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Evaluation of the financial risk and forecasting the ecological transition related with CO2 impacted by the Covid19 Crisis

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Internship / work-study / research dissertation

Evaluation of the financial risk and forecasting the ecological transition related with CO2 impacted by the Covid19 Crisis.

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**Master 2 Pro
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Preface:

Grenoble IAE, University Grenoble Alpes, does not validate the opinions expressed in theses of masters in alternance candidates; these opinions are considered those of their author.

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Introduction

I. Corporate finance (Definition)

Corporate finance is that the area of finance that deals with sources of funding, the capital structure of corporations, the actions that managers want increase the worth of the firm to the shareholders, and also the tools and analysis want to allocate financial resources. the first goal of finance is to maximize or increase shareholder value. [1]

Correspondingly, finance comprises two main sub-disciplines. Capital budgeting is anxious with the setting of criteria about which value-adding projects should receive investment funding, and whether to finance that investment with equity or debt capital. assets management is that the management of the company's fund that cope with the short-term operating balance of current assets and current liabilities; the main target here is on managing cash, inventories, and short-term borrowing and lending (such because the terms on credit extended to customers).

The terms finance and company financier are related to investment banking. the standard role of an investment bank is to judge the company's financial needs and lift the suitable variety of capital that most closely fits those needs. Thus, the terms "corporate finance" and "corporate financier" is also related to transactions during which capital is raised so as to form, develop, grow or acquire businesses. Recent legal and regulatory developments within the U.S. will likely alter the makeup of the group of arrangers and financiers willing to rearrange and supply financing for sure highly leveraged transactions.[2]

Although it's in essence different from managerial finance which studies the financial management of all firms, instead of corporations alone, the most concepts within the study of finance are applicable to the financial problems of all types of firms. Financial management overlaps with the financial function of the accounting profession. However, financial accounting is that the reporting of historical financial information, while financial management is worried with the deployment of capital resources to extend a firm's value to the shareholders

1. History

Corporate finance for the pre-industrial world began to emerge within the Italian city-states and therefore the geographic area of Europe from the 15th century. Public markets for investment securities developed within the Dutch Republic during the 17th century. By the first 1800s, London acted as a middle of finance for companies round the world, which innovated new types of lending and investment. the 20th century brought the increase of managerial capitalism and customary stock finance. Modern finance, alongside investment management, developed within the last half of

the 20th century, particularly driven by innovations within theory and practice in the U.S. and Britain.

The primary goal of monetary management is to maximise or to continually increase shareholder value. [3] Maximizing shareholder value requires managers to be ready to balance capital funding between investments in "projects" that increase the firm's long run profitability and sustainability, together with paying excess cash to make the most of the shape of dividends to shareholders. Managers of growth companies (i.e. firms that earn high rates of return on invested capital) will use most of the firm's capital resources and surplus cash on investments and projects that the company can still expand its business operations into the long run. When companies reach maturity levels within their industry (i.e. companies that earn approximately average or lower returns on invested capital), managers of those companies will use surplus cash to payout dividends to shareholders. Managers must do an analysis to see the acceptable allocation of the firm's capital resources and cash surplus between projects and payouts of dividends to shareholders, additionally as group action creditor related debt. [3] [4]

Choosing between investment projects are going to be based upon several inter-related criteria.

(1) Corporate management seeks to maximise the worth of the firm by investing in projects which yield a positive net present value when valued using an appropriate discount rate in consideration of risk.

(2) These projects must even be financed appropriately.

(3) If no growth is feasible by the corporate and excess cash surplus isn't needed to the firm, then financial theory suggests that management should return some or all of the surplus cash to shareholders (i.e., distribution via dividends). [5]

This "capital budgeting" is that the planning of value-adding, long-term corporate financial projects concerning investments funded through and affecting the firm's capital structure. Management must allocate the firm's limited resources between competing opportunities (projects). [6]

Capital budgeting is additionally concerned with the setting of criteria about which projects should receive investment funding to extend the worth of the firm, and whether to finance that investment with equity or debt capital. [7] Investments should be made on the idea of value-added to the longer term of the corporation. Projects that increase a firm's value may include a good sort of differing types of investments, including but not limited to, expansion policies, or mergers and acquisitions. When no growth or expansion is feasible by an organization and excess cash surplus exists and isn't needed, then management is predicted to disburse some or all of these surplus earnings within the sort of cash dividends or to repurchase the company's stock through a share buyback program.

2. Capital structure

Achieving the goals of finance requires that any corporate investment be financed appropriately. [8] The sources of financing are, generically, capital self-generated by the firm and capital from external funders, obtained by issuing new debt and equity (and hybrid- or convertible securities). However, as above, since both hurdle rate and cash flows (and hence the riskiness of the firm) are going to be affected, the financing mix will impact the valuation of the firm, and a considered decision is required here. Finally, there's much theoretical discussion on other considerations that management might weigh here

3. Sources of capital

Debt capital

Corporations may depend upon borrowed funds (debt capital or credit) as sources of investment to sustain ongoing business operations or to fund future growth. Debt comes in several forms, like through bank loans, notes payable, or bonds issued to the general public. Bonds require the companies to form regular interest payments (interest expenses) on the borrowed capital until the debt reaches its day of the month, therein the firm must pay back the requirement fully. Debt payments may also be made within the variety of fund provisions, whereby the corporation pays annual installments of the borrowed debt above regular interest charges. Corporations that issue callable bonds are entitled to pay back the requirement fully whenever the corporate feels it's in their best interest to pay off the debt payments. If interest expenses can not be made by the corporation through cash payments, the firm may use collateral assets as a variety of repaying their debt obligations (or through the method of liquidation).

Equity capital

Corporations can alternatively sell shares of the corporate to investors to boost capital. Investors, or shareholders, expect that there'll be an upward trend in value of the corporate (or appreciate in value) over time to form their investment a profitable purchase. Shareholder value is increased when corporations invest equity capital and other funds into projects (or investments) that earn a positive rate of return for the owners. Investors choose to buy shares of stock in companies which will consistently earn a positive rate of return on capital within the future, thus increasing the market price of the stock of that corporation. Shareholder value can also be increased when corporations payout excess cash surplus (funds from retained earnings that aren't needed for business) within the sort of dividends.

