internal and external risk can be found in the definition of systemic and non-systemic risk: systemic is referred to the risk that comes from the system, in this case, the whole market. The non-systemic or idiosyncratic is referred to the risk that doesn't come from the system and depends by firm specific characteristics.[4]

[4] Coleman, T.S. (2011), *A practical guide to risk management,* The Research Foundation of CFA Institute, July 2011

Both are intertwined so that the systematic risk is described and related to the non-systematic risk usually by the CAPM model according to the formula:

$$k = Rf + b*(Rm-rf)$$

where 'k' is the return on the equity investment that is set equal to the risk-free rate 'Rf' (which is usually the national treasury bill's interest rate) that represents an investment with no risk, relatively safe, summed to the difference between the market rate of return 'Rm' and the risk-free itself, multiplied by the firm's beta 'b'. The market rate of return is usually chosen among stock indices that represent the industry like S&P ones, or the whole market.

The beta variable is a measure that indicates how the single index moves with respect to the market fluctuations, how much it is sensitive to them and towards which direction (positive or negative). For instance, a beta that is equal to 1 points out a situation where the reference index reacts as the market does. A beta lower than 1 highlights a scenario where the firm reacts less than the market to its ups and downs, while a beta greater than 1 means that the title reacts in a stronger way than the market itself.

As a last case, the beta could also be negative, and so it means that the firm index that is taken into account reacts in the opposite way with respect to the market trend; of course, it means that if it is comprised between 0 and -1, it reacts less than the market towards the opposite direction, more than the whole market itself if it is higher than -1. This kind of index are usually called countercyclical.

Beta may be computed dividing the covariance and the variance variables.

It's been talking about the covariance between the index and the market returns and the variance of the return of the market. This suggests us that it can also be negative when the covariances of the two indices move in opposite directions.

In such a sense, the systematic risk is represented by the volatility of the market index and has the property that is not diversifiable: indeed, each and every firm must face it but diversifying the portfolio of investments can reduce the non-systemic risk that is represented by the firm's own risk.

1.3. Speculative and Pure risks

Another important distinction between two different risk classes is between speculative risk and pure risk.[5] Before getting over the difference between the two, it is proper to explain the meaning of symmetric and asymmetric risk.

We are in the domain of symmetric risk when we are treating an action or an investment (from the point of view of a company) that has a more or less equal probability to have good or bad results and so upside and downside risk. In this context, examples of symmetric risks are met when we make an investment on a stock index, when we undertake an action that has operative risk.

Asymmetric risk instead represents all those risks that have a strongly upside risk opportunity or downside risk threat that at first sight could not be considered from an average investor. The first examples that comes to mind are lotteries or all the gambling games in general, which have a strong positive asymmetry because the cost is known and relatively very small with respect to the possible gain in case of win.

On the other hand, asymmetric risk comprehends also all the risks regarding actions that can lead to a huge loss despite the small probability to happen. These are all the events that fall into the field of insurance, like fires, catastrophes, earthquakes and tragic episodes in general, like hurricanes, accidents. In those cases, we are not satisfied if those events don't happen, but certainly we have a great concern if they happen right to us.

Given this brief introduction, usually the speculative risks are those which have symmetric risk or in the majority of the cases slightly positive asymmetric risk; on the contrary the pure risks are usually strongly negatively asymmetric.

Thus, for example, we get that if we invest on the stock, we are facing a speculative risk, as if we use derivatives to hedge and cover financial risks. If we are a pharmaceutical company and plan to invest in order to develop or improve a particular product we face a speculative risk, indeed we have upfront costs but, on the other hand, we would have a good improvement in the net gain of the firm. The same reasoning could be done for the total sale of a firm which has a symmetric risk in going up or down.

[5] Floreani, A. (2004), *Enterprise risk management,* I.S.U. Università Cattolica, Milano

The pure risks are faced, speaking from the point of view of a company for example when it has to cope with some unexpected event that causes a big loss not only economically speaking. Recently, floods in Italy have caused huge problems, interrupted the production chain, destroyed a lot of machineries, if not all the production rooms, and certainly forced a great number of entrepreneurs to stop the production for a while and so to affect negatively the near future sales.

This was only an example, but in order to figure out more correctly what the pure risks are in practical terms, we may also think to an accident that may occur to a worker causing a severe injury. It's quite straightforward to notice that in this case we would have a strong downside risk that's not offset by a possible positive result.

Actually, there are several ways to define speculative and pure risks: we may say that a natural characteristic of pure risk is that its manifestation is immediate and so it is the loss it can cause, while on the other hand a speculative risk it is something that takes time to show off and the economic manifestation takes place through time as if the observation of a determined result is retarded with respect to the real event. Furthermore, speculative risks can't be offset because usually are notified once occurred, while at the same time pure risks can be offset taking a proper coverage, an insurance coverage in the vast majority of the cases.

A final differentiation between speculative and pure risks, often underlined, is the following:

- speculative risks are those who are voluntarily chosen by the subject that faces them;
- pure risks are not chosen and occur independently from the will of who suffers them.

Indeed this last differentiation seems to fit almost properly; an investment in a bond takes several years to pay off and the real effectiveness depends upon different variables, among which inflation. If the inflation is going to be much higher than forecast the real gain on the interest will be drained, dragged down, but if the inflation keeps lower than forecast the gain on the interest rate will be significant. Usually, when one decides to invest knows a-priori what kind of risk is going to face and even the potential gain or losses with respect to the standard forecast scenario.

On the contrary, a pure risk like a fire that burns from the melting process room of a particular metal is not something that the entrepreneur chooses to deal with. A flood that ruins all the first floor of an administration department is not an event chosen by the CEO; certainly, both of them can take active measures to cover those risks with an insurance plan and take prevention measures in order to try to avoid them.

Speculative and pure risks can also be split in more sub-categories which have determined characteristics:

1) Pure risks can be divided in risks on firm's goods, risk on people and risk of responsibility.

2) Speculative risks instead can be split in business risks, and derived risks.

Let's start with pure risks: so, we define risks on goods, all those regarding a loss or damage to the company even though not physical. If a fundamental machinery gets broken, we can talk about risk on good. If the value of an investment on a device gets lower than expected, decays fast, we are in front of a process that belongs to the kingdom of the risk on goods. The same is worth for the human capital: even though we are talking about single workers, the loss in terms of human capital, namely some professional figure that covers a key role in a firm is hard to replace but it is mostly a relative competitive disadvantage that must be seen from the point of view of the whole company.

On the other hand, the risk classified as purely on people concerns injuries, wounds or even deaths that can bring heavy damage to the single person. A fire may not kill an employee but can lead him to a permanent condition of inability, the same is valid for an accident and looking at them carefully, those risks are not so much under the control of the firm given that they can also happen in any time in the private lives of anyone and may cause consequences even for the firm.

The risk of responsibility treats all the damages that can be made to third entities by the firm directly or through its component or products.

In a commercial meeting if a pre-determined agreement, blows up in a sudden because of the weird behaviour of a single employee, we are in the domain of the risk of responsibility. It caused a direct damage to another firm, and in this sense a more explicative example could be the case of an advising agency that takes the mediator role to favour an agreement between two parties in the field of mergers and associations. If the agreement is of paramount importance at least for one firm or for both, a wrong attitude or several mistakes of the mediator could lead to a severe loss in terms of opportunity cost for both companies if the deal doesn't close out as expected.

For what concerns the direct and physical damage, the classical case of a defective product can be considered where a customer gets hurt or injured: in this case the firm faces also the pure risk of responsibility with respect, of course, to the customer.
The other flank is formed by the various types of speculative risks and, as previously said, it can be divided in two main branches: derived risks and business risks.
The derived risks can be split once again in financial structure risk, investment risk and asset-liability risk. The financial structure risks are those who concerns the firms or economic entities that are currently in deficit or in need of financial resources. These institutions face clearly a financial risk that depends upon the interest rates and even the economic cycle in general.
Even if it sounds quite similar, the opposite is valid for the investment risk. It concerns who has surplus resources to invest and it is peculiar of all the money savers, an individual investor, a family, or of the institutions that receive an excessive and not necessary amount of cash: they could be banks in a certain period or insurance companies which have the premium paid certainly before the accident or the adverse event occurs.
The last one is the asset-liability risk which comprehends all the two previous categories at the same time: it can be the case of the exchange rate that must be taken into consideration when you have to invest money on a foreign market or check it in case you borrow money abroad to finance your activity.
The business risk itself can be divided instead in strategic risks, operative risks and financial risks:
1) The strategic risk treats all the issues regarding possible developments in the firms' next actions. This is certainly a broad definition and going more in depth we can name M&A plans, deals, or simply decisions to increase the volume and the presence of a firm in a specific geographic area, to invest in research if it is of particular importance to the sector. This type of risk plays an important role in the commodity risk management process.[6]

[6] Oliver Wyman (2012), *In practice guide: six steps to commodity risk exposure, Marsh and Mc Lennan companies,* October 2011

2) The financial risks have their origin in the trend of all the financial products traded by a company or by an individual investor: a derivative product bears, for whatever reason it is used, a financial risk depending on the trend of the underlying asset which can also depend on the economic cycle or the level of the central bank interest rates policy and so on.

3) All the risks taken to manage directly a company are instead operative risks: this definition is related to the usual management of the research and purchase of raw material at the best price, then to the transformation of this material through the most efficient machineries and finally the sale phase in which the product has to be set on the market and sold to the client that is disposed to buy at the higher price.

The core of this text concerns how the derivative products are used to cover the risk in the commodity market, to reduce the market price risk.

1.4. The particular risks of the commodity market

The commodity market risk is going to be treated more carefully later in the next chapters, in the meantime we rank it in the speculative risk family because, in the field of commodities, the risk regarding the financial market on the good is strictly related to the risk to purchase and sell the material itself.[7][8]

For instance, if I buy a future related to the oil index, I own a financial tool but in fact I take a commitment to buy a certain unit of oil in the future. This is the same consideration made in the case of operational risks and this is why commodity derivatives fall into the third box of speculative risks, given that the commodity prices tend to be so much volatile and subjected to high levels of uncertainty.[9]

Furthermore, for a long position on a put option is valid the same reasoning: you simply buy the right to sell a certain amount of the good and therefore it has to be considered an operational risk.

It is important to point out that this process has a paramount importance inside the firm and it's generally followed by the monitoring phase and the building phase of a model that can solve or at least minimize the firm management risk.

We are going to open an introduction of what is the risk management, talking about what it means in the field of commodities and how it can be treated and managed. It is of fundamental importance for the development of this project, because before building up strategies and ways to counterbalance the risk of a firm we should know very well the space in which it is set and starting from the beginning could be a good idea. The world of commodities is very wide and varies a lot sector by sector.[10] It appears for instance difficult to compare the trend of the market relative to the oil market, silver market, and both to the market of cotton or sugar.

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[7] Larson, D., Varangis, P. & Yabuki N. (1998), *Commodity risk management and development,* Development Research Institute, Washington D.C.

[8] Deloitte (2018), *Commodity price risk management,* MCX

[9] Till, H. (2016), *Commodity risk management,* University of Colorado Denver business school, Volume N°5/WP/2016

[10] Poitras, G. (2013), *Commodity risk management,* Taylor & Francis, New York

Hence, first of all, before treating its applications and how to reduce the relative risks, let’s define what commodity is.

A commodity is any tangible good that can be traded on the market and so it is a physical item.

Whoever trades a commodity, a firm or an individual, has to deal with its changes in value, and this basically is the commodity risk in general: the uncertainty and the fluctuation in the market value of a commodity.

Furthermore, the commodities can be roughly divided in two main categories: soft commodities and hard commodities.

Hard commodities can be further divided into metals and energy commodities.

The principal characteristic of the soft commodities is that are all grown up products and inside this huge set we can find completely different things: soybeans, coffee, rice, cotton, flax, silk, wheat, cocoa, sugar are all examples of soft commodities even though may be used in completely different market: food market, textile market and so on.

The hard commodities on the other hand have in common the opposite property:

they are never grown product but instead mined elements. They already exist in nature but have to be extracted to be traded, not cultivated.

Thus, as previously mentioned, the metals like gold, silver, copper, zinc, aluminium, steel, bronze, are all hard commodities while coal and oil falls into the field of energy commodities.

Then, for any commodity we can identify 5 types of risk:[11]

1) The price risk is the uncertainty about the commodity price and the negative results that a rapid change can cause in a company. The market price risk is the one that will be analysed more in depth along this text, but at the moment it is proper to say that the potential damage is mirrored with respect to the point of the production chain a business is located. Thus, a producer of a certain commodity will benefit from higher prices if in particular the demand doesn’t react too much fast, because the total revenue will be higher too. On the contrary, a company that has to buy that particular commodity in the same situation has a loss because the supply side will cost more. Vice versa, a fall

[11] CPA Australia (2012), *Guide to managing commodity risk,* Southbank, October 2012

in prices will penalize the producers and favours the businesses that use that commodity as a supply and then sell the processed product.

2) The quantity risk is the risk related to the availability of a commodity: if a product is abundant there is no problem through the whole production chain, while if it gets scarce the producers find difficult to gather it and consequently to sell it. This type of risk is tightly related to the price risk, but has a different interpretation.

The scarcity of a commodity will induce the producers to increase the price in order to get the same revenues it obtained earlier: this cost will shift thus towards the customers that bear the burden.

3) The cost risk is similar to the previous one but it is referred only to the input of a firm that trades a commodity while the quantity risk to the availability that can affect both costs and revenues. An increase in the price of a commodity is the only possible cost risk given that it can increase the costs of those who buy that commodity.

4) The foreign exchange rate risk is perhaps the more significant risk for big companies who trade with foreign suppliers or clients. The change in the exchange rate may cause a loss with respect to the price decided in a contract if at the time of the manifestation of the revenue/cost the exchange rate is different and more profitable.

5) The political risk concerns mostly the regulation aspect. All the laws and bureaucratic issues that slow down the trade flow may represent a further source of risk for a company. Moreover, the relationships between the country you work in and the countries of the main partners is another driver that affect the firm's capability to succeed in its operations.[12]

[12] Pwc (2009), *Navigation: managing commodity risk through market uncertainty,* New York, May 2009

II FINANCIAL RISK MANAGEMENT IN THE INDUSTRIAL WORLD

2.1. Derivatives

The derivatives are a set of tools and even though it's hard to find a broad definition that they can have in common, some terms can be provided in order to put them inside a definite frame.

The first one is the notional value: it says how much is worth an existing position that is namely the market value of a single unit of asset multiplied by the number of units bought in a contract.

The market value of a derivative is the market price of a single contract, so it can be also intuitively represented by the notional value but with the difference that the position pointed out in the notional value can be referred to more contracts.

The trading volume refers to the number of derivative contracts that are traded in a limited period of time, for instance it is usually taken into account one-day period.

The exposure and namely the credit exposure is how much the investor could lose if the counterparty doesn't meet the requirements to pay back or doesn't have the liquidity necessary to face its obligations.

The open interest is finally the term that defines all the contracts standing in an open position and that haven't been closed yet.[13]

In the last two decades, the derivatives market has grown a lot and more precisely since 2004 the annual volume of trading has become 43 billion contracts c.ca while 20 years before it stopped barely at 8.

The different types of contracts are the following:

- Equity derivatives, that represents and has always done, the great majority of all the derivatives traded overall;
- Currency derivatives;
- Commodity derivatives that has become the second most traded type in the last ten years but well far away in terms of percentage than the equity ones;

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[13] Roshan Singh, R. (1997), *Derivatives and risk management,* Excel Books Private Limited, New Delhi

- Interest derivatives, which were the second most traded 20 years ago, with a slice (market quota) of 25% but along the decades decreased in terms of representativeness overall and also in absolute value;

Anyhow, it is fundamental to highlight the derivative contracts themselves just to give an exhaustive idea of what they are and how they work. The main derivatives are options, swaps, forwards and futures with the last two being relatively similar but with the main difference that forwards have only one deadline at maturity while futures can be closed out even during the period the goes from the subscription to the delivery. A similar difference can be found when we talk about the options because there are three main types: European options, American options, and Bermudan options: the first two present indeed the same difference of the forward and future contracts, the European can be traded only at maturity and the American options can be traded at any time during the period following the purchase. The Bermudan options positions are similar to the American ones but can be closed out only at determined dates (days or weeks).

2.2. Forwards and Futures

The simplest and most intuitive derivative product, for what concerns its features, is forward. It is called in such a way because the investor can sign a contract to buy or sell at a certain point in time in order to buy or sell a determined number- of contracts in the future, usually 3-months, 6-months or 9.

Another similar tool, futures, has more or less the same features but of course along with the similarities, the futures have a price that can slightly differ with respect to the forward mainly because it gives the investor the option to close the position all over the period it covers. The price of the forward is different than the one of the underlined stocks but it should converge, slowly, step by step, when it reaches the maturity, independently if at the subscription it was higher or lower.[14][15]

One of the most used products in the field of derivatives are the futures: as we said the difference between the forward and the futures can look like a detail, but it is of paramount importance when we have to shape its price and how it works. Basically, it helps an investor to commit to buy or sell a real amount of a specific good in a certain date in the future, that can be referred to a 3-month future contract, 6-month future contract, 9-month etc…

It can be very useful, for instance, when a counterpart has the need to invest. He knows that it will have to buy some good in a future date but doesn't know the price trend precisely; he may try to lock in the price with a long hedge buying the needed quantity at the future price, if he fears for example that the price will probably hike in the next few months.

If a firm client knows that has to buy an amount of raw material in 6 months and the 6-month future price is 1'100$, he could be scared by the fact that in the next 6 months the price of this material will soar on the market and so he can buy the forward to block the price and prevent the damage by the hypothetical rising cost of his firm.[16] Let's

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[14] Schwager, J. & M. Etzkorn, M. (2017), *A complete guide to the futures market,* J. Wiley & Sons, Inc., Hoboken (New Jersey)

[15] Roshan Singh, R. (1997), *Derivatives and risk management,* Excel Books Private Limited, New Delhi

[16] Hull, J.C. (2021), *Options, futures and other derivatives,* Pearson, Harlow (UK)

suppose that the Stock price St, rises, let's say to 1'125$ in 6 months and the contracts to buy are 8 (each contract refers to 1 unit of a good), the total payoff that derives from the subscription of the future, that, from now on, we will call total future payoff is equal to (1'125-1'100)*8= 200.

If on the contrary, the future has been already bought, but at the end of the six months the stock price of the good is 1'075$ the total payoff from the long hedging would be negative, namely (1'075-1'100)*8=-200. The hedging process has led to an overall loss in the future market.

In further situations, we observe the opposite behaviour.

Our hedger knows that he has to sell a certain quantity of tons of a metal. At time 0 the future 3-month price is 120$ and he wants to avoid a hypothetical loss deriving from a decrease in prices in the immediate future. Our hedger should be eager to lock in the price and sell the same amount in 3-months but signing immediately the commitments sell through the forward market. If the stock price St in 3 months turns out to be equal to 95$ and the number of contracts (each one represents 1'000 unit of good) to be sold is 15, the total gain from this sale is the following (120$)*15*1'000=1'800'000$, that we can split in 2 main parts:

- the gain derived from the spot market that always represents the quantity of good purchased or sold, multiplied by the spot price at the expiring date of the future in this particular case it is 95$*15*1'000=1'425'000$.

- the gain from the total payoff of the future that is, the difference between the price of the future and the spot sale price multiplied as always to the quantity sold. In this particular case it is equal to (120-95)*15*1'000=375'000$. Note that it can be calculated also as the difference between the total gain and the gain from the spot price, it should give the same result. Indeed, we would have 1'800'000-1'425'000=375'000$. This was a case in which the total payoff of the future was positive just because the spot price turned out to be lower than the future price.

In the other way round, the asset price on the market can be higher at time t1 than the price of the future of the underlying asset at time t0. Let's say for instance that the a 3-month future price is 70$ and the St at the end of the 3 months hits 90$.

In a short hedge the investor sells the derivative in order to lock in the price when he expects it to go down. Now the price went up and so our hedger has gained less than it would have done if he hadn't hedged.

Practically, it means that the total gain is as in the previous example computed by multiplying the quantity sold with the price of the future sold, (70$)*(15*1'000)=1'050'000$, but this time is less than the gain from the spot sale because the difference from the two prices as presented above is negative.

It is formed by spot sale gain plus the total payoff and it can be calculated also in the following way:

(95$)*(15*1'000)+(-25$)*(15*1'000)=1'425'000$-375'000$= 1'050'000$.

The position leads thus to a loss in the futures market of 375'000, and the sale would be less profitable than if the hedger had not gone through selling futures

For sake of simplicity, we have kept the standard assumption of 15 contracts sold and that each one is worth 1'000 unit of the good.

From a more relative point of view, we could have considered the profit of the sale in the single markets:

1)In the first case the Future price was 120$ at time t0, while the realized stock price at time t1 was 95$. If we consider the stock price at time t0 as well, we can find out the net profit from both the stock market and the future market.

Let's suppose the price S0 of the asset was 130$, the hedger would have a gain in the future market of (120-95)*15*1'000=375'000$, but at the same time a potential loss in the Stock market of (95-130)*15*1'000=-525'000$. This brief explanation is useful to highlight that in this case hedging has improved the position of 375'000$ and counterbalanced the effect of the price decrease.

2)In the second case the Future price was 70$ at time t0, while the realized Stock price is at time t1 was 90$. If we take into consideration that the Stock price in time t0 was 80$, we find the net profit of the positions in the stock market and in the future market.

Let's suppose the price S0 of the asset was 60$, smaller than the price at time t1 and smaller than the future price at time t0, the hedger would have a loss in the future market of (70-90)*15*1'000=-300'000$, but at the same time a gain in the Stock market

(90-80)*15*1’000=150’000$. This brief explanation is useful to highlight that in this case hedging has worsen the position of 300’000$: if he had not signed a 3-month future contract we could have sold our asset at a higher price than the stock price at time t0, namely at 90$ instead of 80$.

2.3. The option derivative offsetting the market price risk

Another set of tools whose use has been increasing enormously in the last two decades are the options and there are two main typologies: call options and put options.

These products work differently with respect to the futures and the swaps, indeed when you buy them, you buy in fact the right to buy or sell the underlying asset.

First of all, let’s fix two terms that will have a paramount importance in options understanding: from now on ‘S’ is going to represent the current stock price of a commodity, while ‘K’ will represent the strike price of the option, namely, the price at which who decides to exercise the option agrees to buy at or to sell at.[17]

So, you are going to exercise that right if it will be profitable to do so at a certain time in the future depending on the spot price S movement with respect to the strike price K.[18]

If you buy a call option you own the right to buy an asset at a certain point in time or in a certain period of time, on the other hand if you buy a put option you own the right to sell an asset at a certain point in time or in a certain period of time.

Furthermore, talking about the call options, an investor can buy one at a price called ‘premium’ on the market hoping that the strike price of the option at the deadline will be lower than the Spot price on the market. Indeed, if this turns out to be our case, our investor could exercise the option buying the underlying asset and then sell it on the market immediately. The difference between the spot St and strike price K is the gain per unit and all of that multiplied by the units of the good traded (to which should be subtracted the value of the option premium), gives the total payoff of the call option.

If on the contrary the Spot price at the end of the period is not the one expected and it is lower than the strike price, the option won’t be exercised by our investor, the payoff would be equal to 0 and the total loss would be simply equal to the acquisition price of the product (premium).

Let’s build up an example to show in a clearer way this mechanism:

- We buy at 60$ a call option on a raw material which has the strike price 95$ and is going to expire in 3 months.

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[17] Smith, C.D. (2008), *Option strategies,* J. Wiley & Sons, Inc., Hoboken (New Jersey)

[18] Hull, J.C. (2021), *Options, futures and other derivatives,* Pearson, Harlow (UK)

1) The investor expects the price going up to a higher value and he's right. After 3 months the spot price is 115$. Taking into account that the option gives the right to buy 5'000 units of the good, the investor will exercise the option and then sell the underlying asset gaining (115-95)*50=1'000$, at which should be removed the initial price of the option 60$, 940$.