Preferred stock

Preferred stock is an equity security which can have any combination of features not possessed by stock including properties of both an equity and a document, and is mostly considered a hybrid instrument. Preferreds are senior (i.e. higher ranking) to stock, but subordinate to bonds in terms of claim (or rights to their share of the assets of the company). [9]

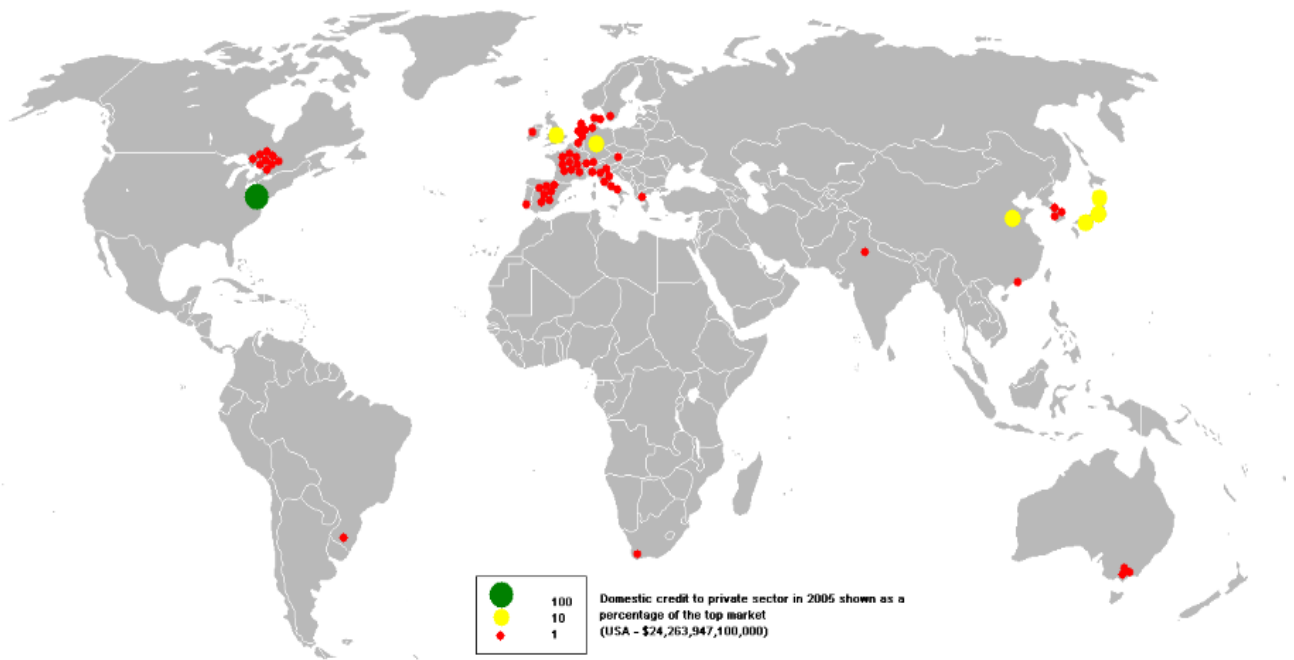
Preferred stock usually carries no voting rights, [10] but may carry a dividend and should have priority over stock within the payment of dividends and upon liquidation. Terms of the well-liked stock are stated in an exceedingly "Certificate of Designation".

Similar to bonds, preferred stocks are rated by the most important credit-rating companies. The rating for preferred is mostly lower, since preferred dividends don't carry the identical guarantees as interest payments from bonds and that they are junior to all or any creditors.

Preferred stock could be a special class of shares which can have any combination of features not possessed by stock. the subsequent features are usually related to preferred stock: [11]

- Preference in dividends
- Preference in assets, within the event of liquidation
- Convertibility to stock.
- Call ability, at the choice of the corporation
- Nonvoting

Capitalization structure



As mentioned, the financing mix will impact the valuation of the firm: there are then two interrelated considerations here:

- Management must identify the "optimal mix" of financing – the capital structure that leads to maximum firm value, **[12]** (WACC) - but must also take other factors into consideration (see trade-off theory below). Financing a project through debt ends up in a liability or obligation that has got to be serviced, thus entailing income implications independent of the project's degree of success. Equity financing is a smaller amount risky with reference to income commitments, but ends up in a dilution of share ownership, control and earnings. the price of equity (see CAPM and APT) is additionally typically beyond the value of debt - which is, additionally, a deductible expense – so equity financing may lead to an increased hurdle rate which can offset any reduction in income risk. **[13]**
- Management must try and match the long-term financing mix to the assets being financed as closely as possible, in terms of both timing and cash flows. Managing any potential asset liability mismatch or duration gap entails matching the assets and liabilities respectively consistent with maturity pattern ("Cashflow matching") or duration ("immunization"); managing this relationship within the short-term could be a major function of assets management, as discussed below. Other techniques, like securitization, or hedging using interest rate- or credit derivatives, also are common. Related considerations

- Much of the speculation here, falls under the umbrella of the Trade-Off Theory during which firms are assumed to trade-off the tax benefits of debt with the bankruptcy costs of debt when choosing the way to allocate the company's resources. However economists have developed a collection of other theories about how managers allocate a corporation's finances.
- One of the most alternative theories of how firms manage their capital funds is that the hierarchy Theory (Stewart Myers), which suggests that firms avoid external financing while they need internal financing available and avoid new equity financing while they'll engage in new debt financing at reasonably low interest rates.
- Also, the Capital structure substitution theory hypothesizes that management manipulates the capital structure such earnings per share (EPS) are maximized. An emerging area in finance theory is right-financing whereby investment banks and corporations can enhance investment return and company value over time by determining the proper investment objectives, policy framework, institutional structure, source of financing (debt or equity) and expenditure framework within a given economy and under given market conditions.
- One of the more modern innovations during this area from a theoretical point of view is that the Market timing hypothesis. This hypothesis, inspired within the behavioral finance literature, states that firms rummage around for the cheaper variety of financing no matter their current levels of internal resources, debt and equity. Investment and project valuation.
- In general, [14] each project's value are going to be estimated employing a discounted income (DCF) valuation, and also the opportunity with the best value, as measured by the resultant net present value (NPV) are going to be selected (applied to finance by Joel Dean in 1951). this needs estimating the scale and timing of all of the incremental cash flows resulting from the project. Such future cash flows are then discounted to work out their present value (see continuance of money). These present values are then summed, and this sum net of the initial investment outlay is that the NPV. See Financial modeling #Accounting for general discussion, and Valuation using discounted cash flows for the mechanics, with discussion re modifications for finance.
- The NPV is greatly stricken by the discount rate. Thus, identifying the right discount rate – often termed, the project "hurdle rate" [15] – is critical to picking good projects and investments for the firm. The hurdle rate is that the minimum acceptable return on an investment – i.e., the project appropriate discount rate. The hurdle rate should reflect the riskiness of the investment,

typically measured by volatility of money flows, and must take into consideration the project-relevant financing mix. [16] Managers use models like the CAPM or the APT to estimate a reduction rate appropriate for a selected project, and use the weighted monetary value of capital (WACC) to reflect the financing mix selected. (A common error in choosing a reduction rate for a project is to use a WACC that applies to the complete firm. Such an approach might not be appropriate where the danger of a selected project differs markedly from that of the firm's existing portfolio of assets.)

- In conjunction with NPV, there are several other measures used as (secondary) selection criteria in finance. These are visible from the DCF and include discounted payback period, IRR, Modified IRR, equivalent annuity, capital efficiency, and ROI. Alternatives (complements) to NPV, which more directly consider economic profit, include Residual Income Valuation, MVA / EVA (Joel Stern, Stern Stewart & Co) and APV (Stewart Myers). With the price of capital correctly and correspondingly adjusted, these valuations should yield the identical result because the DCF.

4. Quantifying uncertainty

Given the uncertainty inherent in project forecasting and valuation, [17] [18] analysts will wish to assess the sensitivity of project NPV to the assorted inputs (i.e. assumptions) to the DCF model. In an exceedingly typical sensitivity analysis the analyst will vary one key factor while holding all other inputs constant, *ceteris paribus*. The sensitivity of NPV to a change in this factor is then observed, and is calculated as a "slope": $\Delta\text{NPV} / \Delta\text{factor}$. For instance, the analyst will determine NPV at various growth rates in annual revenue as specified (usually at set increments, e.g. (-10%, -5%, 0%, 5%...), so determine the sensitivity using this formula. Often, several variables is also of interest, and their various combinations produce a "value-surface", [19] (or even a "value-space",) where NPV is then a function of several variables. cf. Stress testing.

Using a related technique, analysts also run scenario based forecasts of NPV. Here, a scenario comprises a selected outcome for economy-wide, "global" factors (demand for the merchandise, exchange rates, commodity prices, etc...) yet as for company-specific factors (unit costs, etc...). As an example, the analyst may specify various revenue growth scenarios (e.g. -5% for "Worst Case", +5% for "Likely Case" and +15% for "Best Case"), where all key inputs are adjusted so on be in line with the expansion assumptions, and calculate the NPV for every. Note that for scenario based analysis, the assorted combinations of inputs must be internally consistent (see discussion at Financial modeling), whereas for the sensitivity approach these needn't be so. An application of this technique is to work out an "unbiased" NPV, where management determines a (subjective) probability for every scenario – the NPV for the project is then the probability-weighted average of the varied scenarios. **(rNPV, where cash flows, as opposition scenarios, are probability-weighted.)** A further advancement which "overcomes the restrictions of sensitivity and scenario analyses by examining the results of all possible combinations of variables and their realizations" [20] is to construct stochastic [21] or probabilistic financial models –

as against the standard static and deterministic models as above. [18]

For this purpose, the foremost common method is to use town simulation to research the project's NPV. This method was introduced to finance by David B. Hertz in 1964, although it's only recently become common: today analysts are even able to run simulations in spreadsheet based DCF models, typically employing a risk-analysis add-in, like in danger or globe. Here, the income components that are (heavily) impacted by uncertainty are simulated, mathematically reflecting their "random characteristics".

In contrast to the scenario approach above, the simulation produces several thousand random but possible outcomes, or trials, "covering all conceivable globe contingencies in proportion to their likelihood; [22] see town Simulation versus "What If" Scenarios. The output is then a histogram of project NPV, and therefore the average NPV of the potential investment – yet as its volatility and other sensitivities – is then observed. This histogram provides information not visible from the static DCF: for instance, it allows for an estimate of the probability that a project contains a net present value greater than zero (or the other value).

Continuing the above example: rather than assigning three discrete values to revenue growth, and to the opposite relevant variables, the analyst would assign an appropriate probability distribution to every variable (commonly triangular or beta), and, where possible, specify the observed or supposed correlation between the variables. These distributions would then be "sampled" repeatedly – incorporating this correlation – so on generate several thousand random but possible scenarios, with corresponding valuations, which are then accustomed generate the NPV histogram. The resultant statistics (average NPV and variance of NPV) are going to be a more accurate mirror of the project's "randomness" than the variance observed under the scenario based approach.

These are often used as estimates of the underlying "spot price" and volatility for the important option valuation as above; see Real options valuation .Valuation inputs. A more robust town model would come with the possible occurrence of risk events (e.g., a credit crunch) that drive variations in one or more of the DCF model inputs.

5. Dividend policy

Dividend policy is concerned with financial policies regarding the payment of a cash dividend in the present or paying an increased dividend at a later stage. Whether to issue dividends, [22] and what amount, is determined mainly on the basis of the company's inappropriate profit (excess cash) and influenced by the company's long-term earning power. When cash surplus exists and is not needed by the firm, then management is expected to pay out some or all of those surplus earnings in the form of cash dividends or to repurchase the company's stock through a share buyback program.

If there are no NPV positive opportunities, i.e. projects where returns exceed the hurdle rate, and excess cash surplus is not needed, then – finance theory suggests – management should return some or all of the excess cash to shareholders as dividends. This is the general case, however there are exceptions. For example, shareholders of a "growth stock", expect that the company will, almost by definition, retain most of the excess cash surplus so as to fund future projects internally to help increase the value of the firm.

Management must also choose the form of the dividend distribution, as stated, generally as cash dividends or via a share buyback. Various factors may be taken into consideration: where shareholders must pay tax on dividends, firms may elect to retain earnings or to perform a stock buyback, in both cases increasing the value of shares outstanding. Alternatively, some companies will pay "dividends" from stock rather than in cash; see corporate action.