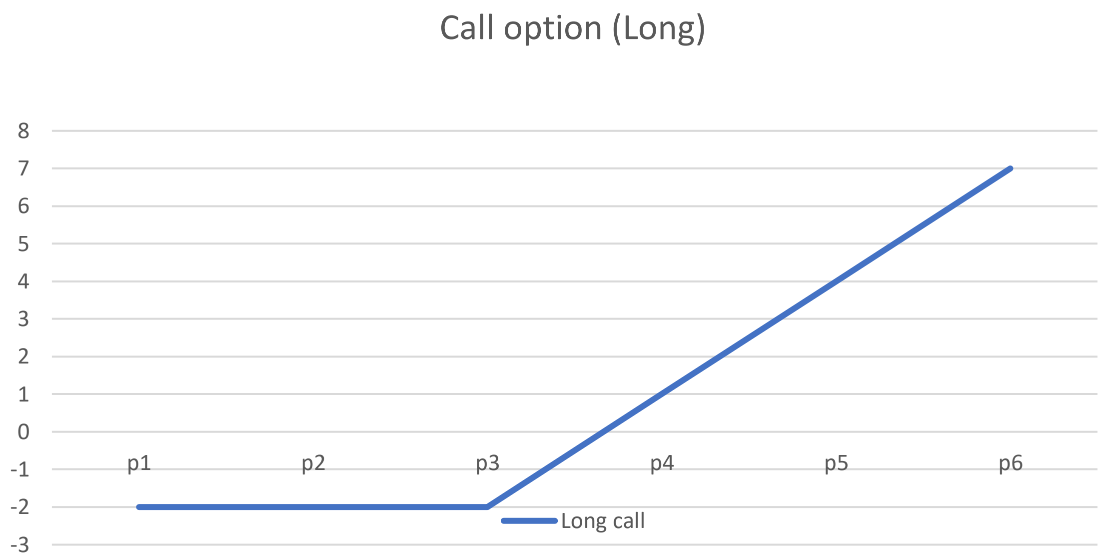
2) The investor after 3 months notices that the price has gone down, under the strike price threshold of 95, let's say 85$. In this case it's not convenient to him to exercise the right because it's not profitable. Exercising and then selling the underlying asset would bring to a loss much greater than the sole derived by the acquisition of the option, -60$.

3) There is a third situation to analyse when we talk about call options, and is when the spot price at the expiring date is greater than the strike price K, but at the same time if we consider also the initial expense regarding the option premium, the profit turns out to be slightly negative.[19]

Numerically speaking, taking into account the previous examples, if we get a spot price after 3 months that is 1$ higher than the strike price, and so 96$, if we consider the same amount of units purchased and then sold we should have a total payoff of the call option that's equal to (96-95)*50=50$.
It is certainly positive but if we then subtract the 60$ of expense relative to the price of the product itself, we have a loss in total, given by 50-60=-10$.
In those cases, it is always convenient to exercise the option, the important thing it's that the spot price is higher the strike one. Indeed, in the third example if the investor hadn't exercised the right to buy the asset, he would have incurred in a greater loss than it would have had in the case described above, 60$, as in the second example, not exercising the option.
The example of the profit path of a call option for different range of prices is well described in the graph below, presenting in the x-axis the variability of the stock price

[19] Hull, J.C. (2021), *Options, futures and other derivatives,* Pearson, Harlow (UK)

and on the y-axis the profit per value that obviously depends on the strike price. The graph has an upward slope.



Graph. 1

When the stock price is lower than the strike price, lower than p3, the function is negative, flat and it is in particular, equal to the premium price of the option itself, -2 in this example.

When the stock price becomes higher than the strike price, the function changes shape, and becomes linear and increasing according to the function 'St-K'.

When the difference between the stock and the strike price overcomes the option premium, the profits are then purely positive.

Let's talk about how a put option works and when it is convenient to exercise it.

On the other hand, a put option is purchased in order to get the right to sell an underlying asset. In such a situation the investor hopes to see the stock price going down at the expiring date of the put option in order to exercise it.

Let's take similar data to the previous example on the call option:

We buy a put option at a premium 80$, it is going to expire in 3 months and has a strike price K of 95$.

1) The stock price after three months the put option has been purchased, turns out to be 75$. So, in such a situation, the investor finds convenient to exercise her right and sell the asset. The total payoff of the put option is equal to the difference between the strike price K and the spot price St (K - St) multiplied by the units traded, and at this

amount must be subtracted the acquisition price or 'premium' of the put option, in order to get the net profit.

Namely, (95-75)*50=1'000$ at which we subtract the initial cost of the product, 80$, and we get 920$,as the net profit deriving from the option.

2) The stock price after 3 months goes down or stays below the strike price.

In this case, the investor expected the price to go down but the situation didn't verify and so it's not convenient to exercise the right. The loss would simply be the one related to the purchase of the put option, 80$. If he had exercised, assuming the price of the stock unveiled at 105$ at the deadline, we would have a loss of (95-105)*50= 500$ at which we should sum the premium price of 80$, thus finally 580$.

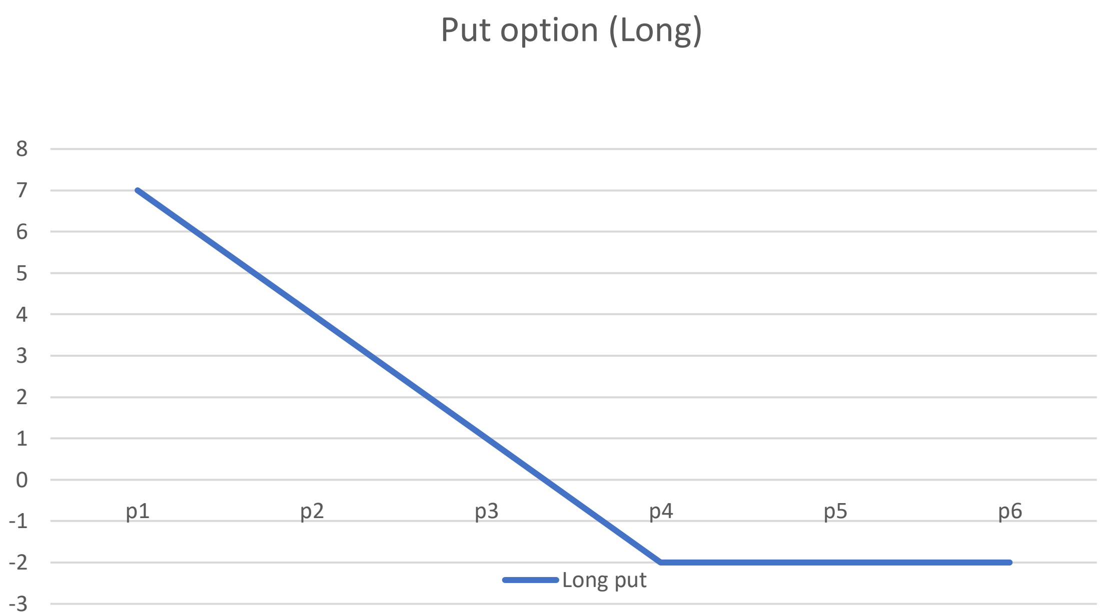
3) As a third case, like previously seen with the call option, the price of the underlying stock stays below the strike price K but it doesn't assure the investor a net profit, the put option must be exercised anyway. If the stock price gets anyway lower than the strike K but slightly, let's say 94$, we have a specular case with respect to the call option one: the investor might and should exercise the right to sell, buying the underlying asset, because on the contrary, in this case K is greater than St.

However, he can't reach the profit, in fact (95$-$94)*50=50$ at which we have as usual to subtract 80$, and thus we get a loss of 30$.

Also in this case, the investor has all the convenience to exercise the option because otherwise he should bear a loss equal to the put option premium that is equal to 80$, certainly more than 30$.

Down below is shown the graph path of the put option profit at every change in price of the asset from the point of view of the investor, and it has a downward slope.

As we have already seen we have a positive profit until the stock price reaches a certain threshold, K-St=-2. When hits the K value p4, it stands flat on the value of the premium.



Graph. 2

These first two cases are the simplest and take the point of view of an investor who buys the two types of option.

In doing so, he bets on the trend of the stock price and behaves consequently. But what if an investor already owns a derivative and wants to sell it or to short it?

If you are an in investor, (speculator, arbitrageur, or hedger) as it usually happens in firms that buy and sell derivatives, you may find yourself in 4 different situations:[20]

- going long for a call option; in this case you buy the right to buy the underlying asset in a certain time in the future. If American, the right can be exercised anytime until the deadline, if European the right can be exercised only at the deadline and if Bermudan it's a mixed features between the two in a sense that the asset can be bought only at a certain date in time.

- going long for a put option; here the investor buys the right to sell the underlying asset and the same characteristics of the call are valid for the put.

[20] Cohen, G. (2016), *The bible of option strategies,* Pearson Education, Inc., Old Tappan (New Jersey)

- going short for a call option; in this case the investor owns an option and wants to sell the right to buy it.
- going short for a put option. Finally, the last scenario is the one in which the investor owns a put option and sell the right to sell the underlying asset.[21]

The last two cases are yet to be seen, and the result of the payoff is computed in a different way.

Suppose we want to short a call option on the market at a price of 60$, whose strike price is 95$, 3 months before the expiring date;

1) In the case the stock price is higher at the expiring date than the strike price K, who bought the option will be eager to exercise the right to buy in order to resell immediately the asset on the market. In this case our counterpart has the same role we had in the first example where we went long on a call option. Our investor needs therefore to sell the asset to the trader who wants to buy it. If we assume that the stock price after 3 months reaches a peak of 105$, then our counterpart is going to exercise the right, forcing us to sell him the asset immediately.

2) As an alternative scenario, it may be that the strike price stays below the stock price and in this case our dealer won't find convenient to exercise the right relative to the call option. Indeed, if St turns out to be 85$, the option won't be useful to the counterpart and so our reference investor is going to have a gain equal to 60$ that is the premium of the option itself received at the moment of the sale.

3) When we assume a short position, the breaking point is when our dealer has already exercised the right to buy but in fact, the opportunity cost that we miss is not big enough to cause our investor an overall loss. If we take the point of view of an option owner that has just sold it, certainly it doesn't matter to us if the counterpart that makes a deal with us has a total profit, but if he exercises the right and what effect has this operation to us. To simplify the explanation, let's pick up a numerical example.

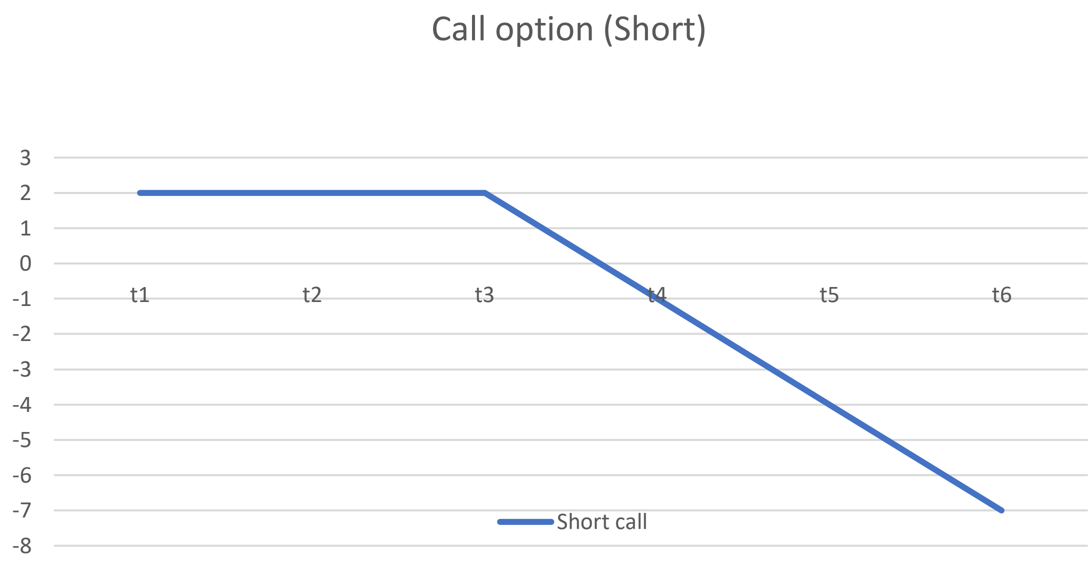
In this case if the stock price gets to a value of 96$, even though there is not going to be a profit (96-95)*50-60$=-10$, the counterpart exercises his right. From the point of view of our investor, the situation is now different: when St gets bigger than K, we find a range of value in which our investor makes anyhow profits.

[21] Hull, J.C. (2021), *Options, futures and other derivatives,* Pearson, Harlow (UK)

The graph below shows well the profit path of a short position in a call option for different ranges of price.

It is a downward graph and so it means that the more the stock price goes up and the less the total payoff of the option is positive or good.

Of course, in case the stock price is low, as we explained before that option won't be exercised and so the graph will be flat on the positive value of the premium price of the option, +2 in this example.



Graph. 3

The last situation in which one who deals with the option may face is a short position in a put option. It means that the position is the opposite one with respect to the short call option.

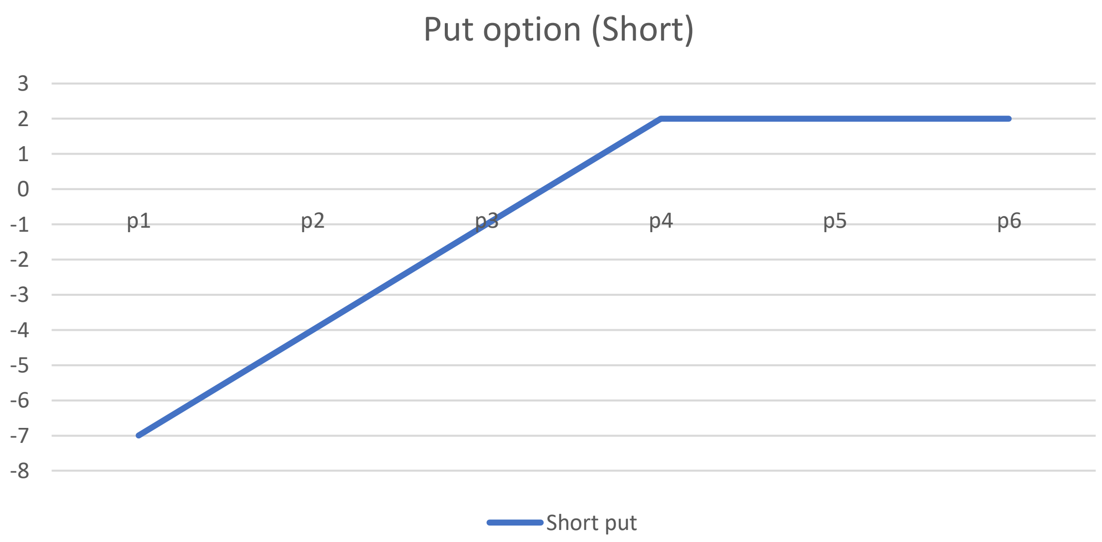
Let's assume as usual that:

we sell a put option at 80$, it expires in 3 months and it has a strike price of 95$;

1) After 3 months we have a situation in which the stock price stands above the strike price K. It means that basically our counterpart won't exercise the right to sell. He would incur in a loss. Let's say that at the end of the third month after the sale, St rose to 110$, selling the stock at a K of 95$ would not be profitable and losing (95-110)*50=750$ is not convenient. For our investor the profit would be simply equal to the premium price of the put option, in this case 80$.

2) Instead, in the case we have a stock price at the end of the reference period (option deadline), that is lower than K, let's suppose 80$, we find ourselves in the classic situation when the counterpart will exercise the option and so we have an implicit loss

equal to the profit of our dealer. Our total option payoff will be equal to the premium of the option at which we have to subtract the opportunity cost we lost. In this case 80$-(80$-95$)*50 = 80$-750$ = -670$. According to the function, Premium – (K- St)*n°Asset.
3) Finally, in case the price of the stock at the deadline ends up to a value of 94$, our counterpart will take the chance and exercise the put even though he knows that won't make a profit. Indeed, the total payoff from the purchase of the put option for the counterpart will be the usual, computed as a long position on a put option (95-94)*50-80=-30$. Of course, it would have been worse if the option had not been exercise: it would have led to a loss of -80$. From our point of view, the profit-loss relationship is upside down. It means that until our counterpart has a loss, we have a profit.
In the graph below is shown how the profit path of a short position behaves under the change of the stock price.
At the beginning, for very low values of the stock price our investor has a loss equal to -(K-St).



Graph.4

These are all the situations that an investor can cope with while trading with options.

2.4. Strategy combinations with more options of the same type

An option trader may want to buy and sell at the same time more options in order to build up more complex positions.

These strategies are several and their main aim is to ease the risk, limit the upper and lower bound of the profit graph and have a sort of control over the total result of the strategy: it is useful to limit the uncertainty.

We are going to introduce the entire subject presenting two examples of combinations, operations on the market that change your position to better answer to the change in the market price.

This can be done through a covered call and a covered put. A covered call option consists in buying the underlying asset, the stock itself, and at the same time selling the call option. It will be giving us a result that is the opposite of simply selling a call option.

We would be infinitely exposed to the lowest prices but we would make double profits, even though capped for the highest values, at the expiring date for prices higher than the reference stock price.[22]

The outcome is graphically the same as we would sell a put option alone.

The same argument, with opposite practical results, holds for the covered put options. In those cases we sell both the underlying asset and a put option in order to get an effect that backs us in case of very low prices, when the market is bearish.

We have capped and high profits for the lowest group of prices but on the contrary infinite potential losses if the price soars. The outcome is graphically the same as we would sell a call option on its own.

The first type of option strategy is the one in which the hedger buys and sells more options of the same kind. These are called spreads. The first one that we are going to analyse is the bull spread strategy: the investor buys one option, let's say call option, with a certain strike price K2 and sells another call option with a different strike price, a lower one, K1.[23]

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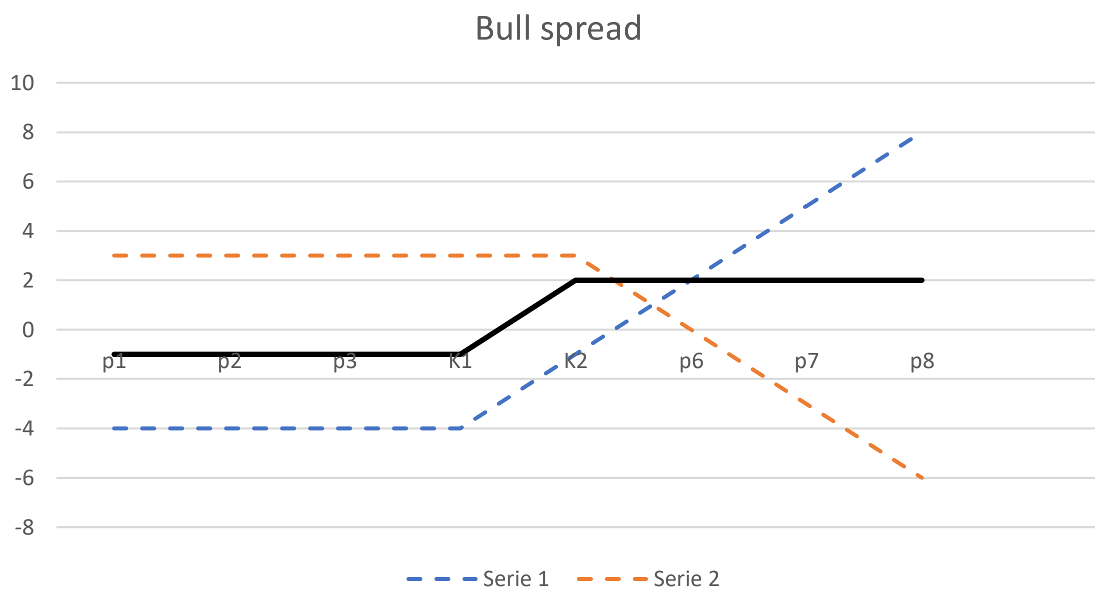
[22] Cohen, G. (2016), *The bible of option strategies,* Pearson Education, Inc., Old Tappan (New Jersey)

[23] Hull, J.C. (2021), *Options, futures and other derivatives,* Pearson, Harlow (UK)

The strategy situation is better explained by the graph below in which we can see the profit with respect to the price for each option and the final result.



Graph. 5

In the graph the long position in the call option is represented by the dotted blue line, it is negative given the cost 4 at the beginning and then becomes positive. The opposite is valid for the short position, that is positive at the left of the graph in presence of low stock prices.

From the assumption that usually the call option we buy has a lower strike price than the one we sell. It allows us to create a sort of limited effect both in the profit and loss side. Under a certain price the loss is limited, over a certain price the profits are limited too. Basically, the only range in which the function is not steady is when the stock price fluctuates between the two strike prices K1 and K2.

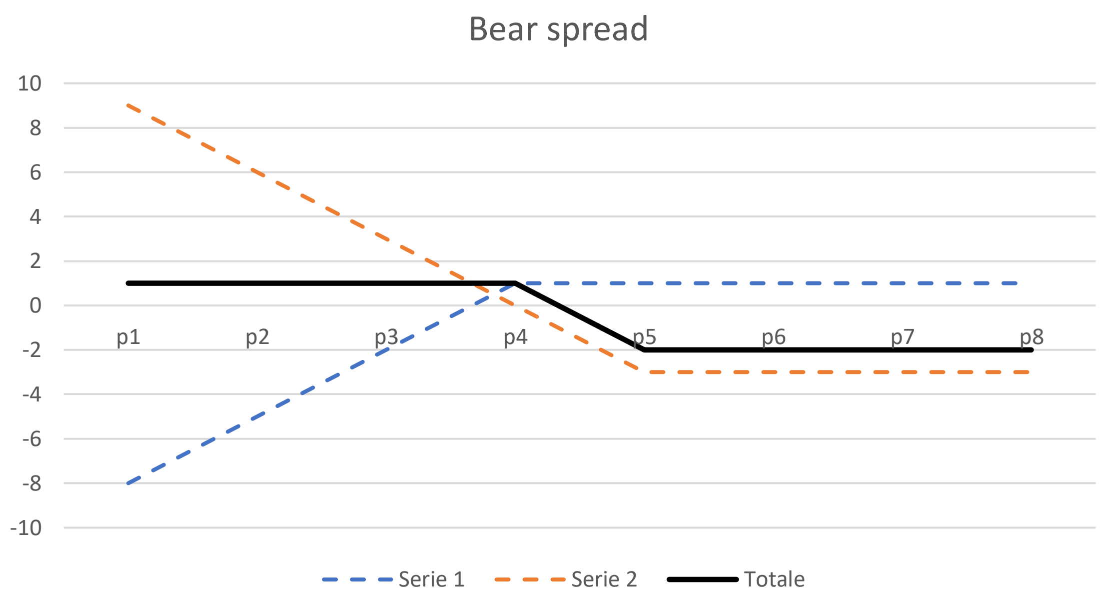
Of course, the same example would hold also if we had taken put options as an example. We should have bought a put option with a lower strike price than the one we should have sold. This way we obtain a symmetric graph with respect to both the call option up above, but with the same total result. The strategy would be anyhow profitable if at the expiring date, the price of the underlying asset would get higher than the higher strike price K2.

On the other hand, with a lower stock price than K1 we would have a loss but limited to the premium price of the put option bought.

The second strategy type that we are going to analyse, also in the family of the spreads are the bear spreads.

It consists in buying one call and selling one call with two different strike prices, or buying one put and selling another put with the same expiring dates but with two different strike prices.

Let's take this time the point of view of an investor that trades put and applies a bear strategy.



Graph.6

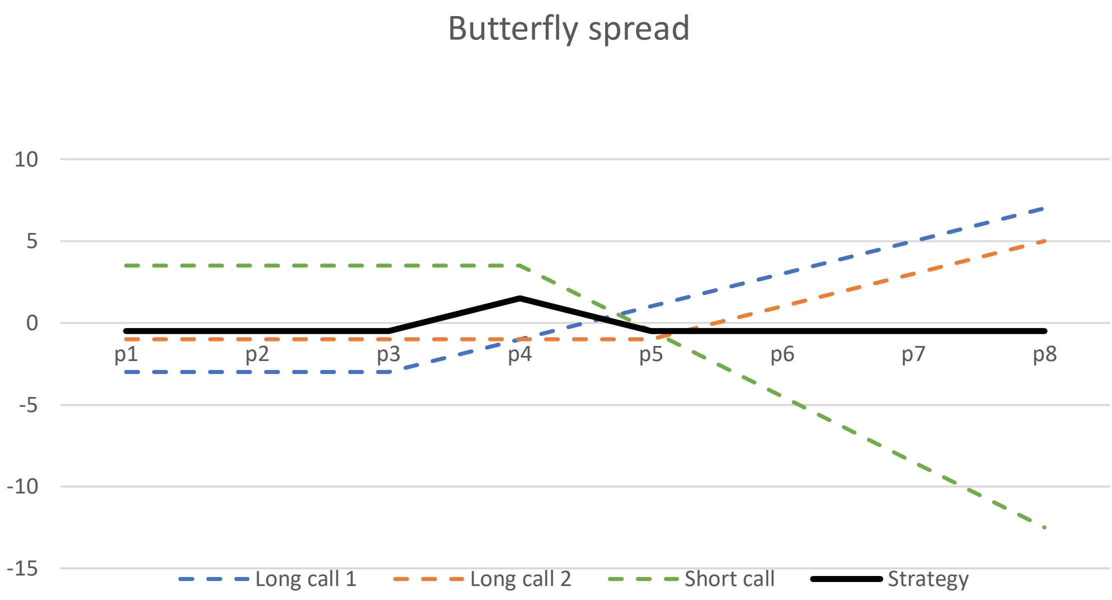
In this case the put option in which we have a long position has a higher strike price, K2, than the one that we have shorted. The result we have is though similar to the one of the bull spread, but mirrored. We have the profit and the loss upper and lower bounded, but the investor makes a profit over the entire strategy if the stock price at the expiring date gets lower than p4.