Financial theory suggests that the dividend policy should be set based upon the type of company and what management determines is the best use of those dividend resources for the firm to its shareholders. As a general rule, shareholders of growth companies would prefer managers to retain earnings and pay no dividends (use excess cash to reinvest into the company's operations), whereas shareholders of value or secondary stocks would prefer the management of these companies to payout surplus earnings in the form of cash dividends when a positive return cannot be earned through the reinvestment of undistributed earnings.

A share buyback program may be accepted when the value of the stock is greater than the returns to be realized from the reinvestment of undistributed profits. In all instances, the appropriate dividend policy is usually directed by that which maximizes long-term shareholder value.

II. Evaluation of the financial risks with the Monte Carlo mounted simulation:

I. Definition Monte Carlo method:

The term Monte-Carlo method, or Monte-Carlo method, refers to a family of algorithmic methods designed to calculate an approximate numerical value using random processes, i.e., probabilistic techniques. The name of those methods, which refers to gambling at the Monte-Carlo casino, was invented in 1947 by Nicholas Metropolis [1], and first published in 1949 in a writing co-written with Stanislaw Ulam [2]. The primary Monte Carlo paper, "The Monte Carlo Method" by Metropolis & Ulam, was published in 1949 within the Journal of the American Statistical Association.

Since then, several different areas have been using the town simulations. With the appearance of non-public computers and also the popularization of faster computational machines, the Monte Carlo simulations have been increasing popular as a very important alternative for the answer of complex problems.

Monte-Carlo methods are particularly accustomed calculate integrals in dimensions larger than 1 (in particular, to calculate surfaces and volumes). They're also commonly utilized in high-energy physics, where probabilistic simulations estimate the form of a proof or the sensitivity of a detector. Comparison of the measured data to those simulations may reveal unexpected features, like new particles.....

The Monte-Carlo simulation method also makes it possible to introduce a statistical approach to risk into a financial decision. It involves isolating variety of key project variables, like turnover or margin, and assigning them a probability distribution. For every of those factors, an oversized number of random draws are made within the probability distributions determined previously, so as to seek out the probability of occurrence of every of the results.

The real development of the Monte-Carlo methods came about under the impetus of John von Neumann and Stanislaw Ulam, notably during the Second war and research on the manufacture of the atom bomb. Specifically, they used these probabilistic methods to unravel partial differential equations within the context of Monte-Carlo N-Particle transport (MCNP).

Monte Carlo simulation is often accustomed evaluate the chance and uncertainty that may affect the end result of various decision options. town simulation allows the business risk analyst to include the whole effects of uncertainty in variables like sales volume, commodity and labour prices, interest and exchange rates, further because the effect of distinct risk events just like the cancellation of a contract or the change of a law.

Monte Carlo methods in finance are often wont to evaluate investments in projects at a business unit or corporate level, or to judge financial derivatives. They'll be wont to model project schedules, where simulations aggregate estimates for worst-case,

best-case, and presumably durations for every task to see outcomes for the project. [3] town methods are employed in option pricing, default risk analysis. [4] [5] [6]. Additionally, they will be accustomed estimate the financial impact of medical interventions [7].

Monte Carlo methods are utilized in finance and mathematical finance to value and analyze (complex) instruments, portfolios and investments by simulating the varied sources of uncertainty affecting their value, and so determining the distribution of their value over the range of resultant outcomes [8] [9]. this can be usually done by help of stochastic asset models. The advantage of Monte Carlo methods over other techniques increases because the dimensions (sources of uncertainty) of the matter increase.

Monte Carlo methods were first introduced to finance in 1964 by David B. Hertz through his Harvard Business review [10], discussing their application in finance. In 1977, Phelim Boyle pioneered the employment of simulation in derivative valuation in his seminal Journal of economic Economics paper [11].

The Monte Carlo method encompasses any technique of statistical sampling employed to approximate solutions to quantitative problems. [12] Essentially, the Monte Carlo method solves a controversy by directly simulating the underlying (physical) process then calculating the (average) results of the method. [8] This very general approach is valid in areas like physics, chemistry, engineering science etc. In finance, the town method is employed to simulate the assorted sources of uncertainty that affect the worth of the instrument, portfolio or investment in question, and to then calculate a representative value given these possible values of the underlying inputs. [8] ("Covering all conceivable globe contingencies in proportion to their likelihood." [8]) In terms of monetary theory, this, essentially, is an application of risk neutral valuation [13] .

Some examples:

- In corporate finance [14] [15] [16], project finance and real options analysis, [8] Monte Carlo Methods are employed by financial analysts who wish to construct "stochastic" or probabilistic financial models as critical the normal static and deterministic models. Here, so as to investigate the characteristics of a project's net present value (NPV), the income components that are (heavily) impacted by uncertainty are modeled, incorporating any correlation between these, mathematically reflecting their "random characteristics" [16]. Then, these results are combined in an exceedingly histogram of NPV (i.e. the project's probability distribution), and therefore the average NPV of the potential investment - further as its volatility and other sensitivities - is observed. This distribution allows, for instance, for an estimate of the probability that the project contains a net present value greater than zero (or the other value).

- In valuing an option on equity, the simulation generates several thousand possible (but random) price paths for the underlying share, with the associated exercise value (i.e. "payoff") of the choice for every path. These payoffs are then averaged and discounted to today, and this result's the worth of the choice today. Note that whereas equity options are more commonly valued using lattice based models, for path dependent exotic derivatives - like Asian options - simulation is that the valuation method most typically employed; see Monte Carlo methods for option pricing for discussion on further - and more complex - option modeling.
- To value fixed income instruments and rate derivatives the underlying source of uncertainty which is simulated is that the short rate - the annualized rate of interest at which an entity can borrow money for a given period of time; see Short-rate model. for instance, for bonds, and bond options [17], under each possible evolution of interest rates, a unique yield curve is observable and a unique resultant bond price. to see the bond value, these bond prices are then averaged; to value the bond option, as for equity options, the corresponding exercise values are averaged and present valued. an identical approach is employed in valuing swaps, swaptions, [18] and convertible bonds [19]. As for equity, for path dependent charge per unit derivatives - like CMOs - simulation is that the primary technique employed [20] (Note that "to create realistic charge per unit simulations" Multi-factor short-rate models are sometimes employed [21]).
- Monte Carlo Methods are used for portfolio evaluation. [22] Here, for every sample, the correlated behaviour of the factors impacting the component instruments is simulated over time, the resultant value of every instrument is calculated, and also the portfolio value is then observed. As for finance, above, the varied portfolio values are then combined in a very histogram, and therefore the statistical characteristics of the portfolio are observed, and also the portfolio assessed PRN. the same approach is employed in calculating value in danger,[23] [24] a far better known application of simulation to portfolios.
- Monte Carlo Methods are used for private financial planning. [25] [26]. as an example, by simulating the general market, the probabilities of with retirement on a target income will be calculated. As appropriate, the worker in question can then take greater risks with the retirement portfolio or start saving extra money.

- Discrete event simulation will be employed in evaluating a proposed capital investment's impact on existing operations. Here, a "current state" model is built. Once operating correctly, having been tested and validated against historical data, the simulation is altered to reflect the proposed capital investment. This "future state" model is then accustomed assess the investment, by evaluating the advance in performance (i.e. return) relative to the value (via histogram as above); it should even be employed in stress testing the look.

Although Monte Carlo methods provide flexibility, and might handle multiple sources of uncertainty, the employment of those techniques is nevertheless not always appropriate. In general, simulation methods are preferred to other valuation techniques only there are several state variables (i.e. several sources of uncertainty) [16]. These techniques are of limited use in valuing American style derivatives. See below.

II. Applicability

Level of complexity

Many problems in mathematical finance entail the computation of a selected integral (for instance the matter of finding the arbitrage-free value of a selected derivative). In many cases these integrals will be valued analytically, and in still more cases they will be valued using numerical integration, or computed employing a partial equation (PDE). However, when the amount of dimensions (or degrees of freedom) within the problem is large, PDEs and numerical integrals become intractable, and in these cases Monte Carlo methods often give better results.

For quite three or four state variables, formulae like Black–Scholes (i.e. analytic solutions) don't exist, while other numerical methods like the Binomial options pricing model and finite difference methods face several difficulties and aren't practical. In these cases, Monte Carlo methods converge to the answer more quickly than numerical methods, require less memory and are easier to program. for easier situations, however, simulation isn't the higher solution because it's very time-consuming and computationally intensive.

Monte Carlo methods can cater to derivatives which have path dependent payoffs during a fairly straightforward manner. On the opposite hand, Finite Difference (PDE) solvers struggle with path dependence.

In finance, the binomial model provides a numerical method for evaluating options. it had been first proposed by Cox, Ross and Rubinstein (1979). The model could be a discrete model for underlying dynamics. The evaluation of the choice is calculated by applying the risk-neutral probability that the discounted prices are martingales.

The binomial method, to value the choices, is widely used because it's able to take under consideration an oversized number of conditions that the appliance of other models isn't easy. This can be largely thanks to the very fact that the binomial

method takes under consideration changes within the underlying asset (unlike other methods that only take into consideration a set point).

For example, the binomial method is used for US options (these can be exercised at any time) and Bermudian options (these can be exercised at different times). The binomial method is more mathematically relatively simple and can be easily programmed into software (or possibly on a spreadsheet).

Although slower than the Black-Scholes method, the binomial method is considered more accurate, particularly for long-term options and dividend-paying security options. This is why there are several versions of the binomial model that are used by people working in the options market [27].

For options with multiple sources of uncertainty (for example real options) or for complex options (for example Asian options) the application of the binomial method in “tree” presents difficulties and is not practical. In these cases it is better to use the Monte-Carlo Method.

The Black-Scholes model is used to designate two very similar concepts: the Black-Scholes model or Black-Scholes-Merton model which is a mathematical model of the market for an action, in which the price of the action is a stochastic process in continuous time; as opposed to the «Cox Ross-Rubinstein model» which follows a stochastic process in discrete time (cf. stochastic processes are random time functions);
the partial differential equation of Black-Scholes which is the equation satisfied by the price of a derivative of a primitive.

The fundamental thesis of the Black and Scholes model was that the purchase option price is implicitly indicated if the underlying is traded on the markets.

The use of the Black-Scholes model and formula is widespread in financial markets, to the point that some quotations are based on volatility rather than absolute prices. Indeed, the other parameters of the model (maturity, strike price, risk-free interest rate and underlying price) are easily observable on the markets.

However, the Black and Scholes model does not accurately model the real world. Experience shows that volatility actually depends on the exercise price and maturity.

In practice, the volatility area (implied volatility based on the strike price and maturity) is not flat. Often, for a given maturity, the implied volatility relative to the exercise price has a form of smile (called the smile of volatility): at the currency, the implied volatility is the lowest and the further away from the currency, the higher it is.

Also is notable that the smile is often not symmetrical on the stock market: higher on the put side than on the call side. This is due to the fact that market participants are

more sensitive to the downside risk than to the upside risk.

For a given exercise price, the difference between the observed implied volatility and the currency volatility is called the skew.

The volatility surface of an underlying also changes over time. Market participants continually reassess it, modifying their anticipation of the probability, for each exercise price and maturity that an option will end in the current currency. [26]

III. Monte Carlo formalism:

The Monte-Carlo simulation method also makes it possible to introduce a statistical approach to risk into a financial decision. It involves isolating a number of key project variables, such as turnover or margin, and assigning them a probability distribution. For each of these factors, a large number of random draws are made in the probability distributions determined previously, in order to find the probability of occurrence of each of the results.

We have the expression of the mathematical hope of a function g of random variable X , resulting from the transfer theorem, according to which:

$$G = \mathbb{E}(g(X)) = \int g(x)f_X(x) dx$$

where f_X is a density function on the support $[a, b]$. It is common to take a uniform distribution on $[a, b]$:

$$f_X(x) = \frac{1}{b - a}$$

This can be extended to discrete probabilities by summing with a discrete ν measure, of the Dirac type.

The idea is to produce a sample (x_1, x_2, \dots, x_N) of the X -law (so based on the density f_X) on the support $[a, b]$, and to calculate a new estimator of the so-called Monte-Carlo G , from this sample.