On the other way round, if the price rises over the put strike price K2, p5, the entire strategy leads us to a loss.

Also, with this kind of strategy we can build up the same result even using two call options, one in a long position and the other one in a short position, but with the first with a higher strike price K2.

The result would be the same of the one above, with our position having a capped profit with low realized prices, and a specular capped loss if we get high stock prices at the deadline of the derivative.

Another kind of spread strategy that uses only one type of option is the butterfly spread and it involves for the first time more than two products and more than two strike prices.



Graph. 7

Substantially, we buy two call options and then we sell two. We take in to considerations three different strike prices that allow us to build up the strategy.

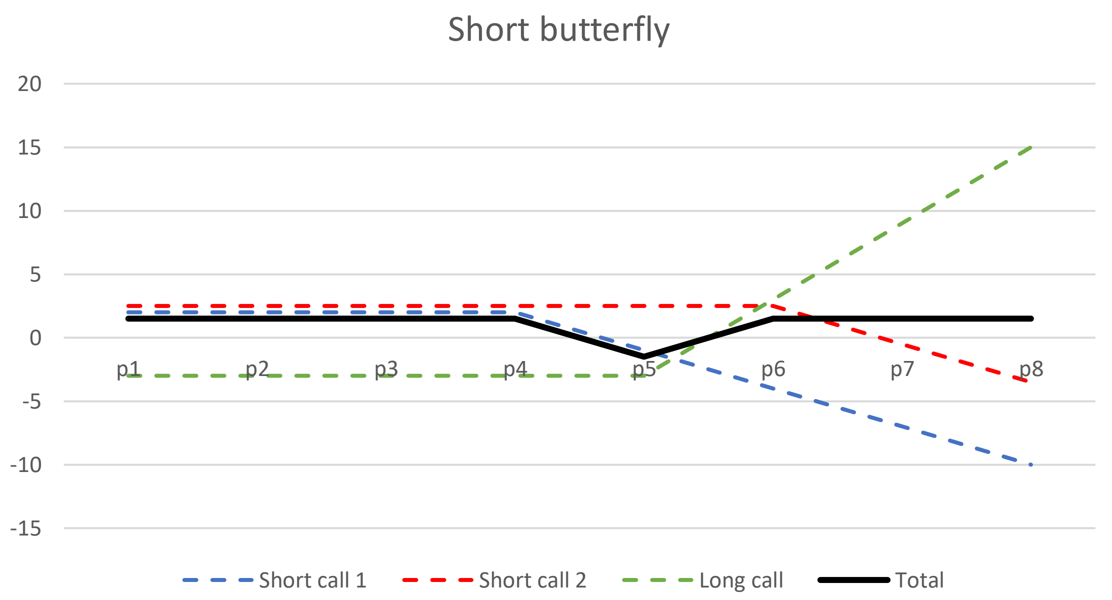
The first long call option must have the lowest strike price, K1, at p3; the second long call must have the highest one, K3, at p5, while the call options we sell must have a strike price in between the two, K2 and accordingly a price premium that is between the two calls bought.

If the butterfly spread is built up this way, it allows us to have a profit when the price range is close to K2, the mid strike price p4.

In case the price gets far from the K2 position we would have a small and capped loss, in both directions. The entity of the loss depends by the relative value and cost of the call we choose, so that we can model our strategy graph as we want. For low prices the two call options have negative profits: it depends by the fact that they can't be exercised profitably and we pay the premium cost anyway. The call option that is more expensive is the one that has the higher strike price, because we pay the possibility to get at least a positive payoff in a wider range of prices. The same result can be obtained if we build up the same strategy using four put options. If we buy two put options, one more expansive with, now, a lower strike price, K1 and one cheaper with the highest strike price K3 and then we sell two put options with a strike price K2=p4 between the two, we get the same function depicted above: a limited profit only in the price range closer to the mid strike price K2 and a very small limited loss for more extreme prices.

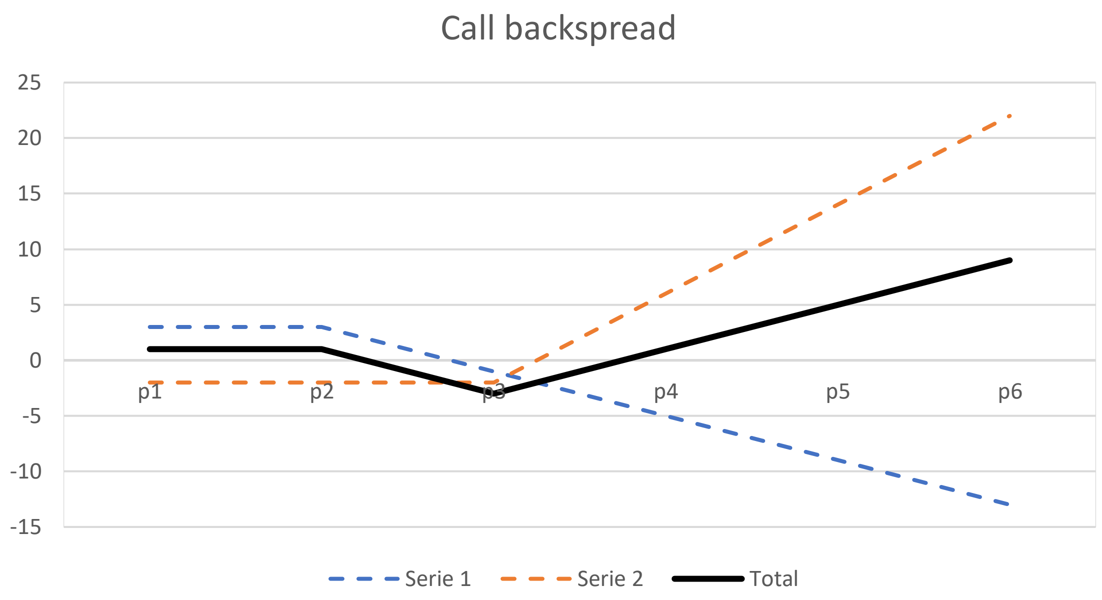
On the other way round, we may take two short positions in two call options and two long positions with a strike price in the middle.

The first call option with the lowest strike price will have the highest premium price. Indeed, as already explained, gives the chance to earn a positive payoff to my buyer for a wider range than the second long call. In between we have the two bought call options with a premium price in the middle between the two sold. The result this time is slightly positive and flat for more extreme prices, while close to the mid strike price k2 we have a negative result. As a consequence of that, also with this reverse butterfly strategy we obtain the same result if we sell two put options with different strike prices, K1 and K3 and then buy two put with the same K2, p5 in the graph below.



Graph. 8

The last but not least type of strategy that uses the same kind of option which we are going to treat is the call and put backspread. When we implement a call backspread we bet on a bullish market and high volatility. We sell a call in the market and buy two call options with an higher strike price K2, at the price level p3. That strategy produces the following graph:



Graph. 9

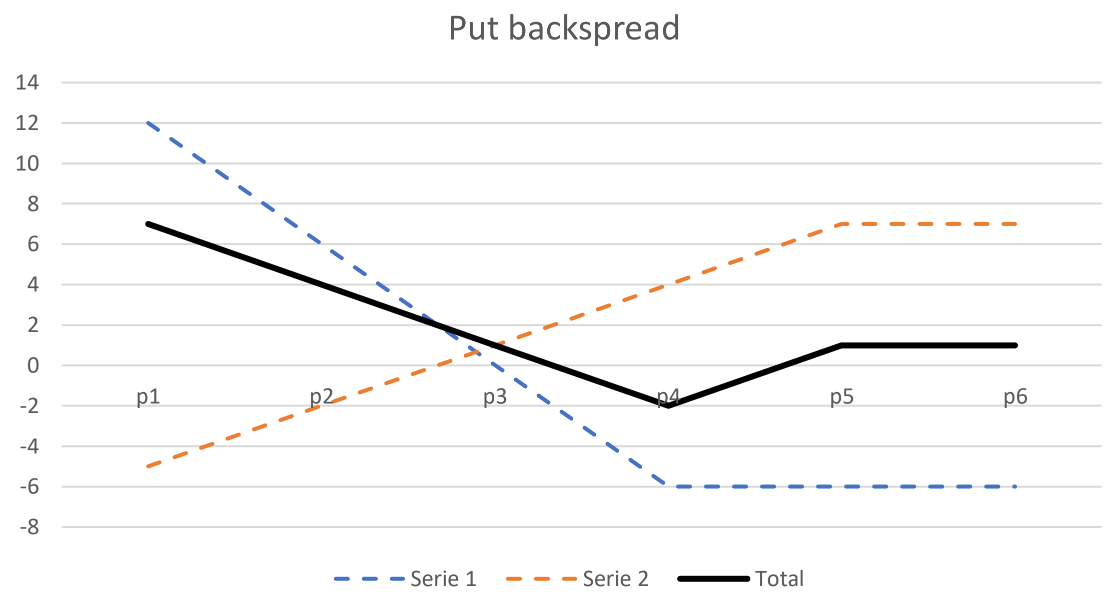
At the beginning, for low stock prices we have a flat profit (given by the difference between the premium of the call sold and the premium of the call bought) until the price gets closer to the strike price K1 and the strategy function becomes negative. When it overcomes K2 and gets close to p4 the function is positive once again and it could earn as the price rises, unlimited profits.

Hence, we hope in a strong volatile market, particularly in an increase in stock price. We would obtain an upside situation selling call option, but it would have the same effect of a butterfly for the lowest range of prices and a short straddle for the highest range. A different argue can be made on the put backspread.

Indeed, we can buy two put options and sell one. The put options we buy should have a lower strike price, K1, while the one we sell should be out of the market with a higher strike price K2, at p5 in the graph below.

Even though we expect a strong volatility and so we would record a loss with an expiring date price that's close to the lower strike price K1, we bet on a bearish market and so expect to see the prices going down. If it occurs, we can record hypothetically infinite profits: the more the price goes down the more our profit gets higher.

On the contrary, if the price goes up and it's higher at the end of the holding time we register a profit that is capped at a certain point by the revenue from the put option we have sold and assumes a steady value from the higher strike price K2.



Graph. 10

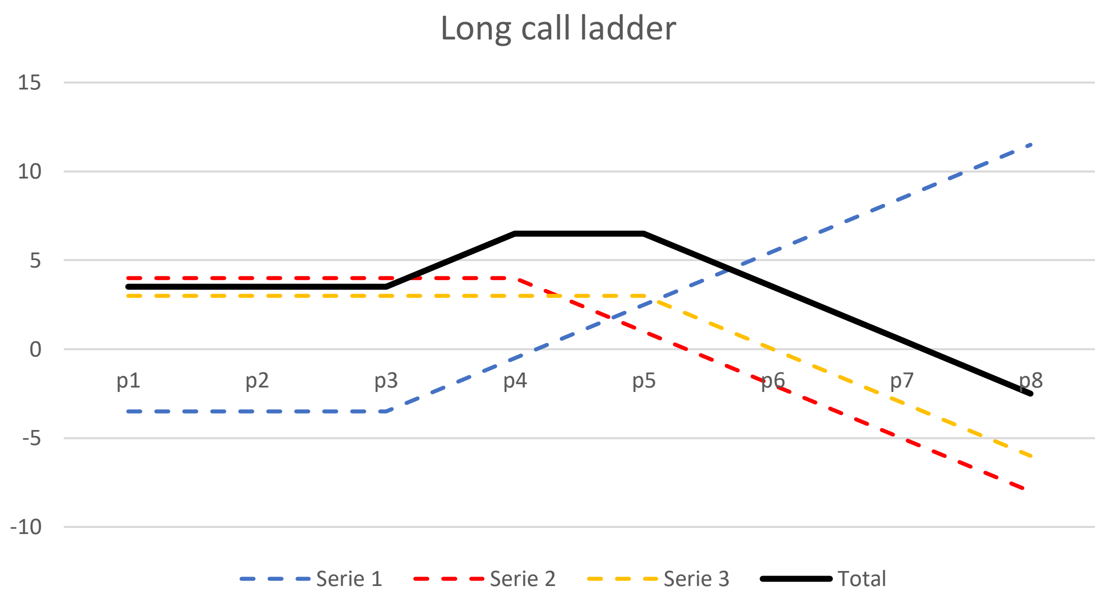
Let's explore now a new strategy that takes into account three different variants. Its name is ladder and we have four types of it: long call ladder, long put ladder, short call ladder, short put ladder.[24]

It will come back later in the next chapters to be used like a basis for hedging purposes. In the long call ladder, we buy one call and sell two, with three different strike prices. The lowest, K1, should be the one of the long call, while K2 and K3 should belong to the short call. It is natural to get to the conclusion that the short call with a higher strike price costs less than the other because the one who buys it from us has a narrower range of prices for which he or she can exercise the call option.

Hence, the graph below shows us a total result in which we expect the price to stay around central values with respect to the current stock price. Indeed, we would get the maximum profit from the strategy, although capped.

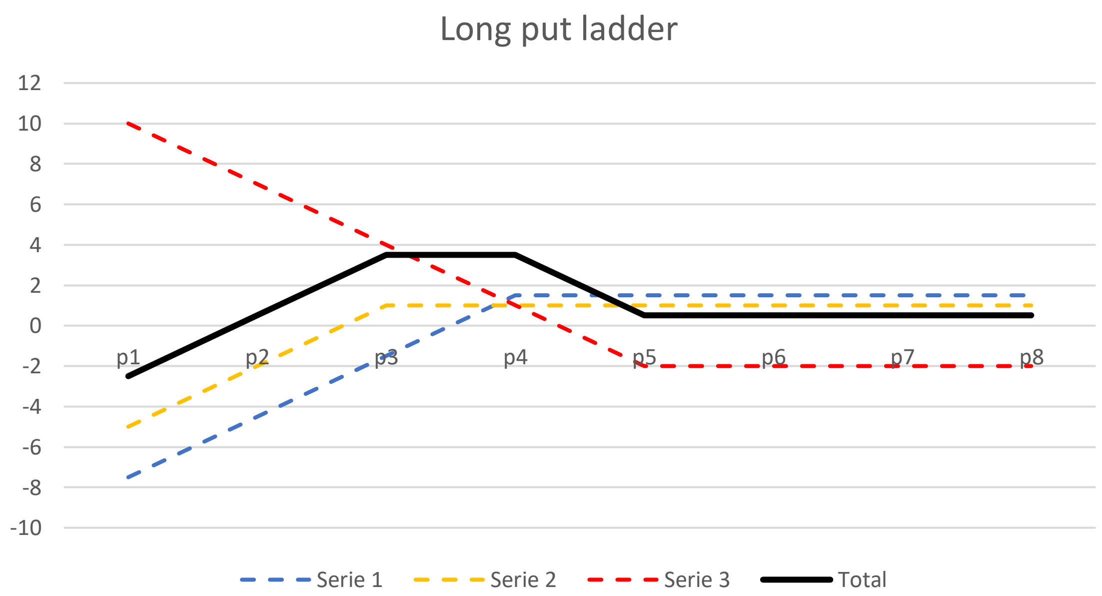
We are also satisfied if the price goes down because we would have a capped and constant profit as well, even though lower than the previous situation. This kind of cover we have for a longer-than-usual range of prices is counterbalanced by a potential infinite loss if the price hikes and overcomes certain values. The profit function starts to decline as we overcome the highest strike price K3.

[24] HSBC InvestDirect Securities Limited (2023), *Option trading strategies,* www.hsbcinvestdirect.co.in



Graph. 11

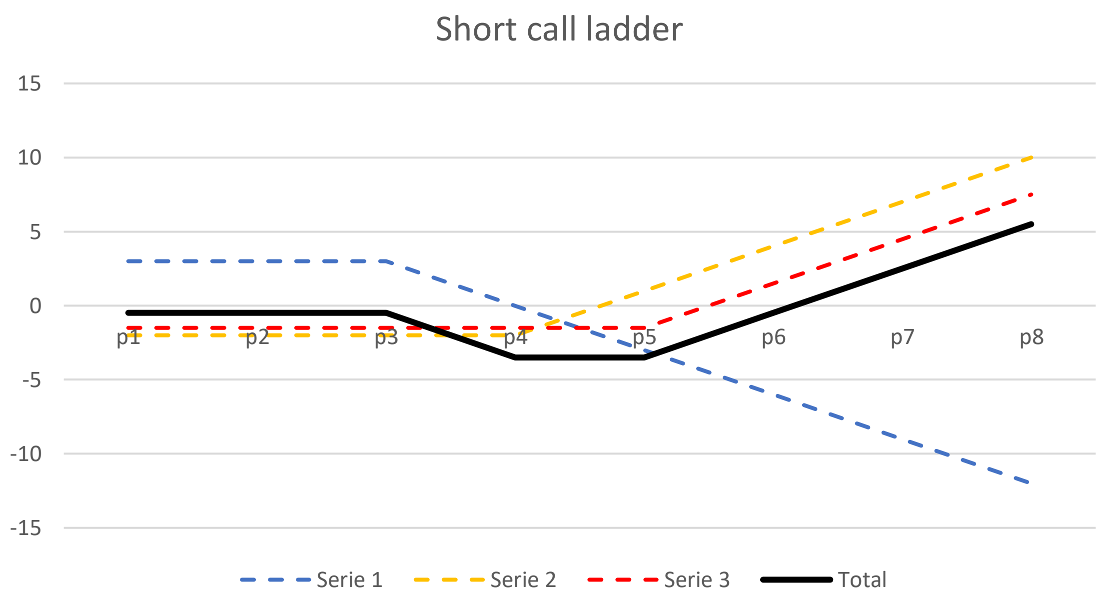
The second one is the long put ladder, that is the same technique as above but using put options. We buy one put option and sell two: the one with the call option is the one with the highest strike price K3, while short put options have the strike price K1 and K2. Also, now the result we get is about a complete cover on the central group of prices, around p3 and p4, and a slightly positive cap on prices higher than K3.



Graph.12

A short ladder on the contrary protects the investor against the extreme range of prices.[25] It is called short because now we buy one option and sell two and this operation has a paramount effect on the result If we compare it to the long ladders. In particular a short call ladder consists in buying two call options and sell one. It means that we now have a negative profit on the central range of prices.

Then we have slightly negative profits for low prices that remain constant for those values lower than the strike price K1, at p3. On the contrary of the price rises sharply we counterbalance the negative trends with hypothetically infinite positive profits. It means betting on a bullish market and on high volatility but more strongly on the first one.



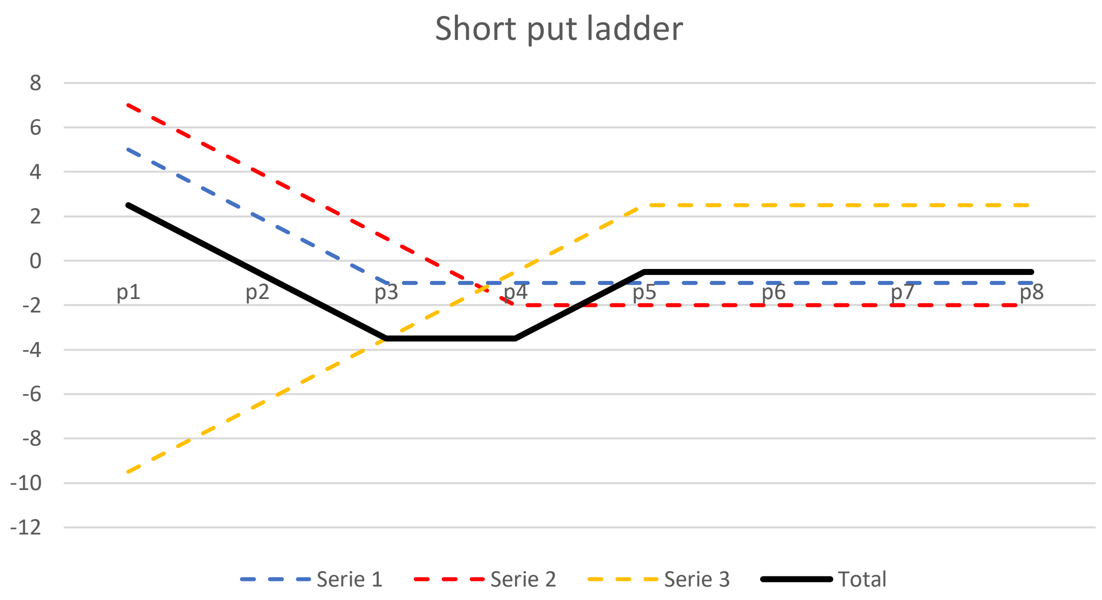
Graph. 13

The short put ladder involves the trade of three put options, we buy two and sell one. In the opposite way with respect to the short call ladder we sell the put with the higher strike price K3, while the put we buy have a lower and different strike prices K2 and K1, respectively at p4 and p3.

These three operations allow us to create a strategy that is bullish on the market and bet also on a strong volatility.

[25] HSBC InvestDirect Securities Limited (2023), *Option trading strategies,* www.hsbcinvestdirect.co.in

For higher prices we have a slightly negative and constant loss, then a more significant loss for a stable movement in price close to the current stock value at the implementation and a sharp increase in the profit function for low price values that can make our gains potentially infinite.



Graph.14

As we have already considered all the cases in which we have different strike prices with more combinations of the same kind of option, we should move our attention on the case in which the strike price stands still and the expiring date is different. This kind of spread is also called calendar spread.

When the time to maturity is different, the option with a longer maturity follows a continuous path curve-shaped. This kind of strategy is also called horizontal spread.

Another family of strategies is the one that uses options with different times to maturity and different strike prices. These are instead called diagonal spread.

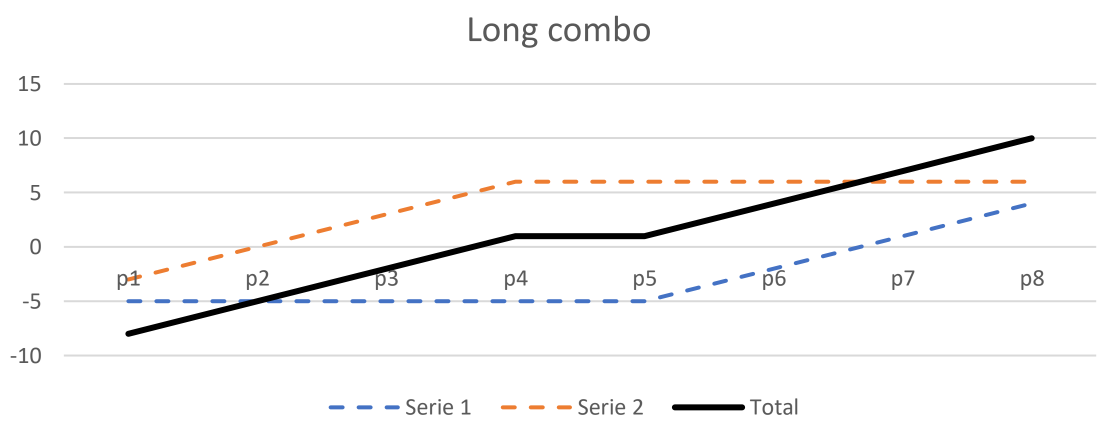
The greater difficulty to implement them is mirrored in a higher range of profit in the prices.

2.5. Strategy combinations of more options of different types

Once we have analysed the principal strategies using the same kind of option but in different ways, now we move on pointing out the variety of strategies that we can create combining call options and put options on the same strategy.

These so-called combinations strategies are several: combo, straddle, strips, straps, strangle and condor, at which we add the collar.