The law of large numbers suggests to build this estimator from the empirical mean

$$\tilde{g}_N = \frac{1}{N} \sum_{i=1}^N g(x_i)$$

which happens to be, moreover, an unbiased estimator of mathematical hope. This is the Monte-Carlo estimator. We see that by replacing the sample with a set of values taken in the support of an integral, and of the function to be integrated, we can construct an approximation of its value, built statistically.

This estimate is unbiased in the sense that :

$$\mathbb{E}(\tilde{g}_N) = G = \mathbb{E}(g(X))$$

It is also necessary to quantify the accuracy of this estimate, via the variance of \tilde{g} . If the sample is assumed (x_1, x_2, \dots, x_N) , this variance is estimated using the empirical variance.

$$S_{g(X)}^2 = \frac{1}{N} \sum_{i=1}^N (g(x_i) - \tilde{g}_N)^2 \simeq \sigma_g^2$$

With:

$$\sigma_g^2 = \mathbb{E}(g^2(X)) - \mathbb{E}(g(X))^2 = \int_{\Omega} g^2(x) f_X(x) dx - G^2$$

By the central limit theorem, we know that the variable:

$$Z := \frac{\tilde{g}_N - G}{\sigma_g / \sqrt{N}} \sim \mathcal{N}(0; 1)$$

which is centered and reduced, follows approximately the normal centered reduced law, or Gauss law. Confidence intervals can then be built, which can be used to frame the error by replacing G with \tilde{g}_N . If this error is denoted e_n , then for a given risk level α we have:

$$|e_n| \leq z_{1-\alpha/2} \frac{\sigma_g}{\sqrt{N}}$$

with probability $1-\alpha$. The real $z_{1-\alpha/2}$ is the quantile of the reduced centered normal law. For example, at risk level $\alpha = 5\%$, we find in tables $z_{1-\alpha/2} = 1.96$. This method makes it possible to quantify the error committed, provided that σ_g is estimated by its empirical counterpart.

$$\hat{\sigma}_g = \sqrt{S_{g(X)}^2}$$

We thus see that the error is of the order of $N^{-1/2}$: for example, multiplying the sample size by 100 allows to divide by 10 the estimation error.

It should be noted that in practice σg is not known and must be estimated; as mentioned above, its empirical counterpart can be used. Various methods, known as variance reduction techniques, improve accuracy (or decrease calculation time) by replacing $g(X)$ with another random variable. These techniques generally fall into one of the following classes: preferential sampling, control variables, antithetic variable, stratification and conditioning.

IV. Probability of stock market performance:

Under the efficient market assumption, market performance is random and follows a standard law. Under these conditions, it's possible to form thousands of random draws to see the possibilities of achieving certain market performances within the future [27].

Monte Carlo methods for option pricing

In mathematical finance, a Monte Carlo option model uses random methods to calculate the worth of an option with multiple sources of uncertainty or with complicated features. The primary application to option pricing was by Phelim Boyle in 1977 (for European options). In 1996, M. Broadie and P. Glasserman showed the way to price Asian options by Monte Carlo. A vital development was the introduction in 1996 by Carriere of random methods for options early exercise features. [28]

- In terms of theory, option valuation relies on risk neutral valuation. [30] Here the worth of the choice is its discounted expected value; see risk neutrality and rational pricing. The technique applied then, is (1) to get an oversized number of possible, but random, price paths for the underlying (or underlyings) via simulation, and (2) to then calculate the associated exercise value (i.e. "payoff") of the choice for every path. (3) These payoffs are then averaged and (4) discounted to today. This result's the worth of the choice. [31]
- This approach, although relatively straight forward, allows for increasing complexity: An option on equity could also be modelled with one source of uncertainty: the value of the underlying stock in question. [31] Here the value of the underlying instrument S_t is sometimes modelled such it follows a geometrical Brownian motion with constant drift μ and volatility σ . So: $dS_t = \mu S_t dt + \sigma S_t dW_t$ where dW_t is found via a sampling from a traditional distribution; (further information under Black–Scholes). Since the underlying random process is that the same, for enough price paths, the worth of a call option here should be the identical as under Black Scholes. More generally though, simulation is used for path dependent exotic derivatives, like Asian options.
- In other cases, the source of uncertainty could also be at a remove. as an example, for bond options [32] the underlying could be a bond, but the source of uncertainty is that the annualized rate (i.e. the short rate). Here, for every randomly generated yield curve we observe a distinct resultant bond price on the option's exercise date; this bond price is then the input for the determination of the option's payoff. the identical approach is employed in

valuing swaptions, [33] where the worth of the underlying swap is additionally a function of the evolving charge per unit. (Whereas these options are more commonly valued using lattice based models, as above, for path dependent rate of interest derivatives – like CMOs – simulation is the primary technique employed. [34]) For the models used to simulate the interest-rate see further under Short-rate model; "to create realistic charge per unit simulations" Multi-factor short-rate models are sometimes employed. [35] to use simulation to IRDs, the analyst must first "calibrate" the model parameters, specified bond prices produced by the model best fit observed market prices.

- Monte Carlo Methods provide a compounding within the uncertainty. [36] for instance, where the underlying is denominated during a foreign currency, a further source of uncertainty are going to be the rate of exchange: the underlying price and also the exchange rate must be separately simulated and so combined to work out the worth of the underlying within the local currency. all told such models, correlation between the underlying sources of risk is additionally incorporated;. Further complications, like the impact of commodity prices or inflation on the underlying, also can be introduced. Since simulation can accommodate complex problems of this kind, it's often employed in analyzing real options [30] where management's decision at any point could be a function of multiple underlying variables.
- Simulation can similarly be used to value options where the payoff depends on the worth of multiple underlying assets [37] like a Basket option or Rainbow option. Here, correlation between asset returns is likewise incorporated. As required, Monte Carlo simulation will be used with any style of probability distribution, including changing distributions: the modeller isn't limited to normal or lognormal returns; [38] see for instance Datar–Mathews method for real option valuation. Additionally, the theoretical account of the underlying(s) could also be specified so as to exhibit jumps or mean reversion or both; this feature makes simulation the first valuation method applicable to energy derivatives.[39] Furthermore, some models even afford (randomly) varying statistical (and other) parameters of the sources of uncertainty. as an example, in models incorporating stochastic volatility, the volatility of the underlying changes with time.

V. Stochastic modeling

A stochastic model would be to line up a projection model which looks at one policy, a complete portfolio or a whole company. But instead of setting investment returns in line with their presumably estimate, as an example, the model uses random variations to seem at what investment conditions could be like.

Based on a collection of random variables, the experience of the policy/portfolio/company is projected, and therefore the outcome is noted. Then this can be done again with a brand new set of random variables. In fact, this process is repeated thousands of times.

At the end, a distribution of outcomes is offered which shows not only the foremost likely estimate but what ranges are reasonable too. the foremost likely estimate is given by the distribution curve's (formally called the Probability density function) center of mass which is usually also the height (mode) of the curve, but is also different e.g. for asymmetric distributions.

This is useful when a policy or fund provides a guarantee, e.g. a minimum investment return of fifty each year. A deterministic simulation, with varying scenarios for future investment return, doesn't provide a decent way of estimating the value of providing this guarantee. this is often because it doesn't give the volatility of investment returns in each future period of time or the possibility that an extreme event in a very particular fundamental measure results in an investment return but the guarantee. Stochastic modeling builds volatility and variability (randomness) into the simulation and so provides a more robust representation of reality from more angles.

Stochastic modeling (insurance)

As presented "Stochastic" means being or having a variant. A stochastic model may be a tool for estimating probability distributions of potential outcomes by with random variation in one or more inputs over time. The random variation is sometimes supported fluctuations observed in historical data for a specific period using standard time-series techniques. Distributions of potential outcomes are derived from an oversized number of simulations (stochastic projections) which reflect the random variation within the input(s).

Its application initially started in physics. it's now being applied in engineering, life sciences, social sciences, and finance valuation

Like any other company, an insurer must show that its assets exceeds its liabilities to be solvent, within the insurance industry, however, assets and liabilities aren't known entities. They rely upon what number policies lead to claims, inflation from now until the claim, investment returns during that period, and so on.

So the valuation of an insurer involves a group of projections, gazing what's expected to happen, and thus springing up with the most effective estimate for assets and liabilities, and thus for the company's level of solvency.

VI. Deterministic approach

The simplest way of doing this, and indeed the first method used, is to appear at the best estimates.

The projections in financial analysis usually use the foremost likely rate of claim, the foremost likely investment return, the foremost likely rate of inflation, and so on. The projections in engineering analysis usually use both the foremost likely rate and also the most important rate. The result provides some extent estimate - the simplest single estimate of what the company's current solvency position is, or multiple points of estimate - depends on the matter definition. Selection and identification of parameter values are frequently a challenge to less experienced analysts.

The downside of this approach is it doesn't fully cover the actual fact that there's a full range of possible outcomes and a few are more probable and a few are less.

Numerical evaluations of quantities

Stochastic models help to assess the interactions between variables, and are useful tools to numerically evaluate quantities, as they're usually implemented using town simulation techniques (see town method). While there's a plus here, in estimating quantities that will preferably be difficult to get using analytical methods, a drawback is that such methods are limited by computing resources likewise as simulation error.

Below are some examples:

Means

Using statistical notation, it's a widely known result that the mean of a function, f , of a variant X isn't necessarily the function of the mean of X .

For example, in application, applying the most effective estimate (defined because the mean) of investment returns to discount a collection of money flows won't necessarily give the identical result as assessing the simplest estimate to the discounted cash flows.

A stochastic model would be ready to assess this latter quantity with simulations.

Percentiles

This idea is seen again when one considers percentiles (see percentile). When assessing risks at specific percentiles, the factors that contribute to those levels are rarely at these percentiles themselves. Stochastic models is simulated to assess the percentiles of the aggregated distributions.

A stochastic model would be to set up a projection model which looks at a single policy, an entire portfolio or an entire company. But rather than setting investment returns according to their most likely estimate, for example, the model uses random variations to look at what investment conditions might be like.

Based on a set of random variables, the experience of the policy/portfolio/company is projected, and the outcome is noted. Then this is done again with a new set of random variables. In fact, this process is repeated thousands of times.

At the end, a distribution of outcomes is available which shows not only the most likely estimate but what ranges are reasonable too. The most likely estimate is given by the distribution curve's (formally known as the Probability density function) center of mass which is typically also the peak (mode) of the curve, but may be different e.g. for asymmetric distributions.

This is useful when a policy or fund provides a guarantee, e.g. a minimum investment return of fifty each year. A deterministic simulation, with varying scenarios for future investment return, doesn't provide a decent way of estimating the value of providing this guarantee. This can be because it doesn't leave the volatility of investment returns in each future fundamental quantity or the prospect that an extreme event during a particular fundamental measure ends up in an investment return but the guarantee. Stochastic modeling builds volatility and variability (randomness) into the simulation and so provides a more robust representation of real world from more angles.

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Its application initially started in physics. It's now being applied in engineering, life sciences, social sciences, and finance

Valuation:

Like any other company, an insurer needs to show that its assets exceeds its liabilities to be solvent. Within the insurance industry, however, assets and liabilities aren't known entities. They rely upon what percentage policies lead to claims, inflation from now until the claim, investment returns during that period, and so on. So the valuation of an insurer involves a group of projections, gazing what's expected to happen, and thus springing up with the most effective estimate for assets and liabilities, and thus for the company's level of solvency.

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Percentiles

This idea is seen again when one considers percentiles (see percentile). When assessing risks at specific percentiles, the factors that contribute to those levels are rarely at these percentiles themselves. Stochastic models will be simulated to assess the percentiles of the aggregated distributions.

Truncations and censors

Truncating and censoring of knowledge can even be estimated using stochastic models. as an example, applying a non-proportional reinsurance layer to the simplest estimate losses.

This is useful when a policy or fund provides a guarantee, e.g. a minimum investment return of 5% per annum. A deterministic simulation, with varying scenarios for future investment return, does not provide a good way of estimating the cost of providing this guarantee. This is because it does not allow for the volatility of investment returns in each future time period or the chance that an extreme event in a particular time period leads to an investment return less than the guarantee. Stochastic modeling builds volatility and variability (randomness) into the simulation and therefore provides a better representation of real life from more angles.

The claims model

The claims arising from policies or portfolios that the corporate has written may also be modeled using stochastic methods. this is often especially important within the

general insurance sector, where the claim severities can have high uncertainties.