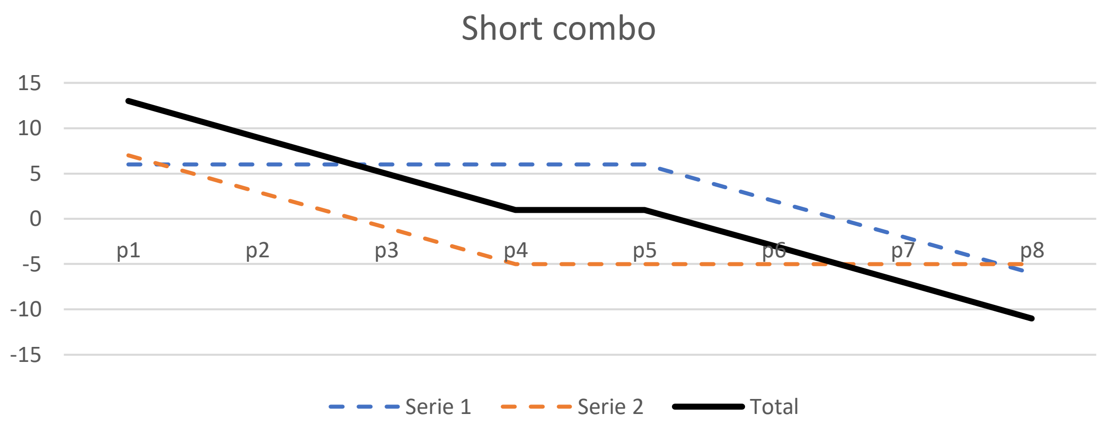
The first combination strategy that we analyse now is the combo. In order to build up a long combo we should buy a call option and sell a put option. This strategy is the basic of the combination strategies large family but shapes also the basis for the collar, a more complex strategy that we are going to point out later. The main difference, consists in having an open position in the underlying asset as well. In the case long combo, to avoid the creation of a synthetic stock position we choose two products, two different strike prices.[26] The put we sell has the lower strike price K1, while the call option we buy has a higher strike price K2. It allows us to get a result that describe our expectation of a bullish market. Thus, if the price hikes we can have potentially infinite profits, but at the same time if the price goes down the loss could be potentially infinite. For a price range close to the current stock price S0 we have also flat but positive profits, and so even though it is one of the riskiest strategies, is slightly safer than a pure long or short position on the underlying asset because of the safe zone around the current stock price.



Graph.15

[26] Cohen, G. (2016), *The bible of option strategies,* Pearson Education, Inc., Old Tappan (New Jersey)

On the contrary, the short combo means betting on a bearish market where the prices go down. The dynamic is the same as before.



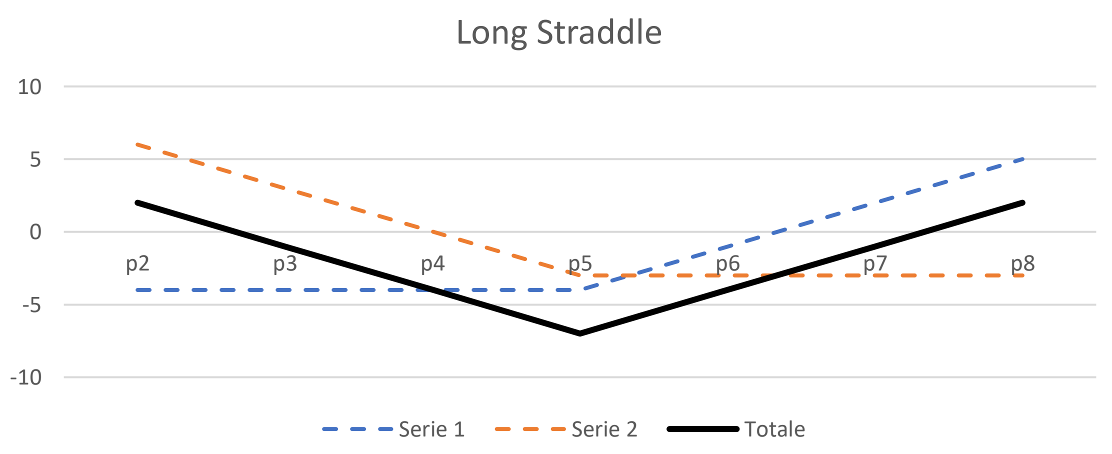
Graph.16

This time we go long on the put option and then short on the call option. The put option will have a lower strike price K1, at p4, while the call option has the higher strike price K2, at the price p5.

As in the long combo but symmetrically, we would have potentially infinite profits if the price falls down, while at the same time not bounded losses if the price goes up.

The plateau in the middle close to the reference stock price represents to us a safer investment than a short position on the stock.

Let's talk about the straddle: it is a technique that is used when strong fluctuations are expected in the price. Using both call and put options, we buy a call option and a put option with the same strike price, K at p5, going long for both derivatives. The graph below is what comes out as a result of the two operations.



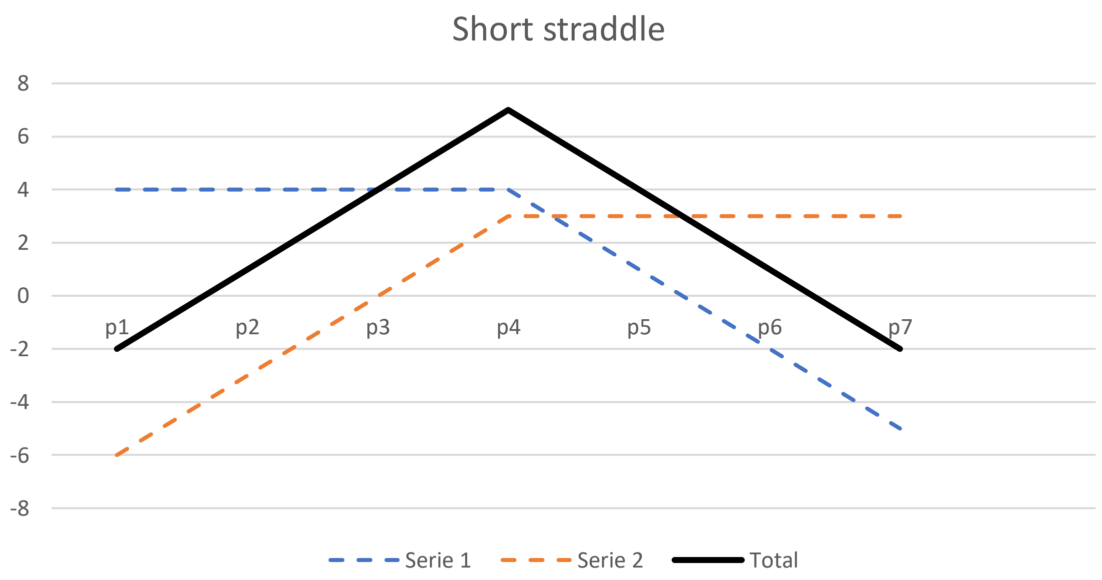
Graph.17

The result of the two positions allows us to have a limited peaked loss in the nearby of the unique strike price as well as not limited profits if the price goes so far from K. It’s a sort of reverse butterfly with uncapped profits.

In order to form a reverse shaped straddle, we should short a call and a put option as well, creating the so-called short straddle.

This time we expect that the market price will remain stable close to the strike price K in order to make a profit. A strong fluctuation both positive or negative would lead to an overall strategy loss.

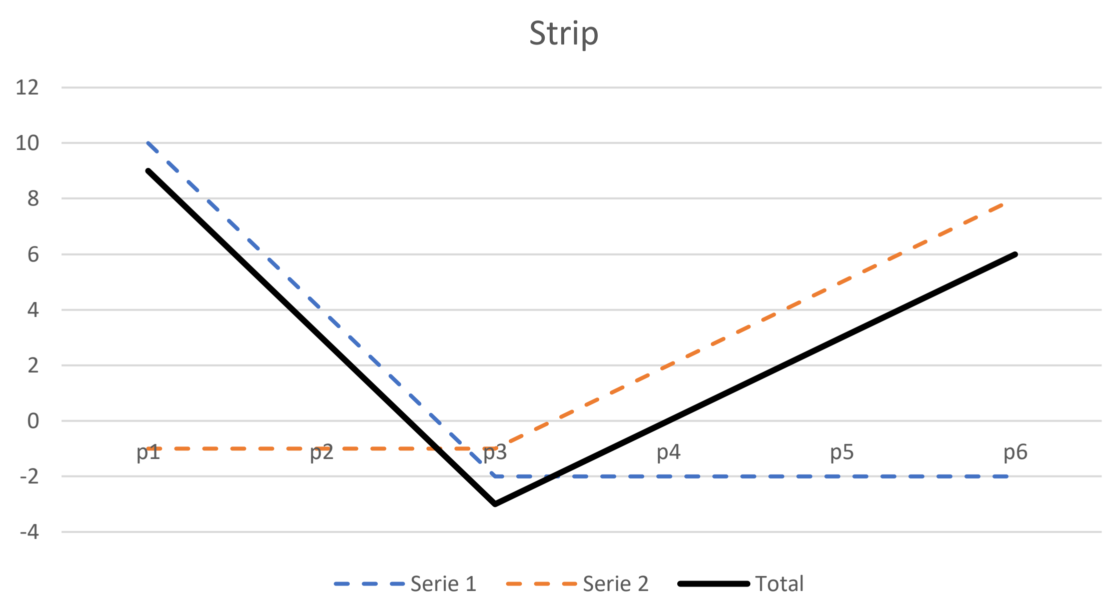
The trend with respect to the price and the profits is well described in the next graph.



Graph.18

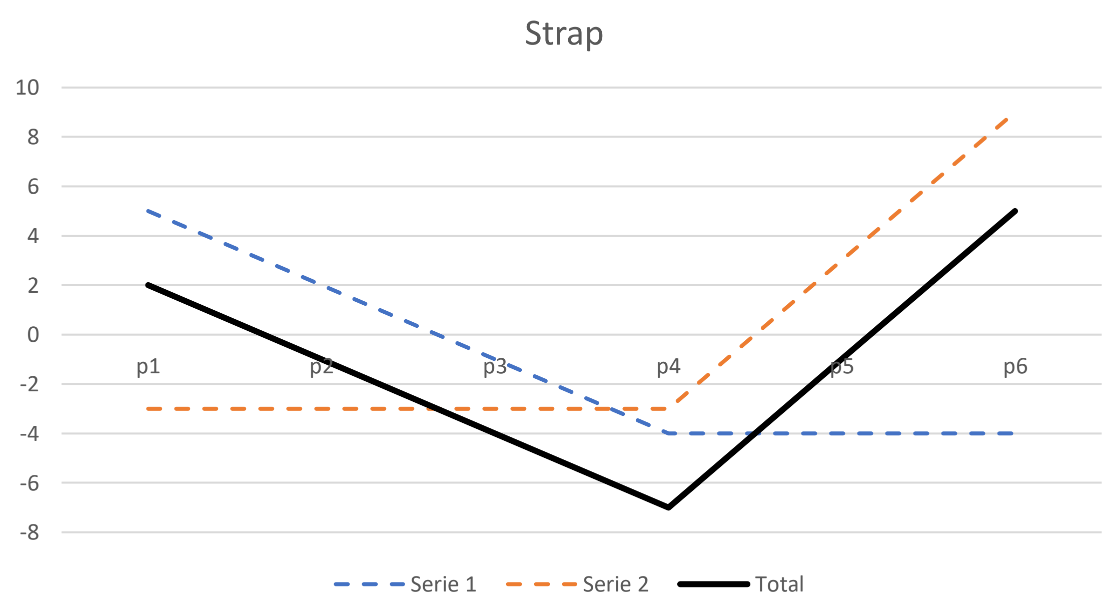
What comes next are strips and straps. Indeed, what we expect when we implement them is a strong fluctuation of the prices far away from the strike price chosen but in the strip case, we are more inclined to forecast a lower price, buying one call option and two put options, making the left leg of the graph steeper than the right one.

The call option and the put option must have the same strike price K, close to the current stock Price S0, in the graph below represented at p3.



Graph.19

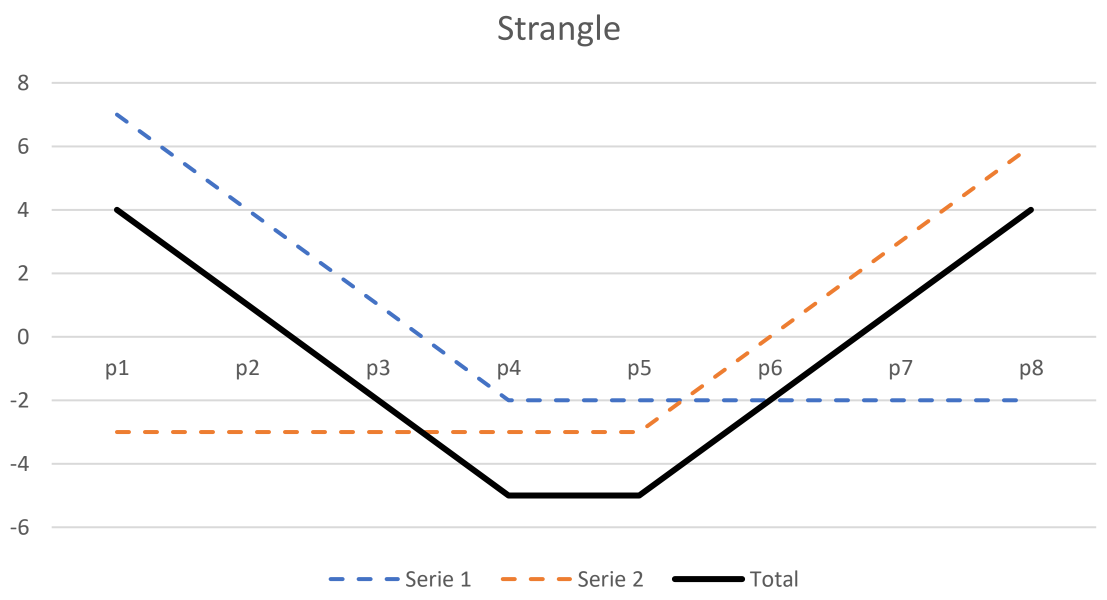
For what concerns the strap, the symmetric pattern holds. We still expect a strong fluctuation in the market but this time is more likely that the price goes up and so to make more profits we should go long on two call options and one put option with the same strike price K. It would form the same graph as a straddle but with a steeper right leg.



Graph.20

The next strategy we examine is the strangle. A hedger creates a long strangle when he thinks that the market will have stronger fluctuations with respect to the use of the straddle.

In order to build up the strategy, we get a long position in a put option and a long position in a call option but with a different and higher strike price K2 at p5.



Graph.21

We have got a sort of modified straddle in which the loss is bounded and the same flat cap comprehends a range of prices and not a single peak price as in the straddle.

Therefore, we get that the expected fluctuations must be stronger than the ones in the straddle, but also the loss that occurs if the stock price stays in between the two strike prices is relatively low. The strangle, as the straddle, can be also reversed upside down. In order to create this effect, we should short a call option along with a put option too, creating the so called short strangle.

The last combination strategy we are going to analyse is the condor.

This strategy is very similar to the strangle, indeed it has a capped loss if it is a long condor, but what is really different from a strangle is that in the profit range the strategy function is bounded.

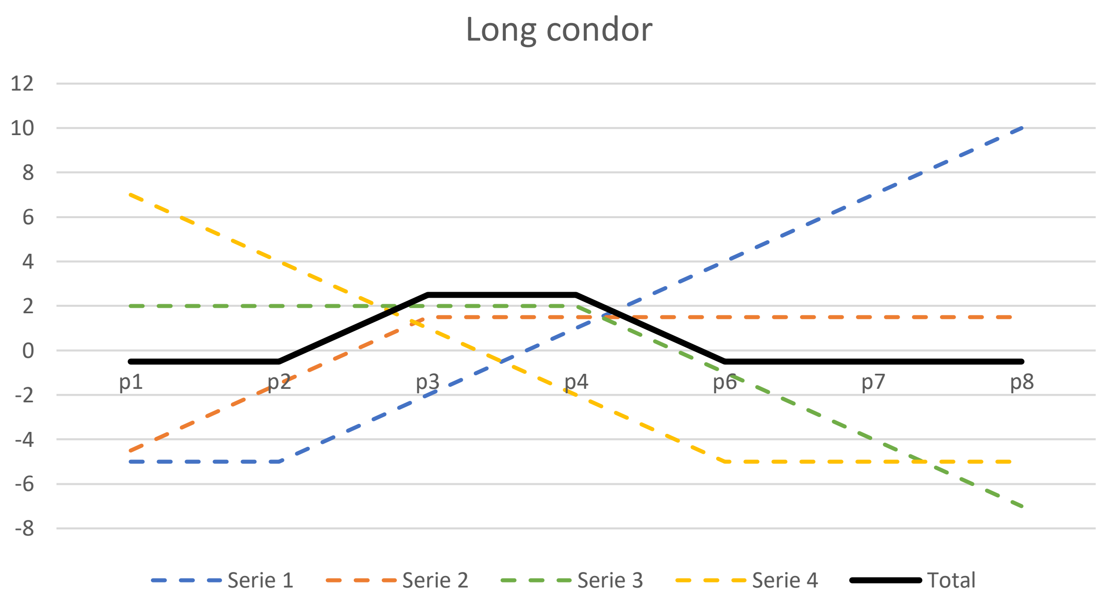
One of the advantages may be that the upper bound allows the function to be profitable in a wider range of prices. This time the different strike prices to be considered are 4 and in a long condor the investor always expects the price to be in a close range to the current stock price S0.

Furthermore, we have two call options and two put options to be traded: namely, we buy a call option and a put option and we sell a call and a put option.[27][28]

Let's describe the graph below from the left to the right.

In order to create a long condor, we should buy the call option with the lowest strike price K1, in the market, then sell a put option with strike price K2.

Finally, we sell a call option with a strike price K3 that is hence out of the market, and buy then a put option with the highest strike price K4. As it can be clearly figured out from the graph, building up this kind of strategy means that we expect the prices to stands still inside a certain box close to the stock price or at least near to the two central strike prices K2 and K3, close to the prices p3 and p4.



Graph.22

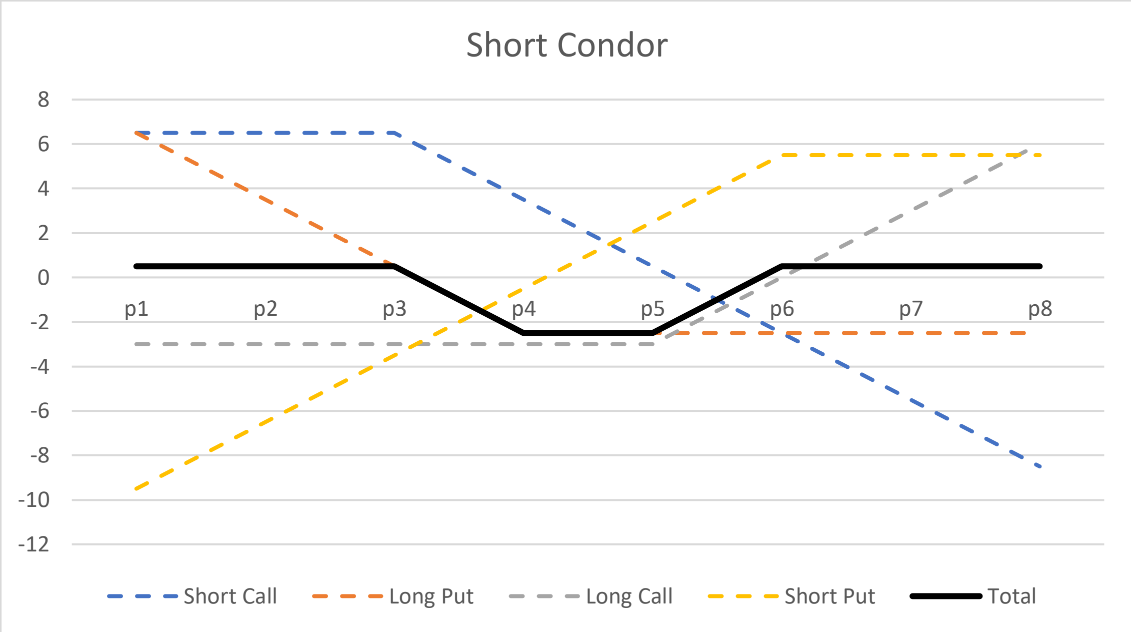
To create a short condor we would have exchanged the strike price positions of the call bought with the call sold, and the same is valid for the put option. Hence the scheme with respect to the strike price would have been the reverse. We would have sold a call option with the lowest strike price K1, then bought a put

[27] HSBC InvestDirect Securities Limited (2023), *Option trading strategies,* www.hsbcinvestdirect.co.in

[28] Mullaney, M. (2009), *The complete guide to option strategies,* J. Wiley & Sons, Inc., Hoboken (New Jersey)

option with a slightly higher strike price K2, bought again a call option with a strike price K3 out of the market, and sold a put option with the highest strike price K4.

This way we would bet towards a market with strong fluctuations as in a strangle but we would have the profits capped as in the long condor is valid for the losses.



Graph.23

As a final paragraph of this chapter, we introduce the use of option derivatives along with a physical position on the stock market as we will run in the last Chapter.

The following graph depicts the first type of collar where we have a long position in a put and a short position in a call. This strategy is of course added to a long position in the stock directly. Independently from the stock price result this strategy is aimed to limit the effects of a change in price. As usual, we have the stock price in the x-axis and the total profit of the strategy on the y-axis.

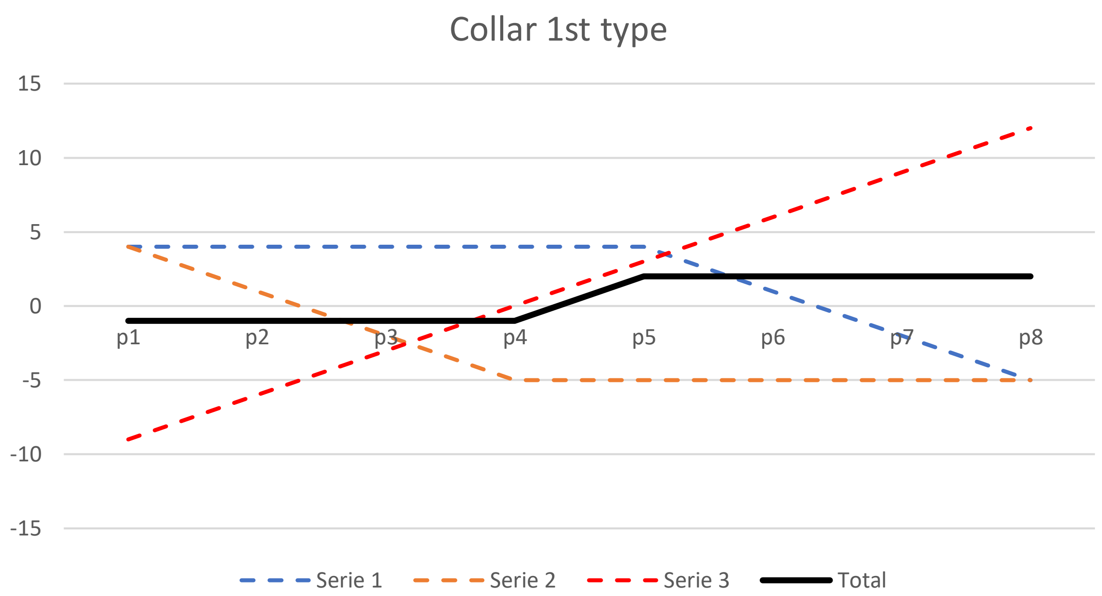
The long position on the stock is represented by the grey line. It is linear and the profits are related to the stock price of the moment in which the strategy is implemented. Then, in blue we have the line which represents the long position on the call. It is positive for low prices because until it is not exercised by the one who buys it from us, we just have the gain matured after the sale: the premium price of the call option. At a certain point, if the stock price reaches the strike price K2 of the call option, the function starts to decline until the missed opportunity gain from the option overcomes the entire value of the sale.

On the contrary, the orange line represents our long position in a put option. It means that we buy a put option.

The orange line starts from a positive result given by the difference between the strike price K1 of our put, that at low levels of the stock price should be exercised, and decreases until it reaches the negative value of the premium price we have already paid at the beginning to open the position and buy the option.

The combined results of these previous three functions gives us the profit function of the whole strategy collar.

The collar is built up with the current stock price in a central position between the strike price K1 of the long put and the strike price K2 of our long call.

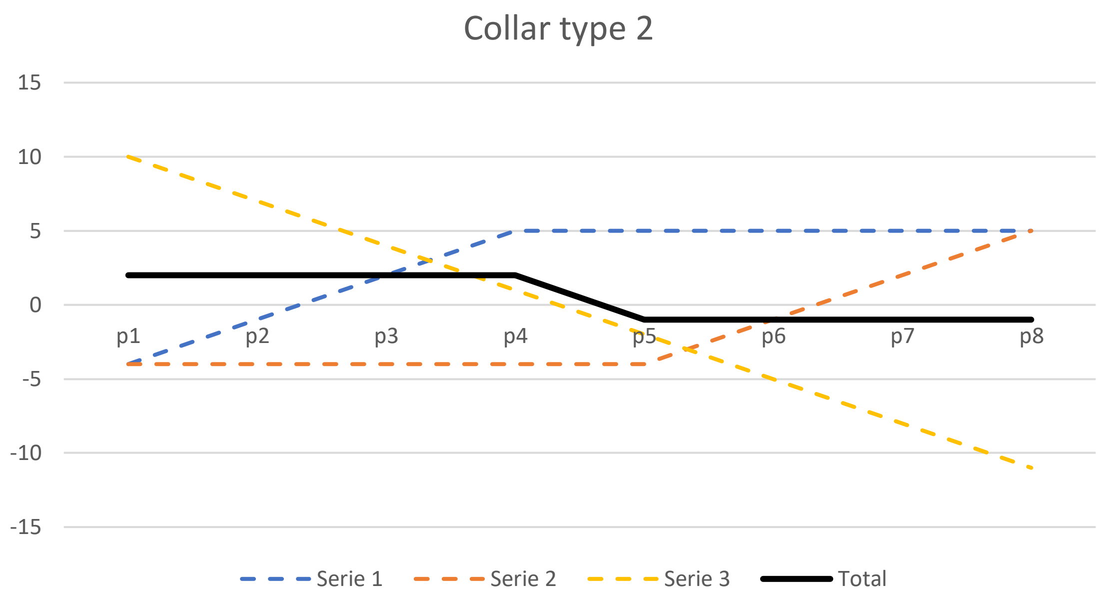


Graph.24

This strategy limits the positive effects of a robust rising in the stock price but at the same time limits also the loss if the price gets lower than expected or much lower than the initial stock price.[29] The range in which the profit value can vary is overall smaller.

Otherwise, we can build up another type of collar that we try to explain through the help of the graph below.

[29] Mullaney, M. (2009), *The complete guide to option strategies,* J. Wiley & Sons, Inc., Hoboken (New Jersey)



Graph.25

Here we have a short position on the stock. Then a long position on the call that is represented by the orange line, and a short position on the put with a lower Strike price K1, at a level price p4.[30]

The total sum of these three functions variable gives the total profit function of the strategy collar we have built up.

Even in this case the collar is made in a way that the current stock price, when we implement the strategy, is placed in the middle between the two strike prices, respectively of the short put and the long call.

The graph limits the possibility of profits through upper and lower bound as in the other type of collar, but this time the total profit of the strategy is positive for low prices and negative for higher prices, far beyond the stock price at time 0.

[30] Mullaney, M. (2009), *The complete guide to option strategies,* J. Wiley & Sons, Inc., Hoboken (New Jersey)

III THE HISTORY AND MAIN CHARACTERISTICS OF THE ALUMINIUM MARKET

3.1. The discovery and the first footsteps of aluminium

A dispute around the name concerns this metal form the very beginning moments of its life: indeed, the name used in the United States referring to the metal is currently aluminum, as it is in Canada, while that's not of course the one used in the great part of the world.

In the early nineteenth century, when the aluminum was first mentioned in official documents we would read 'alumium' for the metal that was first derived from the aluminium sulfate.

At the same time, European scientists preferred the name 'aluminium', because it derived by the alumina which is the aluminium Oxyde Al(2)O(3) and 'ium' was the syllable applied in general to new elements. Finally, a good compromise seemed to be 'aluminum'.

Indeed, at the end of the century, in all the United States the term 'aluminum' was already in use; some examples are provided by the name of the firms who began to produce it as a result of the second industrial revolution: in 1907 the Pittsburgh Reduction Company changed its name in Aluminum Company of America or AlcoA.[31]

Also, the manuals and the researches in the field started to talk about aluminum in the United States by the end of the nineteenth century.

The first testimonies of somewhat recalling aluminium can be found back in the ancient Roman Empire where the historian Pliny the elder tells us that in the first century AD a craftsman came to the emperor Tiberius with a particular chalice in his hand as a gift. This material was particularly shiny and colored like silver, so that the emperor stood still and got stunned. Even though there exist several versions of the same story, the emperor appreciated the present but executed the poor man because he was scared that the spread of a new metal would have devalued silver, which was so important for roman economy, and lead to an economic crisis throughout the empire.

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[31] The Rusal library (2007), 13 *Al; the 13th element,* Moscow, 2007

In 1959, an ancient Chinese tomb has been found in Chiansu. It was dated between the 3rd and 6th century A.C. and presented ornaments made of aluminium alloys, that is a fact which proves alloys being found far earlier than the last 200 years.
Anyhow, during the centuries, aluminium has been traded as a compounded material, in the majority of the cases alum, and was never isolated. Alum was so popular in Asia and in the middle east and until the 16th century was brought to Europe through the silk road. In Italy the first were at work since the 12th century in Ischia, while the first evidences that an Italy State could be a supplier is dated back to the 15th century, when an alum factory was built in Tolfa.
Pope Pius II welcomed his beloved merchant Giovanni De Castro, banned from newly Ottoman Turkey and rose up the price of the roman alum, at that time very used in Europe's pharmaceutical trade. Then stopped immediately the import of the alum from the middle east opening de facto a new market route in the mediterranean sea. For many centuries though, mankind used several products made of aluminium without knowing what there was inside.
Aluminium can be defined as a modern metal because as we said, it has been discovered relatively lately. In a 200 years period it has become one of the most used metals in several sectors: for the majority of the nineteenth century has been considered a precious metal, until it became cheaper, worldwide used in several sectors like food and beverage industry, aerospace industry, transportation, packaging and building industries, and finally considered as a sustainable and almost completely recyclable metal. The ancient eras are for example named according to the metal that was used or discovered in that precise period.
Here we can present some examples: copper was widely used since 7'000 B.C.[32], or 5'000 B.C. for smelted copper, gold became famous in a period comprised by 5'000 and 4'000 B.C., tin and silver in the millennium between 4'000 and 3'000 B.C., iron in the first millennium B.C. In this context, aluminium and magnesium have been discovered and are widely used relatively few days ago at the late nineteenth century and then traded worldwide at the beginning of the twentieth century.

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[32] The Rusal library (2007), 13 *Al; the 13th element,* Moscow, 2007

Since the very beginning of the last century, the aluminium has become widely used through different fields and sectors thanks to its several properties like high thermal and electrical conductivity or low density but mostly the strength when it is matched with other metals.

We can gather the qualities of aluminium in the following list: low density, low melting point, ductility and softness, reflectivity, electrical and thermal conductivity and safety. These properties have been named just because all were crucial to the spreading process of the metal.

The low density and the lightness of the material allowed the aluminium to give birth and then be used in the aerospace industry. For example, at the very beginning of the twentieth century the Wright brothers' plane, when first flown had an engine made up by aluminium. Nowadays, it is used for airframes, components of satellites and missiles.

The pure aluminium melts at a temperature of 660° C, relatively low if we think about other metals.[33]

This allows the aluminium to be highly recyclable, indeed if we decide to melt it once again, the procedure requires only a 5% of the energy usually applied for the extraction from the alumina.

The aluminium is also ductile and malleable in a way that it can be rolled and transformed in foils, but unfortunately it can be scratched by harder materials.

It is also highly reflective, up until 95% as much as silver and for this reason is used to build up mirrors of large size and thus for huge telescopes and reflectors.

Two of the most important properties are the thermal and electrical conductivity, as previously mentioned. In the twentieth century due to the latter, it has started to be used extensively for electrical transmission lines.

Since the last half-century the electrical conductivity became a quality that was worth the domestic use in house wiring after the contact problems with other kinds of metal relative to the expansion and contraction in different scales had been fixed.

[33] Cobden, R., & Alcan, & Banbury (1994), *Aluminium: physical properties, characteristics and alloys,* European aluminium Association, 1994

Last but not least, aluminium is now highly recyclable (the scrap deriving from the wasted aluminium is introduced once again in the product chain as a raw material) and it is furthermore safe: it's not toxic, the reason why is so commonly used in food and beverages containers moreover the sulphate deriving from the aluminium are applied to purify the water.
The only part to which we should pay a particular attention should be the aluminium fine dust that can irritate our respiratory system if inhaled.
It is always worth to remember that aluminium is the third most abundant element on earth with a heavy share of 8,3% but at the very beginning after its discovery was a precious metal because it was not easy to obtain.
Humphrey Davy, a British chemist, was the first between 1808 and 1809 to try to isolate an alleged undiscovered metal from the alumina and was the one who coined the named we briefly cited at the beginning of this paragraph.
An important turning point occurs in 1825 when a Danish chemist Hans Christian Oersted extracted it as a free metal.[34] Anyhow the German chemist Fredrich Whoeler is the one who gets the credit for having isolated the aluminium for first in 1827: roughly speaking, he has chemically divided the aluminium chloride AlCl(3), passing its vapor over potassium metal 3K, provoking at first the detachment of the three chlorum atoms and the consequent unification of them with the three molecules of potassium, leaving therefore the aluminium isolated.[35]
Later in the century, precisely in 1854[36], a French chemist Henry Deville tried to develop a commercial way to synthetize aluminium using the sodium Na in place of potassium. Three molecules of sodium (Na) were used to isolate aluminium starting from sodium aluminium chloride or (NaAlCl4), forming four molecules of sodium chloride (NaCl).

[34] Chemello C., & Collum M., & Mardikian P., & Sembrat J., & Young L., (2014), *Aluminium: history, technology and conservation, Smithsonian Scholarly press,* Washington D.C.

[35] Cobden, R., & Alcan, & Banbury (1994), *Aluminium: physical properties, characteristics and alloys,* European aluminium Association, 1994

[36] Craig, N.C. (2018), *Early history of aluminum metallurgy,* Encyclopedia of Aluminum and Its Alloys CRC Press, https://www.routledgehandbooks.com/doi/10.1201/9781351045636-140000246

Despite those efforts, and the first public appearance of the aluminium at the Paris Exposition in 1855, the metal wouldn't become commonly tradeable until the last decade of the nineteenth century.

At first, two young men both aged 22 years old, Charles Hall and Paul Heroult, discovered an electrolytic process: carbon electrodes are used to produces aluminium from the aluminium chloride.

This made the whole process of aluminium production far cheaper and allowed the metal to be exchanged much more than a few years earlier, replacing totally the method used by Deville (1854). Then the Bayer process, which was patented in 1888 but operative since 1897, found out a better way to extract and purify alumina from bauxite, ore from which the aluminium is primarily derived.

The first evidence of the increasing use of aluminium was the Washington monument which has at the top a pyramid built at the end of the nineteenth century entirely in aluminium.

Through the years it became more and more popular thanks to some of the qualities we have already cited.

Anyway, after the commercialization of this new way of extracting aluminium with the process of electrolysis by Hall and Heroult, it became far more accessible. From the beginning of the new century, it has been used for packaging candy and chocolate, for jewelry, art objects, and several optical instruments.

Sliding to more technical and chemical uses, we could name water baths, funnels and gas burners.

Furthermore, another useful applicability was the alloy addition with other metals to improve the performance of some aluminium outcomes such as sheet, extrusion, wire and forgings.

Alfred Wilm[37], after a hard work in a project lasted 7 years, discovered in 1906 a new alloy to melt aluminium with copper, magnesium and manganese: this new product was called Duralumin, and has been very useful in the military field for aircrafts and vehicles

[37] Craig, N.C. (2018), *Early history of aluminum metallurgy,* Encyclopedia of Aluminum and Its Alloys CRC Press, https://www.routledgehandbooks.com/doi/10.1201/9781351045636-140000246

in general. Indeed, it has a low density like the pure aluminium but at the same time was hard and flexible. The most interesting thing of this particular alloy is that it can age, a property that has been found accidentally but that makes it stronger. If the metal gets heat treated up to 500°C improves its mechanical properties.

Among the important discoveries regarding aluminium, we should mention also the addition of the latter to steel or improve its durability, prevent corrosion, make sure of a smoother cooling and avoid the holes that take shape during the solidification. This way aluminium began to be used also in the steel industry with a chemical composition of 0,01% that means 0,1 kilos per ton of steel.

In this period among the 2 centuries the price of aluminium literally dropped: just before Henri Deville discovery the price in 1855 was 1’000 marks for a kilogram of aluminium, right after was 300 marks per kilo, and after two years for the subsequent three decades assessed at 100 marks.

When Hall and Heroult invention came out, the price had another rapid decrease of more than 50% in two years, reaching 47,5 marks when the society of the aluminium smelters was created, and then to 15 c.ca in 1890 when the market had absorbed the electrolysis effect. After few years, in all the decade 1890 the price fell down definitely to 2 marks per kilogram at the dawn of the new century.

Of course, when the price literally dropped, running experiments and trying to find new alloys became definitely more affordable: aluminium began to be matched with everything at hand.

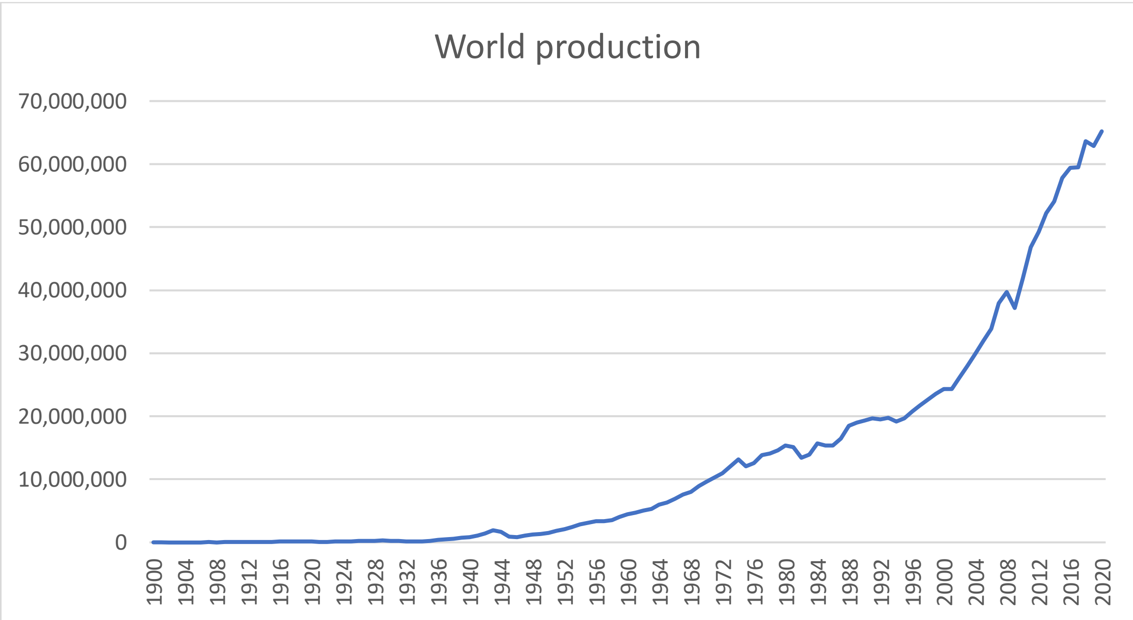
The first half of the twentieth century saw a sharp increase in the aluminium production as a continuing trend downward of the prices.

3.2. The maturity of the aluminum market

In 1900, the total world production of the metal was 6'800 tons, that shortly became more than ten times at the dawn of the first world war reaching the number of 69'000 after a bit more than a decade.

Due to the wide use that has been made of aluminium for aircrafts (that made their first presence in a war), military weapons and transportation vehicles the war pushed the production so high that at the end of it, the production had worldwide doubled (128'000 tons).

Down below we can see in the graph how much the production of aluminium has exponentially grown through time, starting to hike since the blow up of the second world war.



Graph.27

In the meantime, the nominal price slowed down in the first decade of th 1900: there was a fall of 2,74% on average per annum up until 1909. This trend was reversed in the next decade with a nominal growth of 9,43% on average, but this data is not pure because deflected by two anomalies that represents the two central years of the world war 1915 and 1916 where there was an increase of 82,93% and 78,67% respectively. During the war period, as previously said due to the strength but mostly to the resistance at corrosion, was made a massive use in building barrels, tanks, trains and ships to transport war stuffs by the powers involved. At the end of the war, the construction of bodies of cars and airplanes for civil flights (when invented at the beginning of the century rudimental planes were made of wood, canvas and didn’t contain any kind of metal), along with a better casting properties of the new alloys, pushed up the production once again at the beginning of the roaring 20s and this trend went on until the blow up of the second world war and despite the world crisis and the wall street crash of 1929.

During the decades 20s and 30s the production had an average growth per year of respectively 11,89% and 12,98%. In the same period the nominal prices in dollar continued to fall down at an average rate of 1,40% per year in 20s and 1,82% per year in 30s. It is curious to note that in the meantime the real prices referenced to the 1998’s Us dollar value, decreased in 20s at a yearly rate of 1,72% (quite similar to the nominal one) but the real price grew slightly during the 30s at an average rate of 0,44% per year, meaning that after the 1929 there has been a crisis which cause a general deflation in the world economy that didn’t affect the production of aluminium as previously stated. It must be noticed that both the prices, nominal and real didn’t change from 1928 to 1929.

All this context with the production sharply increasing and the prices considerably decreasing, lead to a considerable increase of consumption. If we take a comparison with the beginning of the century, in 1900 the average consumption per capita was 4,7 grams and rose up to 251,2 grams close to the end of the fourth decade in 1937, more than 50 times. In the same time span other non-ferrous metals had an evident growth but more limited.

In order to have further proves of the power of the aluminium in those years, we already mentioned the growing importance it had in the aerospace sector: in 1925, the mass percentage taken by aluminium in an airplane was on average 10%, while on the eve of the second world war the percentage risen up to 75-90%, a plane contained 2,5 tons of the metal. The aluminium was indeed not only on plane bodies but also propellers, oil tanks and radiators, fuselage interiors.

Another application of the aluminium in the first decades of the twentieth century were the high-altitude balloon that were indispensable to study earth’s atmosphere. The car sector experimented immediately the aluminium as a basic component of the product: in 1909 Pierce and Arrow, an American company together with Aluminium Casting & Co.

built the first car body completely in aluminium; given the relatively expansive nature of the alloy to be used for cars the massive production had to wait up until 1923.

Practically, after the first world war, the period of peace gave a boost to the aluminium sector in the industrialized countries. Especially in the United States, in 1933, Franklin Delano Roosevelt's New Deal established new guidelines of every sector for a new and fair competition: in this context, 13 representatives of the aluminium market gathered and decided to create the Aluminium Association.

The main aim and result in the short term has been to change the denomination of the numerous alloys in a way that they can be listed out easily with codes (i.e. Duralumin is known as alloy 2017).

Every year new types of alloys are coined and now are more than five hundred; this system is internationally recognized in order to simplify the nomenclature and 24 countries signed the new system.

The classification follows several criteria that point out the quantity of other metals present in the alloy along with aluminium.[38]

Let's start with the purest classes:

- 1xxx series is the class that comprehends a higher or equal purity than 99%. Pure aluminium is so used in the electrical sector and chemical industries, because it is an excellent thermal and electrical conductor. It is also so much resistant to corrosion.
- 2xxx series is the group where the copper is the principal element matched. A flaw of this mixture is the resistance to corrosion, that may be improved only with a remelting with a purer aluminium under the sheet form. This class is so useful in the military field (aircraft and aerospace) and in the automotive sector for car bodies, but in order to work optimally must bear a heat treatment.

-3xxx series; In this class the principal element is manganese that is used for strength applications that require good workability. The aluminium can that is widely applied in the food and beverage industry is the alloy 3004 that's part of this group.

[38] Chemello C., & Collum M., & Mardikian P., & Sembrat J., & Young L., (2014), *Aluminium: history, technology and conservation, Smithsonian Scholarly press,* Washington D.C.

-4xxx series: The fourth class is occupied by the silicon that is added to the aluminium because it provides a material with a lower melting point and it has a wide use in the welding wires but mostly in brazing metals: brazing is indeed the process with which we have the union of two pieces of metal that to be welded need a metal that has a lower melting temperature and it is put in the point of fusion.

-5xxx series is probably the most used in all the aluminium field, it requires a union with magnesium. It is applied in a marine environment due to the good strength, and in the architectural and military sector as well.

-6xxx series is the group that joins silicon and magnesium at the same time to the aluminium, it is thus a sort of fusion of the fourth and fifth series. It is highly heat treatable and has the merit of being easily workable. This is the reason why it is so popular in the extrusion industry: it has good formability, machinability and weldability too.

-7xxx series, the last one, is without any doubt the strongest one. The protagonist in this case is zinc that needs a bit of magnesium to form with aluminium heat treatable alloys of high strength.

The higher strength is offset by a lower resistance to corrosion that is the same problem of the second series.

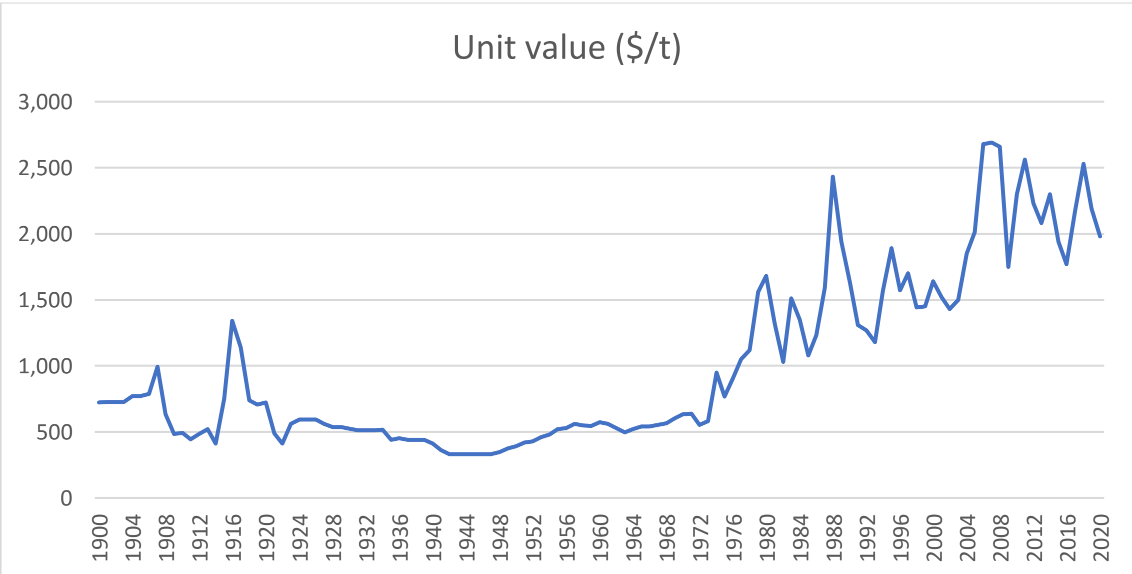
There are two main methods to solve the problem of a bad exposure to corrosion: the first is the one that we have already seen earlier, the fusion with a purer aluminium alloy that is corrosion resistant, the second is the artificial aging that has the advantage to have also a modest reduction in strength.

Sometimes we can meet the eighth and the nineth series but now are not so common anymore.

After this brief excursus, let's get back to the development that the aluminium faced at the beginning of the second world war. As we said, the war vehicle's share of aluminium increased sharply in a few years, from 1939 to 1944 the world production of aluminium more than doubled passing from 787'000 to 1'690'000 tons. The average growth per annum was therefore 20,40% and the dollar nominal price remained roughly the same until 1947, while of course the real one diminished of a third in the whole 40s. In the immediate post war period the production was slightly negative (0,05%) at the end of the decade, but in the 50s went back soaring at a 12,16% per year on average, when the prices both nominal and real grew both respectively at 3,87% and 1,77% per year. This time it is reasonable to think that the growth was lead, by the mass production and consumption and by the industrial revolution that involved the western block countries after the war.

It was not only a matter of car industry, that became more and more popular, but families started to consume much more than before and many home appliances too were made of aluminium or at least had pieces made of it: it's enough to think about televisions, washing machines, pans, kitchen stuffs, ovens, panels, bodies of the vacuum cleaners, cans, refrigerators, spoons, forks and so on. Moreover, aluminium has become a substitute of materials like iron and wood in several sectors. In general, nowadays 33% of the aluminium produced around the world is applied in airplanes and cars, 24% to manufacture packaging material, 10% is used in electrical technology.

Taking out of the box aluminium cans: they have been manufactured for the first time by an American company 'Kaiser aluminium' in 1956 with a 200 ml volume. Two years later Adolph Coors started selling beer in cans. The top part that was composed by a different alloy was put on the market for the first time only in 1963. During the 60s the aluminium production continued to increase following the economic boom wave in the western bloc countries, but at a slightly lower rate that is 8,28% per year on average. The nominal price rose up at an average yearly rate of almost 1% but the real one went down by the same amount c.ca.



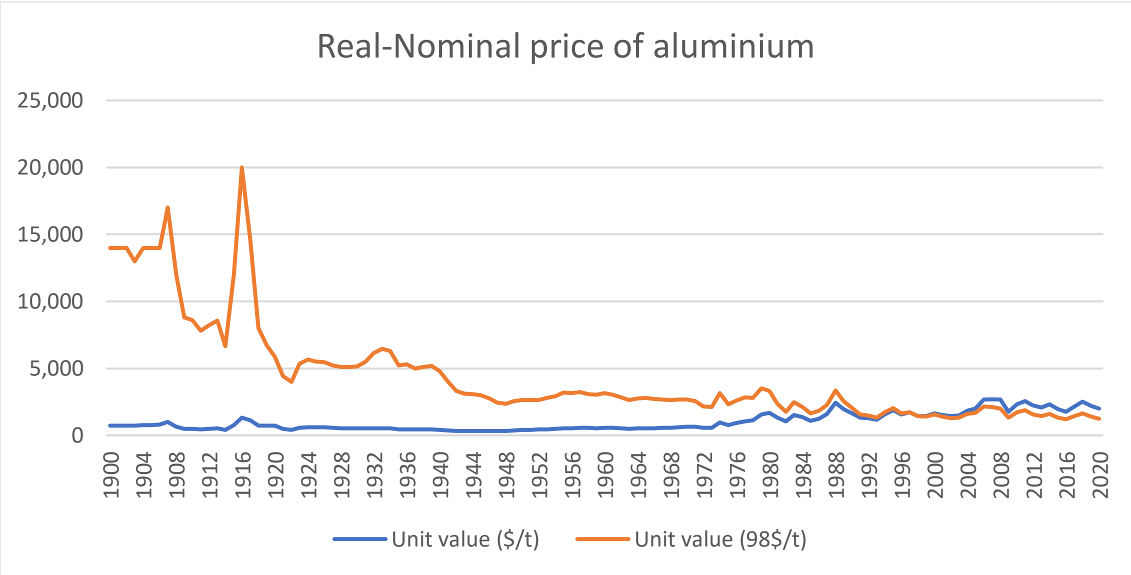
Graph.28

We have just above a real and broad example in the graph of what was the trend of the nominal price of aluminium from 1900 to 2020 where there has been a constant even though non-linear growth.[39][40]

As previously mentioned, we had a total stagnation from the 20s to the 70s, and then the nominal price started to grow up again.

The demand in general, has been pushed by the increasing need of appliances and kitchenware: aluminium pots, trays, pans, kettles, ovens. All of these tools are cheap, easy to use, so practical, and have 2,4 times higher conductivity than steel that was used at that time in place of aluminium.

The graph below shows instead the difference between the real price in orange and the nominal price previously depicted through the lsat 120 years, fixing the crossing to the 1998 value of U.s. dollar. The real price had a paramount fall in the first quarter of the twentieth century that was counterbalanced by the continuative inflation until the crisis at the end of the 20s.[41]



Graph.29

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[39] Lewis D., & Olsson S, (2022), *Price volatility of base metals and steels,* Chalmers University of Technology, Gothenburg

[40] U.S. Geological Survey (2021), *Aluminium Statistics,* https://www.usgs.gov/centers/national-minerals-information-center/aluminum-statistics-and-information

[41] U.S. Geological Survey (2021), *Aluminium Statistics,* https://www.usgs.gov/centers/national-minerals-information-center/aluminum-statistics-and-information

From the 70s the aluminium market has started to change completely, mainly because the main suppliers in the chain production have changed.

Bauxite is the raw material from which we can derive aluminium and so the shift in the location production can affect sensitively the secondary market and its patterns. There is also another step in between: bauxite is transformed in alumina and then alumina is transformed in aluminium.

3.3. 1970-2020: half a century revolution in the aluminium production

At the beginning of the 1970s the portrait of this sector was completely different with respect to the one we can see now: the bauxite production was in total control of 4 main countries: Australia, Soviet Union, Jamaica and Suriname with an overall share of 60% in 1972.

At the same time the alumina market was controlled by 5 main industrialized countries: United States, Germany, France, Canada and Japan which in the same year produced a share of 45% of the whole world, while the bauxite main producers had only a slighter portion. It means basically that the difference in the location production laid in the first step when the industrialized countries bought bauxite from the 4 countries mentioned above which retained a 40%.[42]

Finally, 85% of the alumina production was concentrated in 9 countries but despite of that in the immediate post-war era the situation was even worse and there was a real monopoly on the market.

From the point of view of the single companies, in the seventies the aluminium market was monopolized by six big firms: Alcan, Alcoa, Pechiney, Reynolds, Kaiser and Alusuisse. The consumption of aluminium in 1972 was a matter of few industrialized countries too and the United States had the highest slice of the cake with more than 36%, followed by Soviet Union at 12% and Japan. At the beginning of the decade the market share of the two main protagonists of the cold war was over 60% while in 2010s it was scattered among different countries in a way that USA and Russian Federation (with the other ex-soviet countries) have now a minor role in the total consumption.

As we have already said, the biggest leap in the aluminium consumption was done with the economic growth all along the 50s and the 60s when the western world big 'C' was driven by the massive use of domestic tools and appliances that entered into the average family home for the first time. Indeed, the majority of the population began to use aluminium packages and cans.

So, the situation for what concerns the end-use aluminium only was different country by country: if we pick up the most industrialized countries at the time, United States,

[42] Nappi C. (2013), *The global aluminium industry, 40 years from 1972*, www.world-aluminium.org

Japan and Germany, who led the alumina and aluminium world production, it can be stated that the aluminium was effectively used in different sectors. In Japan the majority went to the transportation sector and to buildings and constructions, with percentages respectively of 20.8% and 30.8% while Germany was the first one in the engineering sector with a 18.4% and a peak of more than 20% in transportation. The United States had a relatively high end-use for packages with a 15% over the total aluminium employment.

In the 70s, added to a massive distribution progress, aluminium was becoming a substitute of several metals and similar materials like cast iron, steel copper wires, glass, timber, zinc and metalized paper.

The real leap that allowed aluminium to become so widespread derives from its declining in real price, and to its recycle process. In the last decades it has become more and more common for the producers to buy the raw material from scraps, and it reduced sensibly the total costs in the sector. In the seventies the percentage of the scraps on the total material bought was still 21% on average in the western countries and at the end of the decade it had risen to 24%, but it would have increased a lot in the following fifty years.

During the 1970s, the change in the total demand of aluminium was driven by the general need in the secondary markets and in the capacities related to the past production while almost no influence had the change in prices.

This period dominated by stickiness in prices is possible for three reasons:

1)The production is controlled by a few actors that are able to control the prices through a concentrated demand that is not sensitive to the price.

2)The curve of the total costs is flexible in a way that in order to increase the total gain the producer doesn't need to increase necessarily the price. So, the price remains almost the same and cost can be reduced.

3)The management can set the production up to the need of the moment and thus the quantity produced changes in place of the price.

These characteristics were constantly present in the aluminium market in the period between 1946 and 1972, where the average nominal price remained close to 453 $ per ton with a low standard deviation and an instability rate of 0.16 that is computed using the standard deviation (in $) over the average price.

In the meantime, the rate of utilization went below the threshold of 80% several times and in the 1970s the same happened with a decline in utilization even greater at the beginning of the 80s.

The outcome is that in the three post-war decades there have been a slight and constant decline in real price at a rate more or less equal to 2% per annum. The technological change and the innovation in the extraction process offset the increase in the cost of the raw material along with the economies of scale have been factors that kept the real price down until 1972. At that time the concentration of the market was really high all along the production chain, the six biggest firms had the 60% market share of the bauxite, 80% of the alumina market and 73% of the aluminium market., and even though this number may seem very high, the market concentration was far higher in the fifties.

The location of the bauxite market was still different with respect to alumina and aluminium: the first was developed in few exotic countries previously mentioned in the chapter, while the second and the third were then transferred in the industrialized countries where the six main companies had their headquarters.

Since 1973, the oil crisis started to push up all the commodity prices, even though it was not involved directly, aluminium was among those metals which followed this pattern. Furthermore, in those years new powers like China, Brazil and India had a rapid increase in population that modified the total energy demand in Asia and contributed drastically to push up the average price. Meanwhile the relocation of the aluminium production took place in the eastern Asia and moved from the coastal areas to the central Asia.

Those relocations happened because of another factor affected the increase in price and it was the electricity cost: it didn’t determine an equal change in all the economies but contributed to the raise in the aluminium price given that to transform it, firms needed a lot of hydroelectric energy.

In late 1970s, as in the early 1980s, two main processes occurred that changed completely the characteristics of the aluminium world market:[43]

1) The index LME (London Metal Exchange) was created in the London Stock Exchange in 1978 and it had a paramount importance since the main reason was to take the power to fix the price off the six main producers and transfer it to the market, in line with the liberal policies that started to be implemented in the industrialized countries, mostly in United States and United Kingdom.

2) The market of aluminium started to experience new actors: a lot of State-Owned Enterprises (SOE) gained market share. At the beginning of the seventies the oligopoly started to decline in favor of SOE and among the reasons that bring the State to intervene in private commodity markets there are:

- Address privately unexploited markets in the commodity field to a better exploitation of natural resources.
- Compensate the lack of investments in the market because of shortsighted managers or an excessive risk aversion of the investors.
- Sometimes the State needs to support the national employment and at the beginning of the 80s the natural resources were seen as an empty place to fill in order to relocate the workers who lost their job.
- Hard commodities may be seen as a national asset to defend independently by the current market conditions, and so a government can try to place assets simply to defend the market to avoid the soil, mine exploitation that would be an advantage for foreign companies.

In the first period of 1980s the state-owned share quota in the aluminium market was 46% if we consider equity participation too, if we take in to account only the total control of a firm, governments had a quota of 31%, with a growing trend.

With the creation of the stock index that could rule the aluminium market, the change was epochal but to give power to the market means also that many factors contribute to set the average price taken as benchmark for the aluminium transactions.

[43] Nappi C. (2013), *The global aluminium industry, 40 years from 1972*, www.world-aluminium.org

One of these factors is the exchange rate and the currency in which the aluminium is evaluated on the stock: the U.S. Dollar ($).
The first thing that comes to mind when the price of a commodity is decided by the market is that its volatility increases a lot. Indeed, the aluminium price started to vary and experience consistent ups and downs from the beginning of the 1980s.
The position of the US dollar with respect to the other main international currencies started to affect the movements of the commodity prices and the aluminium too:[44]

-A weak dollar can cause an increase in the aluminium prices on the London Stock Exchange: the aluminium producers in the United States can take an advantage in this situation, because its currency and so its total price (dependent on the stock exchange and thus on the US dollar) becomes immediately relatively convenient to the foreign aluminium buyers. At the same time the companies in the United States that needs aluminium to sell an end-use product find the cost of the commodity more expensive than before because their currency (US dollar) has lost purchasing power with respect to the other main currencies (Franc, Yen, Yuan).

-A strong dollar can cause a decrease in the average price of aluminum on the London Stock Exchange, but is a disadvantage to the United States producers that find problematic to sell the commodity at a relatively inconvenient price. The foreign companies that use aluminium to produce domestic appliances face problematic issues because they have to buy it at a relatively higher price.
The United States companies that use the aluminium to sell finite products can exploit the advantage that their input costs less than before or if they import from abroad the foreign price becomes relatively cheaper.
These fluctuations have been present in the aluminium market up to the economic world crisis and even after.

[44] Wzorek, A. & Wzorek, L. & Ivashchuk, O. (2017), *Analysis of the factors influencing the price of aluminum on the world market,* Working Paper N°5, Krakov

The pattern from the 1990s has been clear: if we examine the years going from 1995 to 2002 there has been on average a decrease in price that was due to the Russian embargo on the western commodities and on the 'dotcom' crisis at the beginning of the millennium.

Undoubtedly, the trend was affected also by the strong Us dollar position with respect to the Chinese Yuan and the European currencies.

On the contrary, the increase trend at the beginning of the twenty first century, namely in the 2002-2008 period was dragged by the easy credit conditions and the bounce with respect to the previous decade, but also by a weakening position of the dollar if compared with the Chinese yuan and the new-born Euro that was adopted by three out of the first eight world powers officially since 2002.

Another important factor that has influenced the aluminium price in the last five decades more than others is the operating cost curve; this curve is then directly reflected in the market price.

In general, between the 80s and 2002 for 20 years the aluminium price has been slowly decreasing, while right after as anticipated the prices soared up until the worst world financial crisis since the World War II.

The volume and the upwards price of the aluminium market in that period was pulled up by the incredible growth of the BRICS (Brazil, Russia, India, China and South Africa): in nominal pricing, considering the effects of the exchange rates, we can state that at the beginning of this century those economies produced 20% of the world GDP, while at the end of the decade in 2010 despite the recession and the negative influence of the crisis on the production those economies produced 38% of the world GDP.

It means an increasing trend also in the share of the global production, not only in absolute numbers. If we delete the exchange rate influence and put in place the purchasing power parity (PPP) the improvement in production has overtaken the industrialized countries in 2008 reaching a peak of 75% of the total decade in 2010.

This is an important shift in the world commodity market and in the field of energy consumption: indeed, if in a large-scaled country in term of population the middle class starts to take shape and to set up a technological improvement process the request of new goods available and already widespread in the industrialized world gets a considerable push.

The consumption of mobile phones, motorized vehicles and foreign direct investments useful to export western brands in third-world countries, represented the reason why, especially at the end of the cold war and after a reassessment period in 1990s, countries like Russia, China (despite of being a communist country it has experienced an openness for what concern its economy and since the end of the 1970s the system has slowly shifted from a State-directed economy to a semi-liberal market economy, with more and more exchanges on the national market with the main western-block countries especially for what concerns the commodity markets), Brazil and South Africa (which had just got out from the Apartheid regime) had a sort of economic renaissance in 2000s and pulled up the consumption of commodities like steel, copper and aluminum that are necessary to the sectors mentioned above.

Taking a broader point of view, we can go ahead and see what part of the total production has been produced at the beginning and at the end of the century by the Brics and how much in percentage by the rest of the world.

In 2000 the quota of the aluminium produced by the Brics was 6.5% while in 2010 has been 11.7%, in nominal price, thus an almost doubled outcome.

If we annul the effect of the exchange rates, setting the purchasing power parity (PPP), numbers would be more significant with a 15.9% in 2000 and a round 24% 10 years later after the financial crisis.

Even though the recession hit mostly the industrialized countries like United States and European Union, the impact of emerging countries in the aluminium market was remarkable not only from the demand side but also for the new supply they provided.

Talking about how the Brics and the industrialized countries performed in the aluminium market we can point out the trend taking two different points of view, aluminium production and aluminium consumption:[45]

1)The aluminium production of the Brics was 8 Mtons (Million tons) in 2000, one third of the global aluminium output, with Russia representing the principal slice (13.3%), to 23 Mtons in 2010, the 56% of the total world production with China being now the first actor of the emergent countries.

[45] Nappi C. (2013), *The global aluminium industry, 40 years from 1972*, www.world-aluminium.org

At the same time, the industrialized countries reduced their quota over the total, from 40% (10 Mtons) to 21% (8.5 Mtons) in 2010.

Furthermore, Brics in 2010 produced 40% of bauxite and 53% of alumina.

2) From the consumption side the Brics increased it during the first decade of the twenty first century, shifting from a 21% to 48% of the total consumption, more than doubled and close to half of the total production.

In parallel the industrialized world powers lost almost half of their share shifting from a round 60% to 33%, very close to China alone.

In order to find out exactly why this change has occurred in such a prompt way in the span period between 1970 and 2010, we need to examine the characteristics and the change all over the production chain, taking into consideration bauxite and alumina markets too.[46]

In the bauxite production the change shouldn't be remarkable as the sites of extraction are localized in some spots and obviously not transferable. In spite of these, other countries exploited their soils and Australia was the only old bauxite producer to hold on and strengthen its position; at the beginning of the seventies its quota was 20%, in 2010 it achieved 32%.

The other main producer countries in 1972, Suriname, URSS (then become Russia) and Jamaica lost considerably ground while new actor jumped on the stage: China, Brazil and Indonesia with a total quota of 40% (China 14%, Brazil15%, Indonesia 11%), which added to Australia formed a cluster of more than 70% in the hand of barely 4 countries.

Surprisingly, more or less the same happened to the alumina central ring of the production chain, were the share of Jamaica, Suriname and mostly Japan got shrunk in favor of Australia, Brazil and China that as in the bauxite market took almost 70% of the market quota.

While the price of the alumina and bauxite are strongly correlated because of the geographical location where the mineral is mined, aluminium is in fact more dependent by the energy cost. Indeed, energy costs have allowed the shift in the raw material production and the multinational companies which now lead the market have relocated

[46] Nappi C. (2013), *The global aluminium industry, 40 years from 1972*, www.world-aluminium.org

its production sites. Anyway, because of the price of energy, United States counted only for 4% of the global production and China rose to 40% in 2010.
Why was this the case? It's not all about the economic growth that China experienced, it was a relatively convenient soil, full of these natural resources at a cheaper price for Chinese companies, but there were made policies to subsidize the low populated provinces where aluminium was produced.
If we aim to look at the structure of each sector, we find out that even the concentration in 40 years is almost dissolved and fell down in the bauxite and alumina market to 50%, while in the primary aluminium market has fallen from 73% to 48%, which means that less than a half is in the hand of the major groups.
China is the only country with State owned firms that has a market quota higher than 10% in 2010, but another interesting thing that characterizes now the aluminium market is that usually the companies with an important quota are not completely vertical integrated in that market.
In few words, if until the 1980s the majority of the actors was managing all the stages of the production process, gaining market share in bauxite, alumina and then aluminium market, now it's not banal if a large firm operates only in one stage, with bauxite, or only with aluminium, or at most two of those.
Finally, the aluminium consumption had a fast growth in the 2000-2010 decade in China and India, of 17% and 10.4% respectively, stating how much the economic condition of the Brics impacts the aluminium market and the commodity markets in general.
China soared in terms of importance from only 2% in a closed market economy, to a 40% while of course the industrialized countries performances mirrored the behavior of the emerging countries, and United States, Germany, United Kingdom, Italy and France shrank to a 25% total market share, while in 1972 the United States counted for 36% alone.
The transportation sector is the first address of the aluminium production and counts a 43% share in Japan along with a 35% in United States and Western European countries; in 1972 the end-use destination percentage was only around 20%, and this particular attention for the sector is due to the lightness of aluminium that makes it more proper for vehicles and able to prevent it from substitution even though nowadays steel too is used in the automotive.

3.4. The outlook of aluminium market in the next years

There are definitely three further reasons why aluminium is expected to keep its position on the market:[47] it is becoming a substitute of copper, it's widely used in the electronic market and in the mobile phone sector, and last but not least, given that the green economy is soaring in the last years, aluminium is used to build up systems that support renewable energies like solar panels and it is also 100% recyclable; a great part of its scraps are currently bought and re-used by the companies.

Instead, the variables that affects the price of aluminium are several and getting more complex: the incremental use of forward and futures in the last decades has affected the price in addition to the previous mentioned fluctuations of the U.S. interest rate since the London Metal Exchange has been published on the London Stock Market in 1978.

It is not clear though towards which direction the price is moved through the increasing use of derivatives, the certain thing is that with the increasing of trade volumes, the volatility of the price also is increasing: for instance, a price once relatively stable is constantly moving because of the futures.

Usually, forwards tend to have higher prices with respect to the stock index, just to compensate for storage costs of a delayed operation, or simply taking into account interest rates investment opportunities; in this situation investors tend to exploit the opportunity buying stocks and selling futures, increasing the price of the stock and decreasing the price of the futures.

The contrary happens when the stock price gets too close to the future price and the prices rebalance their selves through this process.

Hence, the result is that certainly the aluminium prices in the long term is more unstable and its volatility increases.

In this chapter we have highlighted the change that aluminium market experience mostly in the last 50 years, with an important shift of the actors all along the chain production of the metal.

[47] Luo Z., & Soria A. (2008), *Prospective study of the world aluminium industry,* Institute for prospective technological studies, Seville

It would be interesting to point out how this sector can change in the next years given the high demand that can take place in 4 main sectors where a spread use of it can be made: transportation, electricity, construction and packaging.[48]

1)Transportation requires aluminium because of its lightness and it would have a paramount importance in the emerging Electronic Vehicles sectors. The general increase in demand that will take place from 2020 to 2030 from 86.2 Mtons to 119.5 Mtons. Transportation will be the first end-use sector in terms of growth, passing from 19.9 Mtons, to 31.7 Mtons.

2)In the electrical field, aluminium could be applied as a substitute of the copper: even though it has different qualities, it is lighter and can be adapted through changes in alloys. Its 10.4 Mtons consumed in 2020 are expected to grow up in 2030 up until 15.6 Mtons.

3)The construction is looking towards a green economy and in this case, aluminium is completely recyclable. The predicted consumption in the world is though, 25.9 Mtons in 2030 against the 21.3 in 2020: the forecast would be a contribute of 14% growth with respect to the actual world consumption.

4)The packaging production is always imprinted toward a CO2 saving attitude. In the next years even the 100% recycling aspect is likely to be taken into account and this characteristic is shared with glass.

With respect to the glass, aluminium is lighter and less CO2 is produced in its transformation and transportation.

The 7.3 million tons are forecast to become 10.6 Mtons in 2030.

[48] CRU Consulting (2021)*, Opportunities for aluminium in a post covid economy,* London, January 2022

Moving the attention to the geographical distribution of the consumption it is noticed that the share will be more or less the same as it was in 2020, the highlight will be put on the demand side.

China is predicted to lead the incremental global consumption of aluminium in 2030: since 2015 it has gained 45% of the total consumption and overcome 50% in 2020 with 43.8 million tons.

An increase of 33.3 million tons in production is forecast in 2030 with respect to 2020, out of this China would contribute for 12.3 million tons, more than a third.[49]

The other interesting geographic area which is predicted to increase its aluminium consumption is India along with the middle east. Here, the demand will be dragged up consistently by the increase in population.

India will count 35% of the 8.6 million tons increase in 2030 and represents the population push, while the construction sector will be the protagonist in the middle east, especially in Turkey and Emirates.

On the contrary, Europe is presenting a higher life expectancy, the population is going to decrease and the growth rate to 2030 is expected to be 1% per annum on average.

Even though it has been for decades one of the principal aluminium consumers, especially after the economic boom, now its contribution to the increase in 2030 is limited (4.8Mtons).

Despite of similar patterns, North America will have greater percentage increase in 2030 with respect to Europe, in the aluminium demand. 11.5 million tons consumed in 2020, will become 16.6 ten years later, due mainly to the sector of Electronic vehicles that will make the difference thanks to huge multinationals which have their headquarters in North America.

Definitely, the increase in this decade in the aluminium demand will be caused by an increasing consumption in the following sectors and geographical region:

- Transport in China;
- Transport in North America;

[49] CRU Consulting (2021)*, Opportunities for aluminium in a post covid economy,* London, January 2022

- Electricity in China.

IV CASE STUDIES OF PRACTICAL HEDGING IN THE ALUMINIUM MARKET

4.1. Option strategies to offset the price risk

The previous chapter presents the aluminium market in a detailed way: one aspect which has a capital importance is that after the aluminium price was linked on the London stock exchange in 1978, it had a higher volatility and it has been subject to an uncertainty given by the fluctuations of the Us dollar exchange rate.

In the last 40 years, the majority of the aluminium producers and aluminium buyers have been exposed to the change of the LME index, since usually contracts in the commodity markets are linked to the stock index considered as a benchmark.

Hence, a company who trades aluminium and has to cope with such an uncertainty, is exposed to a risk: the market price risk.

The practical problem that derives can be presented from two different points of view:

1)Company A that buys aluminium and transform it in a finite product. It will be directly affected by LME index only for the quantity that buys.

2)Company B that extract bauxite or buys alumina and transform the ore in aluminium, selling it on the market, and being exposed to the LME index only for the quantity that sells.

In the first case, the aluminium buyers use to take as a reference the LME 3-month cash to purchase the physical commodity and these operations are made, let's say, 3-months earlier with respect to the delivery date, in order to be consistent. Meanwhile, the LME 3-month cash index changes and with it also the LME index changes.

We take as an example a company that signs contracts 3 months before the delivery, to buy the commodity whose price is linked to the LME 3-month index, and the real price paid per ton will be the one realized at the close of the day, 3 months after the agreement.

The market price risk in this case is represented by the change in price that can occur between the day in which the contract is signed, and the delivery day.

As we have already pointed out in chapter 2, there are several tools and derivatives that can be used to offset the market price risk: they have been presented alone, but when you have an open position in the stock market, these derivatives must be combined to the underlined asset to ease the effect of potential inconvenient moves in price.
Practically, these so-called option strategies that will be shown in the next few pages work as a risk-offsetting tools to ease and limit the potential loss derived from the change in price. Those strategies will be applied continuously, month by month, 3 months in advance with respect to the delivery and then the options will be exercised or expired close to the delivery date.
The implementation of each strategy will follow a similar pattern all along the period of 2 years and 9 months, starting from January 2021 to September 2023; of course, with the change in LME index, the strike prices couldn’t be the same all over the months and the years.
In order to ensure the same kind of strategy, the strike price will have to be slightly modified along with the change in the reference stock price.
For instance, if the strategy is implemented with the option strike price right under the stock price, when we face a price per ton in the order of thousand dollars, it may be chosen the option with the closest strike price to a difference of 50$ or 100$ with respect to the reference index.
The next strategies will be presented with option contracts that have a strike price as close as possible to a difference of 50$ with respect to the current LME index, above and below the price. This rule will be valid for a long and short position for call options and put options too.
From now, K will identify the strike price of the option, while S0 will be the notation for the LME index when the contract is signed and S1 will be the notation for the LME price when the delivery has to be made and the option expires.
The former is the one we have to take into consideration when we enter into an option to offset the market price risk and the strike price must be chosen according to it, the latter is the one which determines if the option or the options can be exercised or not.
In order to implement continuously our strategies, we must be aware of how the prices can potentially change in the span period we have to face.

It has been already shown in chapter 3, how much the aluminium prices can be volatile and subject to the variation in Us dollar exchange rate: these are good reasons why an action must be taken to offset the risk and ease our potential losses.
So, we have got just what we need: signing options strategies will allow us to limit our losses in time of bullish market if we take the point of view of an aluminium buyer, or in time of bearish market if we take the point of view of an aluminium seller.
This process, later carefully described, can be applied to all the hard commodities, metals and so on, but of course the features of each market matter and also the time period in which we apply the strategies can change their overall result.
By the way, in the 2 years and 9 months period we are going to take in to consideration the aluminum LME index had a high volatility, mainly because of the covid-19 pandemic effects on the global economy and then because of the Russian invasion of Ukraine which had redrawn some economical balances in European commodity markets.
Furthermore, the aim of this chapter is to compare the effectiveness of different option covering strategies and to do it in the most accurate way, not only the reference time period has to be the same, but also the quantities of aluminium bought or sold on the market must be more or less the same. For example, if we choose small quantities for a period, and huge quantities for another we may bias the strategy performance. Later in this chapter, the quantities bought and sold will comprehend a bracket of tons that goes from 5500 tons per month to 8500 tons per month, and this rule is valid for all the strategies which will be applied on the same data, in order to have a better comparison of their effectiveness. Totally the quantity traded in 33 months will be 244’500 tons for company A and for company B, too.In addition to the premium price for the option, paid or received, it will be considered also a transaction cost that has always to be considered negative for the determination of the profits: basically, it is the fee that the broker agencies apply for each and every transaction they manage. In this case the rule to follow in order to assess it, is straightforward: the more is the quantity of asset underlined in the option traded, the more you have to pay as a fee for the transaction.Those presented above are the general rules and pin points under which we present the different strategies: before listening, them it is useful to show the realized

prices of LME index from January 2021 to September 2023[50] to have an idea of how the index behaved and how much volatile the price was.

Daily Lme closing price, once per month.

	Lme closing	3-month cash
1/6/2021	2062.50	2068
2/3/2021	1973.00	1972
3/3/2021	2203.00	2207
4/7/2021	2239.50	2258.5
5/5/2021	2446.00	2439.5
6/2/2021	2442.00	2463
7/7/2021	2508.50	2528
8/4/2021	2575.50	2580.5
9/1/2021	2667.50	2664.5
10/6/2021	2880.00	2888
11/3/2021	2706.00	2724
12/1/2021	2669.50	2646.5
1/5/2022	2866.00	2885
2/2/2022	3043.00	3028
3/2/2022	3605.00	3570
4/6/2022	3443.50	3467
5/4/2022	2929.00	2962.5
6/1/2022	2701.50	2730
7/6/2022	2358.00	2380
8/3/2022	2403.00	2401
9/7/2022	2230.50	2238
10/5/2022	2289.00	2299
11/2/2022	2227.00	2238.5
12/7/2022	2450.50	2477
1/4/2023	2250.00	2287
2/1/2023	2611.00	2644
3/1/2023	2364.00	2406.5
4/5/2023	2306.00	2354
5/3/2023	2330.00	2343
6/7/2023	2169.00	2215
7/5/2023	2093.00	2147
8/2/2023	2176.50	2227
9/6/2023	2158.00	2206

Tab.3

The aluminium price had a strong volatility, as a reference date it has been taken the close value of every first trading day of each month. While it was close to 2000$ in

[50] LME index (2023), https://www.lme.com/en/market-data/lme-reference-prices/lme-official-price

January 2021, it jumped to 3605$ in march 2022 following an upward trend, and then bouncing back to 2093$ July 2023, finally assessing to 2158$ per ton on 6th September 2023.

Thus, the volatility has been so high, and high change in prices requires taking actions to offset potential risks.

The LME cash 3-months index followed a similar pattern, with relatively small differences in price.

The option strategies taken into account to offset the market price risk that are going to be treated in the next paragraphs for company A are:

1)Synthetic long put;

2)Short collar;

3)Strangle + Asset;

4)Inverse Put Ratio;

5)Call backspread.

The option strategies taken into consideration to offset the market price risk that are going to be treated for company B are:

1)Synthetic long call;

2)Long collar;

3)Strangle + Asset;

4)Put Ratio;

5)Put backspread.

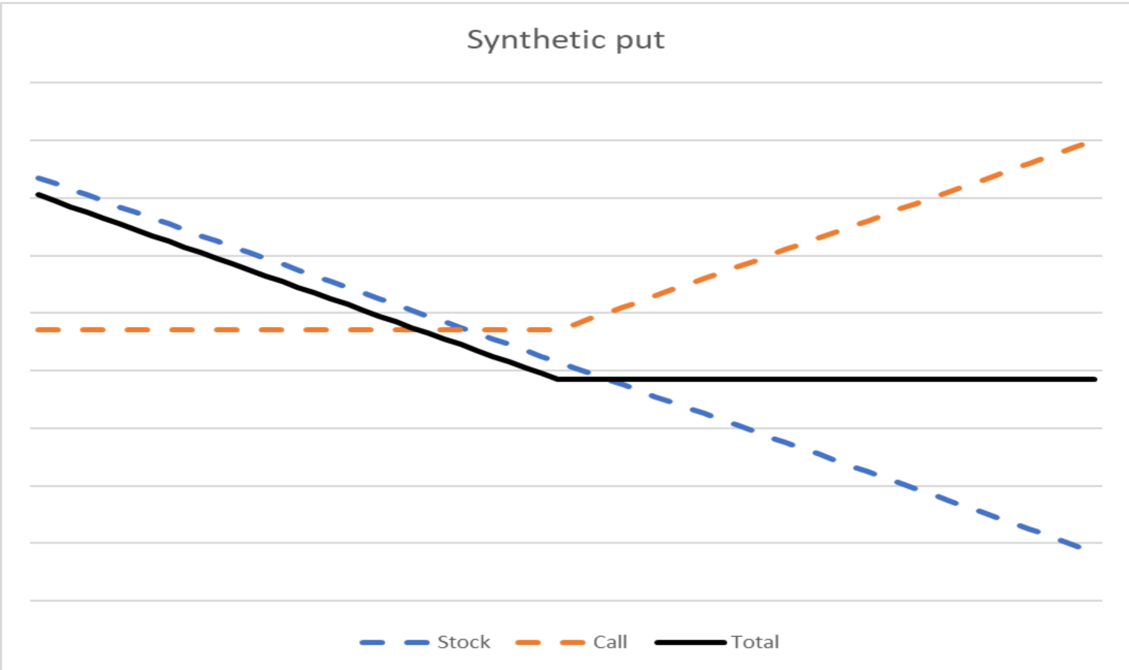
4.2. Hedging strategies for an aluminium buyer

Company A is a firm in the aluminium sector which buys aluminium from its suppliers and sells a finite product.

Since its suppliers sign homogeneous contracts that link the price paid per unit to the realized price on the LME 3-month index at the delivery date, and since the contracts are usually signed with every supplier 3 months earlier than when the company will receive the agreed quantity, Company A is concerned about an increase in prices in the following 3-month period.

In such a situation it's like company A has a short position on the asset, and the easiest way to counterbalance its risky position is to go long in a call option for the same quantity of the asset bought from the supplier and create a synthet3ic long put to limit the loss on the high range of prices.[51]

The following graph will describe well our hedging strategy:



Graph.30

The blue dotted line represents the position on the asset: an increase in price on the x axis will cause a loss on the stock market.

The orange line represents the long position on the call option.

[51] Rusnakova, M. (2015), *Commodity price risk management using option strategies,* Department of Finance Faculty of Economics Technical University of Košice, WP N°61, pp. 149-157

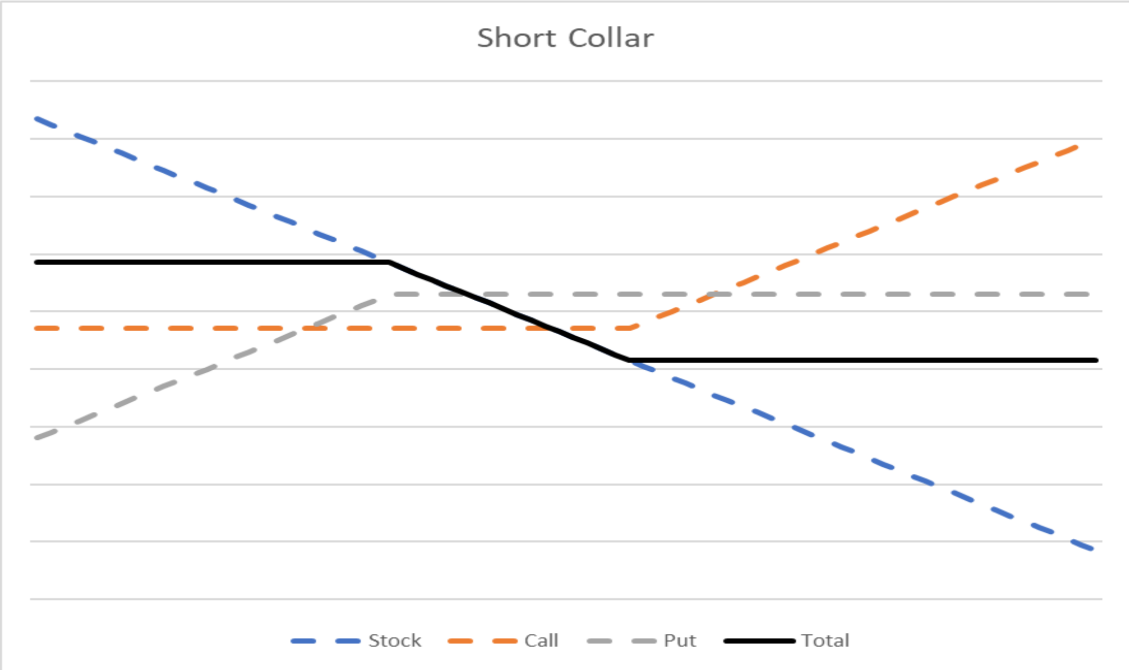
The black line is how looks like the result of the strategy, with a stop-loss shape for higher price, and a increasing for lower realized prices.
Practically, we have to dig deep into numbers. The operations to purchase the tons of aluminium needed for January 2021 start 3-months before in October 2020.
The first trading day of October 2020 the market close is at 1754$ per ton; 3 months later the 3-month cash index is 2068$ per ton, a remarkable increase that Company A could have avoided if it had bought it three months before directly from the market.
The quantity bought was 7500 tons from different suppliers under the same type of contract already decided.
But company A is careful and has decided to buy call options for the exact quantity of the stock, at a strike price K of 1750$, slightly above the 1st October LME price which was 1716$.
The price of a unit call option was 83.33$ and the total transaction cost 22500$.
Given the final rising price, 2062.5$ on the 6th January 2021, the call option was exercised and it brought a profit computed according to the following formula:

$$P/L = -Q*\text{Premium per unit} + Q*(LME - K) - \text{Fee}$$

where Q stands for the quantity, 'Premium per unit' the premium price of the option per ton, 'LME' the close value of the stock index at the deadline and 'K' the strike price.
The result is a profit (1'696'287) for the first month: it means that the strategy worked!
Company A suffered a loss of -2'355'000 in the principal market that was eased by a consistent gain in the option market.
In case the option wasn't exercised the loss would be computed simply as the premium per unit times the quantity purchased.
What if company A had used another strategy?
It is still concerned about a rise in the LME 3-month price, but doesn't want to spend money for the premium price of the option.
Indeed, with the synthetic put option the expense for the amount of call option at the subscription was Q*Premium per unit = 7500*83.33=624'975$ + Fee, a remarkable amount of money.

In order to avoid that, Company A can be long on a option and short to another one to compensate the gain and the loss on the premium price, at the moment of the subscription.

A short collar is what can be used in that kind of situations. It is capped below avoiding important losses for high prices[52], but at the same time even for the low prices range there is a limited profit opportunity. Its shape is shown in the graph below:



Graph.31

A goes long in a call option of the same quantity we have bought on the LME 3-month market and short a put option. The strike price K1 of the put option is lower than the strike K price K2 of the call option. Between the two lies the current LME stock price.

On the 1st October 2020 the aluminium price was 1716$ per ton. So it's reasonable to adopt K1=1650 and K2=1750.

While the computation for what concern the call option where the same of the previous strategy, the put option follows another path. We short it and immediately cash the total premium.

On the 6th of January the call is exercised, while the put it isn't so its Profit is equal to:

[52] Tauser, J. & Cajka, R. (2014), *Hedging techniques in commodity risk management,* Faculty of International Relations University of Economics Prague, WP N°60, pp. 174-182

P/L = Q*Premium per unit - Fee

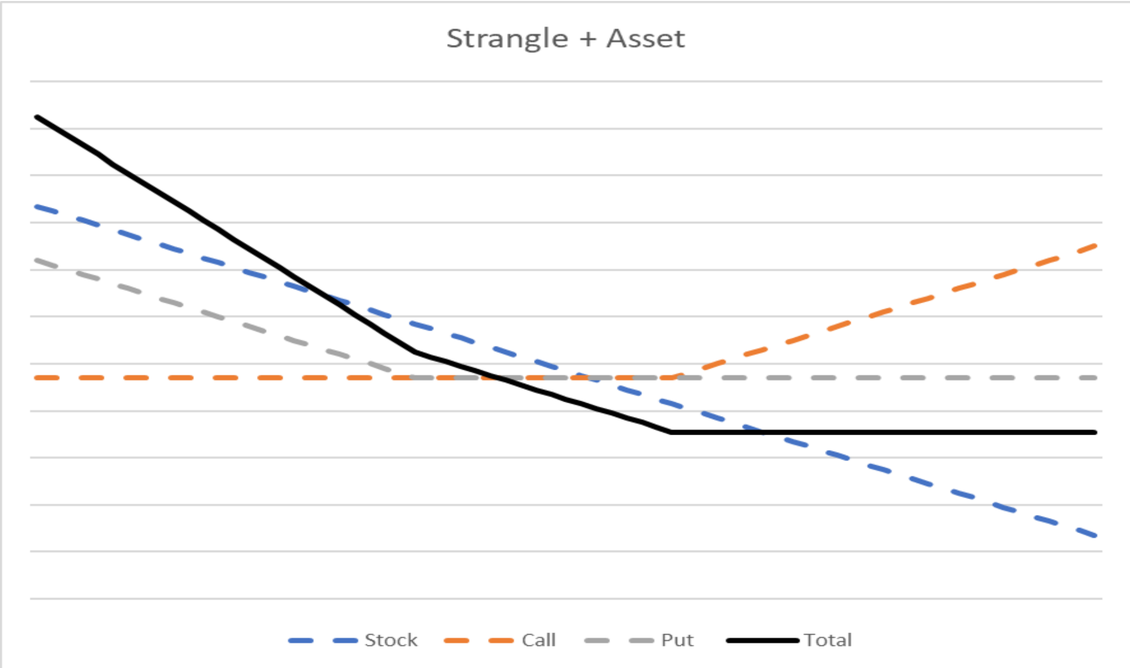
In this case, 7500 tons*83.91$ = 606’842$ that along with the call option exercised contributes to stop the total Loss at -51’871$.

Also in this case the strategy worked! For stable prices, this collar allows call option and put option to offset each other.

Let’s say that company A is risk averse if decided to implement a collar.

What if it was a risk lover firm, but still wanted to cover its position against high prices? Maybe it would accept to spend premium prices at the subscription but in exchange have no limits on the possible gain for prices much lower than the current LME index.[53]

The features of the strategy are shown in the next graph.



Graph.32

Company A goes long on call options and on put options for a quantity of 7500*2=15000 tons of aluminium. The put option has a lower strike price K1 that on 1st October 2020 must have been reasonably 1650$, as previously explained; the call option has a higher strike price K2, 1750$, to form a strangle, which summed to the underlined asset gives a total strategy capped for high prices to limit the losses, but with no limits for low realized prices.

[53] Hull, J.C. (2021), *Options, futures and other derivatives,* Pearson, Harlow (UK)

A particularity of this strategy is that its function becomes steeper for prices below the put strike price K1.

A potential flaw is that if the LME index turns higher than expected at the expiration date, the loss is higher than the one suffered implementing a synthetic put option.

On the 6th of January, to the loss of the stock price is added the one of the total premium paid for the option: -(Q*Premium per unit - Fee) = -651'842$ that wasn't exercised due to the high LME realized, 2062.5$.

The total Loss of the strategy in January 2021 is though -1'310'555$ far greater than the one with the synthetic put.

Two more strategies that can be used by Company A are the Inverse Put Ratio and the Put Backspread.

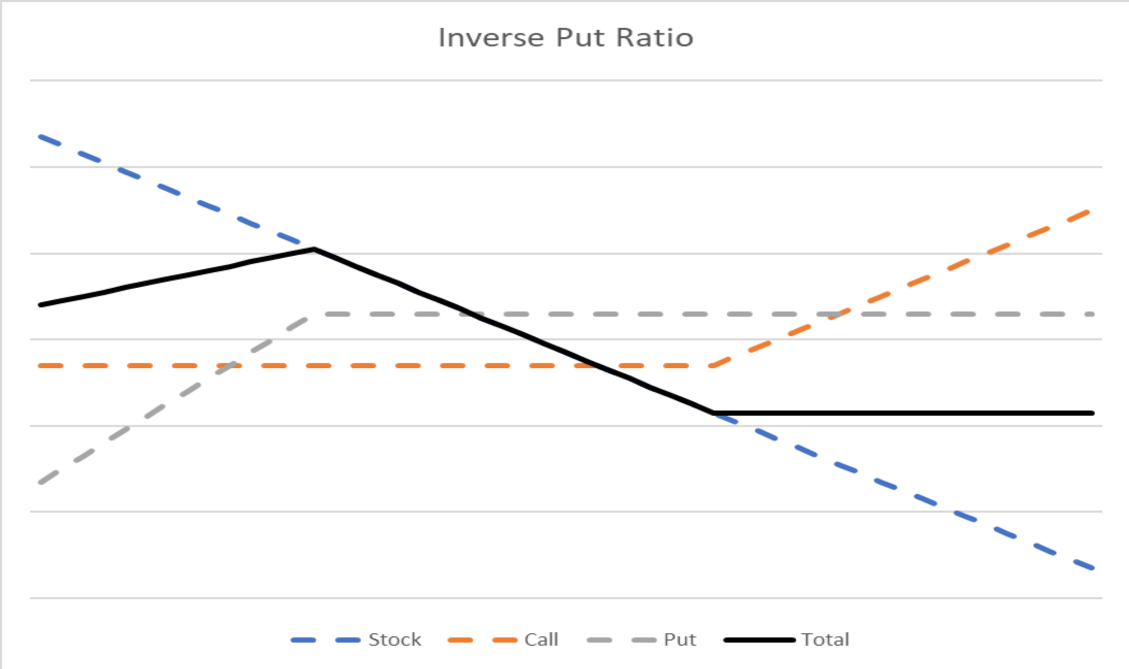
The inverse Put Ratio is a singular strategy that is more conservative with respect to the collar, even though the structure is more or less the same.[54]

On the 1st of October 2020 company A goes long on a call option with a strike price K2 of 1750$ per ton of aluminium and shorts a put with a lower strike price K1 at 1650$.

It seems the same set up used to create a collar but in this case the quantity sold as the underlined asset for the put option is more than the quantity underlined for the call option.

In our practical example, if we buy the call option for 7500 tons, we sell a put option on 7500*1.01=7575 tons. Of course, the multiplier can be a number comprised between 1 and 2, it depends by the slope company A wants to give to the strategy.

[54] Tauser, J. & Cajka, R. (2014), *Hedging techniques in commodity risk management,* Faculty of International Relations University of Economics Prague, WP N°60, pp. 174-182



Graph.33

Indeed, as shown in the graph above the black line which represents the total outcome of the hedging strategy stops the loss for high prices, but even though ensure a profit for low realized LME prices, they become lower for smaller prices than K1, in our case 1650$.

Why company A should take that risk using an Inverse Put ratio?

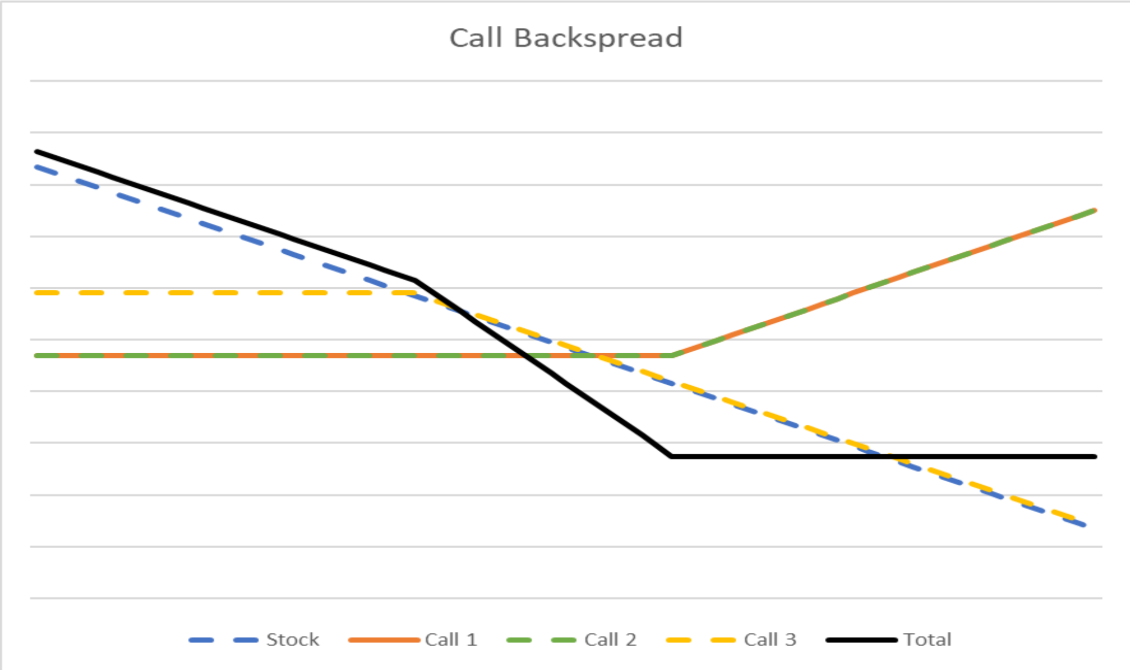
If the underlined quantity for the put option is greater, it will be greater the premium received as well. And as a consequence of that the total loss in case of high prices would be limited and less than in the case of the collar, ceteris paribus.

On 6th January 2021, after the realization of a high LME price, the call option is exercised, while the put option it's not. The loss on the 3-month LME market is offset by the profit on the call option 1'696'287$, and by the total premium received for the put, 613'136$, more than in the collar strategy, which gives a total loss of 45'577$.

This is due to the different quantity underlined the option trading: the hedging strategy not only counterbalanced the loss on the principal market but brought an overall profit to the company A.

The last strategy company A can use is the only one that involves the trading of three options of the same type.

The call backspread[55] is built up buying call options doubling the quantity of the underlying asset, with a higher strike price K2, on 1st October 2020 1750$, and shorting a call option for the quantity traded on the principal market with strike price K1, in our example practically equal to 1650$.



Graph.34

Basically, the total loss of the strategy for high prices is limited by the profit in the long position in the call options.

In practical terms, even if it ensures a total profit for low realized price it is the second riskiest strategy that company A can implement of the five seen up to now.

The total Profit/Loss outcome is derived by the position of the principal market at which we have to add the position in the call options.

In this case, all the three calls would have been exercised, thus leading to a result of:

$$P/L = \text{LME 3-month pos.} + \text{Call 1 } P/L + \text{Call 2 } P/L + \text{Call 3 } P/L$$

That is equal to -2’355’000 + 1’696’287 + 1’696’287 – 2’297’571 = -1’259’996 $

[55] Rusnakova, M. (2015), *Commodity price risk management using option strategies,* Department of Finance Faculty of Economics Technical University of Košice, WP N°61, pp. 149-157

The strategy worked well because we lost less than we would have on the principal market alone!

It is important to note that even though the loss is significant, because of a costly strategy, it is anyway less than in the case of the ‘Strangle + Asset’ (-1’310’555$).

4.3. Hedging strategies for an aluminium seller

Company B is a firm that extract bauxite and transform it in alumina, and aluminium. It is a huge multinational and it has significative market quotas in all the three markets. Since its costs depend by the condition of extraction, mining, and transformation of the raw material its revenue on the contrary depend on the LME index fluctuations.

Company B, has company A as its client and sells the primary material 3 months before the delivery with respect to the LME 3-month index.

Its clients are homogeneous and though the realized unit of price depend by the value realized on the market at the close price of the trading day of the delivery.

Company B fears that in the 3 months next to the agreement the LME 3-months price will go down.

It can go to the option market and try to prevent its position from unexpected and potentially unlimited losses.

In order to do it, the synthetic call can be a solution.

The reasoning is similar to the synthetic put already discussed, but in this case company B tries to protect from a decrease in prices.

In practical terms, along with the position on the principal market, the multinational goes long on put options for a quantity equal to the one it committed to sell on the market.

On 1st march 2022, few days after the beginning of the Russian offensive, company B succeed to sign a contract with its client to sell 6250 tons that will be delivered on 1st June at the realized LME 3-month price on that day. On 1st march, the LME 3-month cash is at 3464$ per ton.

After 3-months, it turns out that the price has shrunk to 2730$ per ton and so company B has to face an important loss on the principal market of -4’587’500$.

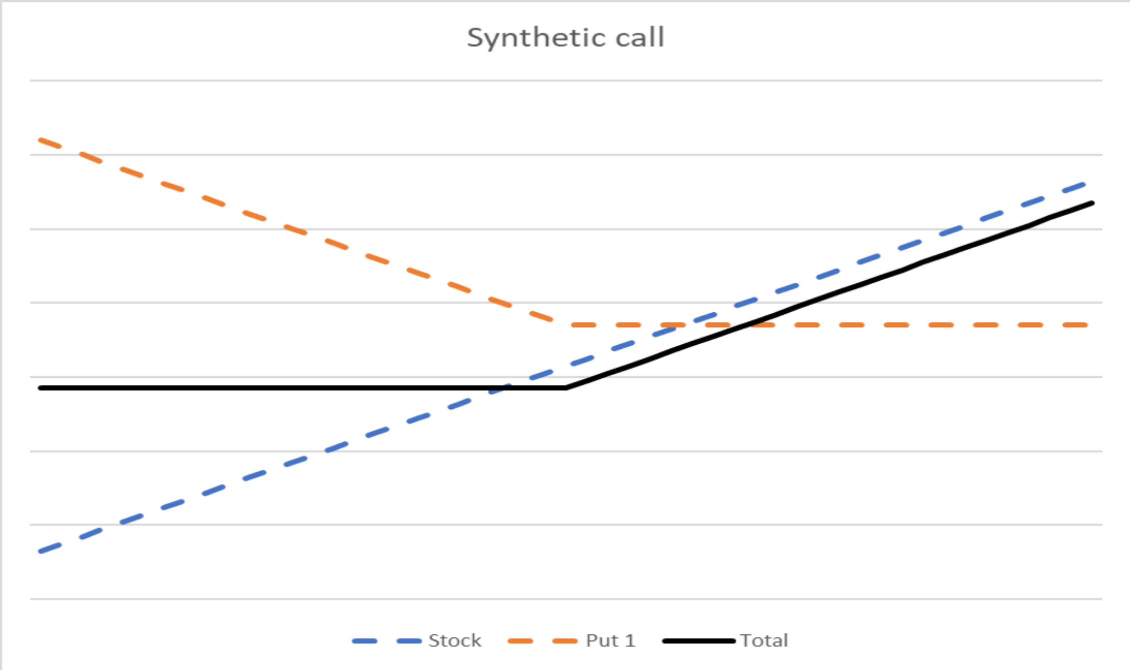
Company B fortunately has been careful and fearing a decrease in price went long on 3-month put options for the right to sell 6250 tons.[56]

The strike price of the put option was 3450$ slightly under the current LME index price on 1st march, which was 3495.5$ per ton.

[56] Rusnakova, M. (2015), *Commodity price risk management using option strategies,* Department of Finance Faculty of Economics Technical University of Košice, WP N°61, pp. 149-157

Three months later, company B decided to exercise the put option and to stop limit its loss.

The graph below is useful to understand how the strategy worked.



Graph.35

The put option profit is computed using the following formula:

P/L = -Q*Premium per unit + Q*(K – LME) – Fee

The notation is the same used in the previous paragraph, also in this case the transaction fee is taken into consideration in order to compute the profit.

It turns out that the profit deriving from the put option 4’109’224$, offset almost completely the loss in the principal market, stopping the feasible total loss to:

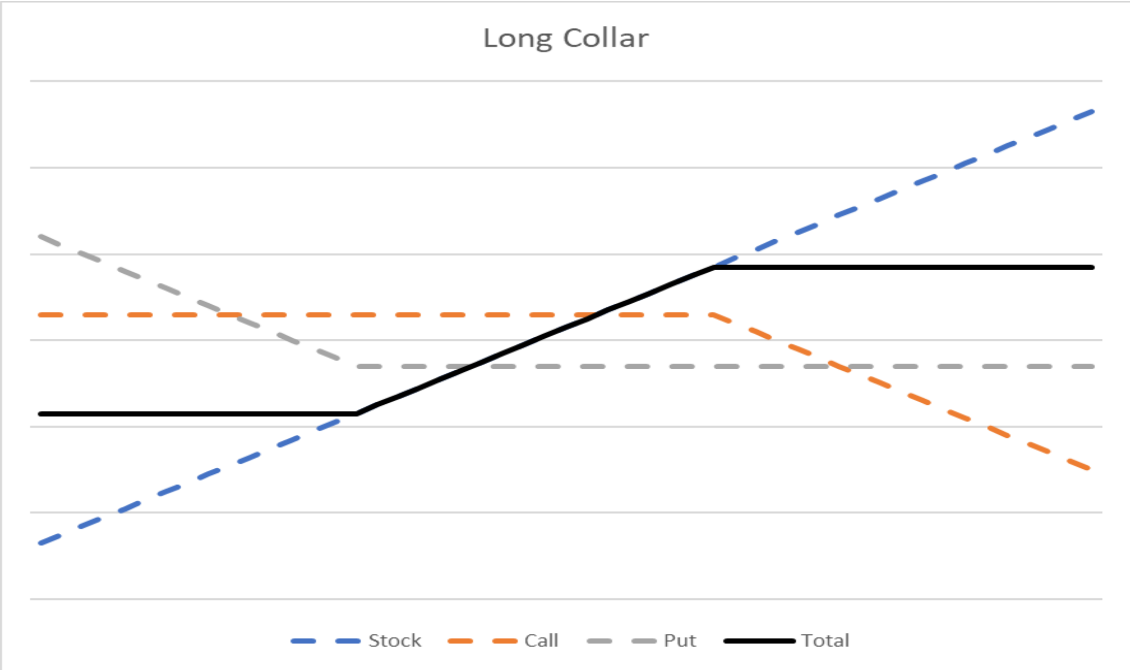
-4’587’500$ + 4’109’224$ = -478’276$.

The synthetic call strategy worked well, but company B may not have been glad to spend 546’375$ to buy a put option by its trustworthy broker on 1st march to counterbalance a potential risk.

In this case, it could have implemented a long collar:[57] it has the same features of the short collar previously explained, but it stops the loss with respect to realized low prices. Company B goes long on a put option with a lower (than the current LME price on 1st march) strike price K1, and shorts a call option with a higher strike price K2.

Given that LME price on 1st march 2022 was 3495.5$, K1 can be chosen at 3450$ and K2 at 3550$ per ton.

After 3 months, the put option is exercised but the call option it's not and so its total premium price contributes to ease the principal market loss.



Graph.36

In the graph above it can be seen how the strategy works. The first thing that can be noticed regards the fact that from the point of view of the aluminium seller the same strategy applied is completely symmetrical to the ones applied by the aluminium buyer. The total premium of the call option is computed simply by:

$$P/L = Q*\text{Premium per unit} - \text{Fee}$$

[57] Tauser, J. & Cajka, R. (2014), *Hedging techniques in commodity risk management,* Faculty of International Relations University of Economics Prague, WP N°60, pp. 174-182

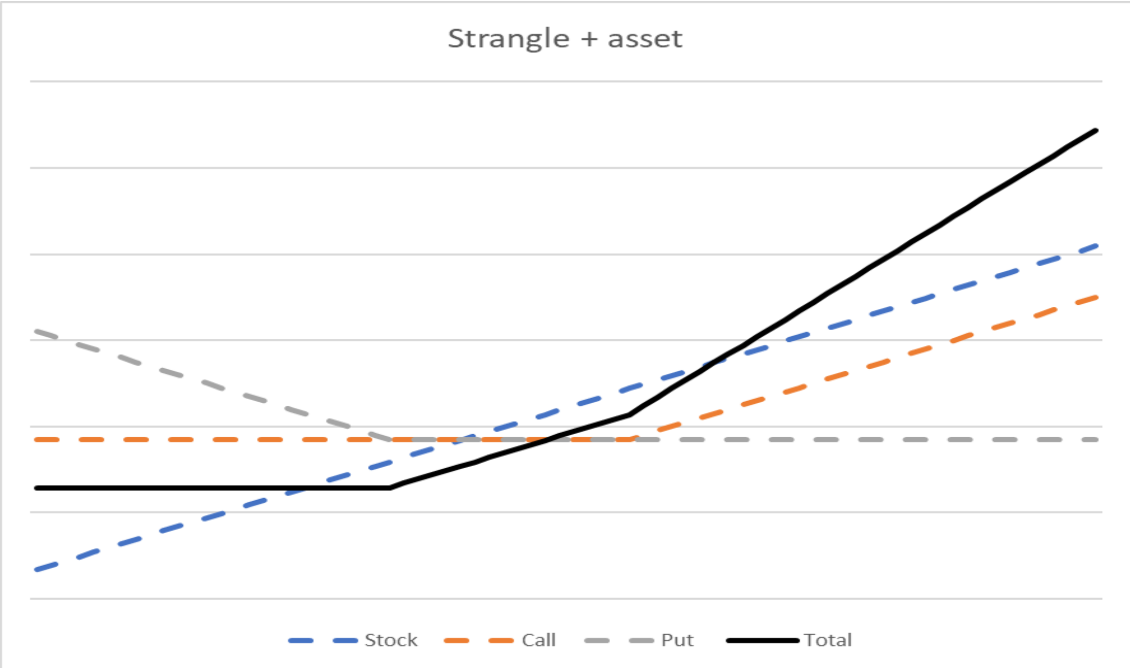
On 1st march 2022, the premium received for the call option is 492’750$ - Fee = 470’259$, that stops the total loss at ‘P/L market’ + P/L Call + P/L Put =-8’017$.

Also in this case the strategy did what was expected.

As it was said company B is a multinational and despite of its hedging program, may be willing to spend more for the options premium to allow potentially infinite profits for higher prices realized.

The strangle added to the asset already bought can be a good choice as it has been said for Company A.[58]

It is shown on the graph below that there is a less favorable stop loss limit for low prices than the collar but on the contrary in case of high price the profit can be infinite.



Graph.37

This is a strategy that is highly advised for huge realities like Company B. Indeed, the result is a combination of the Profit/Loss of the single positions. After 3 months, the put option will be exercised, while the call expires. The total loss will be 993’535$ less than 4’587’500$ lost on the market.

[58] Hull, J.C. (2021), *Options, futures and other derivatives,* Pearson, Harlow (UK)

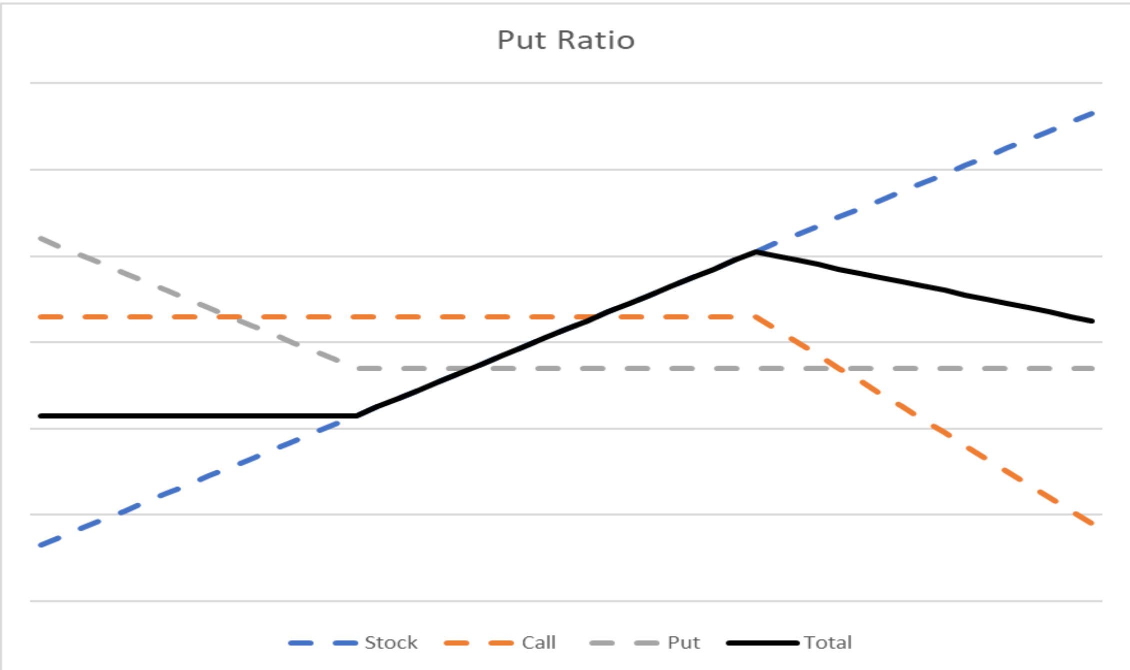
On the contrary, if company B is not willing to spend money on the option premiums, can implement a Ratio spread.[59]It consists, along with the asset already sold, in buying a put option with a lower strike price K1 and selling a call option with a higher strike price K2. Given the price of 3495.5 $ on the LME index on 1st march 2022, its reasonable to take K1 equal to 3450$ and K2 equal to 3550$. This time, the quantity underlying the call option shorted must be more than the quantity sold on the market. In order to simplify the computations, a ratio of 1.01 is taken into consideration.

Three months later, the realized LME price is 2701.5$, so the put option is exercised, while the call option it's not. The loss in the stock market has been counterbalanced by the put option profit and the call option premium, so that the total result is given by the following formula:

Position on the market +P/L Call + P/L Put

With real data we can compute the total profit:

-4'587'500$ + 475'187$ + 4'109'224$ = -3'090$



Graph.38

[59] Tauser, J. & Cajka, R. (2014), *Hedging techniques in commodity risk management,* Faculty of International Relations University of Economics Prague, WP N°60, pp. 174-182

This strategy that doesn't assure a cover in case of very high prices it's not a classical hedging strategy, but when the LME index goes down. It assures an almost complete cover. Indeed, the options profits have quite totally offset the fall in price of the principal market.

The last strategy Company B can consider to limit its risk is the put backspread, that consists in trading three put options, or in other words going long for a quantity that doubles the asset already sold on the market, and going short on a put option for the quantity sold on the market.[60]

The strike price of the long position is in the put is the lower one K1, while the strike price of the short put option is higher, K2.

In practical terms, company B fears a decrease in LME 3-month cash index which is at 3464$ per ton: so it decides to buy put options for 6'250*2 = 12'500 tons with a slightly lower strike price than the current LME index 3495.5$, setting K1 at 3450$.

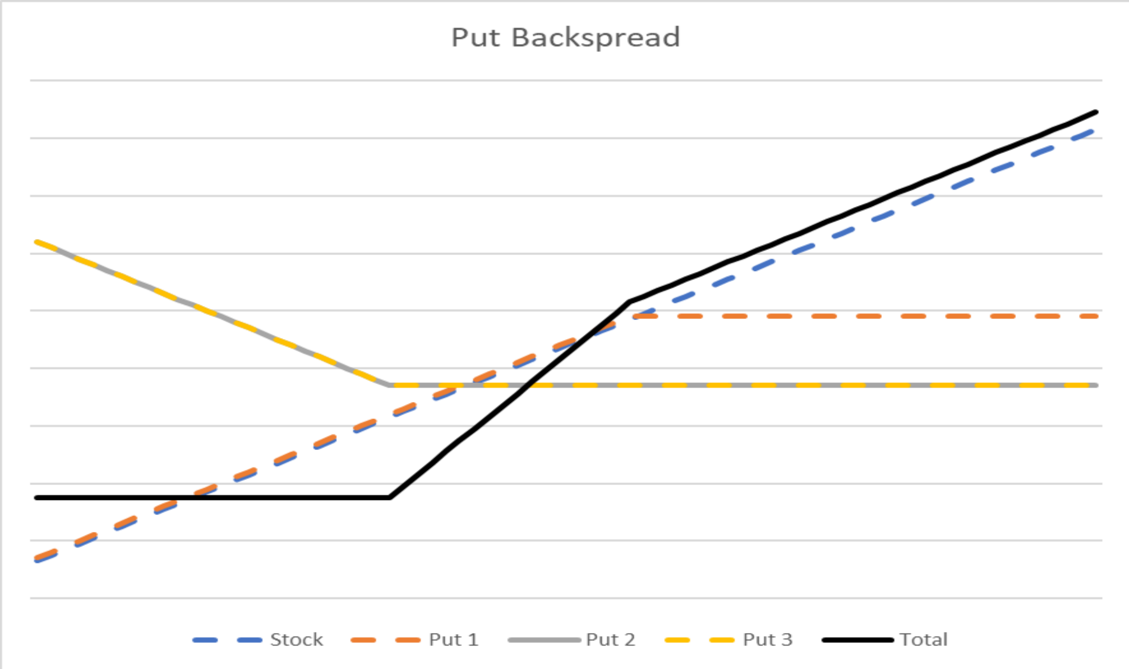
At the same time shorts put options for a quantity of 6'250 tons at a higher strike price K2, let's say 3550$ per ton.

Three months later, LME 3-month cash decrease to 2730$ causing an important loss on the principal market. LME index stops at 2701.5$: as a direct consequence of that all the put options are exercised and thus computing the put option profits like it was explained for the synthetic call option we can calculate the total P/L outcome of the strategy with the following formula:

$$\text{Total P/L} = \text{Market position} + \text{P/L Put 1} + \text{P/L Put 2} + \text{P/L Put 3}$$

For sake of simplicity, the put option quantity bought by company B as treated as two different operations, as in the graph below, at the aim to highlight that to form the strategy correctly the quantity bought must always double the quantity shorted and the quantity that company B has agreed to sell on the market.

[60] Rusnakova, M. (2015), *Commodity price risk management using option strategies,* Department of Finance Faculty of Economics Technical University of Košice, WP N°61, pp. 149-157



Graph.39

Doing the proper computations, company B finds out that its net position after the strategy is:

-4’587’500$ + 4’109’223$ + 4’109’223$ - 4’658’249 = -1’027’301$

The net position was negative of only slightly more than 1 million $, so the strategy worked well!

It has to be noticed that this strategy with respect to the others covers less but allows an overall potentially infinite profit if the price hikes and is favorable.

The reasoning and the need at the basis of the backspread are similar to the ones of the ‘Strangle + asset’ strategy but actually the latter becomes steeper for the highest prices range.

Conclusions

In the last chapter five different strategies have been presented and applied for a company that buys aluminium and for one another that sells it.

Usually, a strategy is applied to counterbalance the potential negative effects of the physical market and so not always it may be the case. The trading team of a company can decide to apply the strategies, in case of company A, only when the forward market points out clearly an increasing trend.

On the contrary, Company B trading board may decide to cover its position just when the forward and future markets forecast a strong decrease in price in the principal market.

In general, the exact trend of the commodity markets are unpredictable and thus for instance company A can decide to apply each month the same strategy or to change it depending by the need of the period.

The strategy would be applied continuously month by month and of course, there is also the possibility that if the price turns to be favorable from the point of view of the principal market, in the option market there would be a consistent loss if the strategies are implemented well.

This is the classical case in which the hedger could have been better off not to hedge at all.

Furthermore, the strategies that are more costly, in the long run can assure a higher profit and may be chosen by huge multinationals which can afford to spend high premiums for the option market.

In order to have a practical idea, let's take into consideration company A as if it had applied each strategy for a time span of 2 years and 9 month from January 2021 to September 2023.

The following assumptions is valid for all the cases: the cumulate loss in the market matured at the end of the period is 8'479'125$.

It means that in 33 months there has been an average upward trend that in the 3-months periods between the signing of the contracts and the deliveries, has brought considerable losses on the principal market.

Generally, to hedge it has been a good move also ex-post, so let's see the outcomes of every strategy in almost 3 years.

The synthetic put brings a total gain of 3’819’229 $, and so it means that 12’298’254 $ is the net profit of the call options bought on the derivatives market.
This is an important positive result that is given to the fact that the strategy can bring potentially infinite profits for low prices.
The short collar strategy confirms this result, the call and put options bring an aggregate result of 5’669’835 $, thus limiting the total profit in the option market and giving a total profit position of -8’479’125+ 5’669’835$ = -2’809’290 $
The result is worse than the one with the synthetic put, and the reason is why this strategy is capped for low price realizations and so when the principal market is favorable, company A accepts always to have limited profits.
For the strangle + asset strategy the result is outstanding, due certainly to the unlimited and steeper profits in case of favorable markets. In the long run this feature makes the difference.
The 8’479’125$ have been more than compensated by the call and put combinations over 33 months by a net profit on the option market of 17’456’272 $, that gives a total outcome of -8’479’125$ + 17’456’272$ = 8’977’147$ obtained by summing month by month the strategy results.
Opting for this strategy means in a certain sense, not only hedging our own position against an increase in price but in the long run, betting on the instability of the price. Indeed, for unstable prices and high volatilities, at least one between the call and the put option is exercised bringing an almost sure profit despite the position on the principal market.
On the other hand, the more conservative Inverse Put Ratio spread brings a total option market profit of 9’870’775$. It’ still remarkable but it’s considerably less than the strangle strategy due to the fact that implementing this strategy is cheap but the profit are capped as for the collar.
The total profit is thus: -8’479’125$ + 9’870’775$ = 1’391’650$.
The Inverse put ratio is instead a more conservative strategy, as explained before, mainly because it’s like betting on relatively stable prices in the long term. Indeed, if it creates a cap for high range prices, it is dangerous for very low prices when it turns to be slightly positive or negative again.

The second riskiest strategy, the backspread, depends by the results in the call option market.

The net profit from the derivatives market is 3’879’268$ with the long positions positive and the short positions very negative, mainly due to the upward trend of the prices mentioned above. This brings to a total strategy loss of 4’599’857$ the worst result, mainly because of the high cost to implement it, trading a considerably higher quantity of aluminium with respect to the other strategies and the cost of the long positions.

The strategies that can be applied in the aluminium sector to offset the market risks are not only the ones seen in this text, trading boards can be as creative a they want to go along with the particular necessities of a company.

Certainly, this can be a good point to start.

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