Frequency-Severity models

Depending on the portfolios under investigation, a model can simulate all or a number of the subsequent factors stochastically:

- Number of claims
- Claim severities
- Timing of claims

Claims inflations are often applied, supported the inflation simulations that are in step with the outputs of the asset model, as are dependencies between the losses of various portfolios.

The relative uniqueness of the policy portfolios written by an organization within the general insurance sector implies that claims models are typically tailor-made.

Stochastic reserving models

Estimating future claims liabilities may also involve estimating the uncertainty round the estimates of claim reserves.

7. Corporate financial risk management:

In the finance sector worldwide, risk management is now emerging as major business opportunity for several reasons. One is that the structural increase in bankruptcies thanks to the recent recession hit at several leading countries. one more reason is that the improved competition between financial institutions worldwide has made the risk–return tradeoff from lending worse than ever. In recent years, interest margins or spreads, especially within the wholesale loan market, became very thin. Also from the regulations hidden within the banking sector,

Financial risk management

is the practice of protecting measure in an exceedingly firm by using financial instruments to manage exposure to risk: operational risk, credit risk and market risk, exchange risk, shape risk, volatility risk, liquidity risk, inflation risk, business risk, legal risk, reputational risk, sector risk etc. the same as general risk management, financial risk management requires identifying its sources, measuring it, and plans to handle them. **[40]**

Financial risk management is qualitative and quantitative. As a specialization of risk management, financial risk management focuses on when and the way to hedge using financial instruments to manage costly exposures to risk. **[41]**

In the banking sector worldwide, the Basel Accords are generally adopted by internationally active banks for tracking, reporting and exposing operational, credit and market risks. **[42] [43]**

Uses of economic risk management:

Finance theory (i.e., financial economics) prescribes that a firm should tackle a project if it increases shareholder value. Finance theory also shows that firm managers cannot create value for shareholders, also called its investors, by usurping projects that shareholders could do for themselves at the identical cost. [44]

When applied to financial risk management, this means that firm managers mustn't hedge risks that investors can hedge for themselves at the identical cost. This notion was captured by the so-called "hedging irrelevance proposition":[45] during a perfect market, the firm cannot create value by hedging a risk when the value of bearing that risk within the firm is that the same because the price of bearing it outside of the firm. In practice, financial markets aren't likely to be perfect markets. [46] [47] [48] [49] This suggests that firm managers likely have many opportunities to make value for shareholders using financial risk management, wherein they need to work out which risks are cheaper for the firm to manage than the shareholders. Market risks that end in unique risks for the firm are commonly the most effective candidates for financial risk management. [50]

The concepts of economic risk management change dramatically within the international realm. Multinational Corporations are faced with many alternative obstacles in overcoming these challenges. There has been some research on the risks firms must consider when operating in many countries, like the three sorts of interchange exposure for various future time horizons: transactions exposure, [51] accounting exposure, [52] and economic exposure. [53]

8. Operational risk management

The term operational risk management (ORM) is defined as a continuing cyclic process which incorporates risk assessment, risk higher cognitive process, and implementation of risk controls, which ends up in acceptance, mitigation, or avoidance of risk. ORM is that the oversight of operational risk, including the danger of loss resulting from inadequate or failed internal processes and systems; human factors; or external events. Unlike other kind of risks (market risk, credit risk, etc.) operational risk had rarely been considered strategically significant by senior management. [54]

Four principles

The U.S. Department of Defense summarizes the principles of ORM as follows: [55]

- Accept risk when benefits outweigh the value.
- Accept no unnecessary risk.
- Anticipate and manage risk by planning.
- Make risk decisions within the right time at the proper level.

- **Three levels:**

In Depth

In depth risk management is employed before a project is implemented, when there's many time to plan and prepare. samples of thorough methods include training, drafting instructions and requirements, and acquiring personal protective equipment.

Deliberate

Deliberate risk management is employed at routine periods through the implementation of a project or process. Examples include quality assurance, on-the-job training, safety briefs, performance reviews, and safety checks.

Time Critical

Time critical risk management is employed during operational exercises or execution of tasks. it's defined because the effective use of all available resources by individuals, crews, and teams to soundly and effectively accomplish the mission or task using risk management concepts when time and resources are limited. samples of tools used includes execution check-lists and alter management. this needs a high degree of situational awareness. [55]

Process

The world organization for Standardization defines the danger management process in an exceedingly four-step model: [56]

a. Establish context**b. Risk assessment**

- o Risk identification
- o Risk analysis
- o Risk evaluation

c. Risk treatment**d. Monitor and review**

This process is cyclic as any changes to true (such as operating environment or needs of the unit) requires re-evaluation per the 1st step.

The Link Between Time Critical and Deliberate



Deliberate

The U.S. Department of Defense summarizes the deliberate level of ORM process in a five-step model: [55]

- a. Identify hazards
- b. Assess hazards
- c. Make risk decisions
- d. Implement controls
- e. Supervise (and watch for changes)

Time critical

The U.S. Navy summarizes the time-critical risk management process in a very four-step model: [57]

Assess true.

The three conditions of the Assess step are task loading, additive conditions, and human factors.

- Task loading refers to the negative effect of increased tasking on performance of the tasks.
- Additive factors refers to having a situational awareness of the cumulative effect of variables (conditions, etc.).
- Human factors refers to the constraints of the flexibility of the organic structure and mind to adapt to the work environment (e.g. stress, fatigue, impairment, lapses of attention, confusion, and willful violations of regulations).

Balance your resources.

This refers to balancing resources in three different ways:

- Balancing resources and options available. this suggests evaluating and leveraging all the informational, labor, equipment, and material resources available.
- Balancing Resources verses hazards. this implies estimating how well prepared you're to securely accomplish a task and making a judgment call.
- Balancing individual verses team effort. this implies observing individual risk warning signs. It also means observing how well the team is communicating, knows the roles that every member is meant to play, and therefore the stress level and participation level of every team member.

Communicate risks and intentions.

- Communicate hazards and intentions.
- Communicate to the correct people.
- Use the correct communication style. Asking questions may be a technique to opening the lines of communication. a right away and forceful type of communication gets a selected result from a particular situation.

Do and debrief. (Take action and monitor for change.)

This is accomplished in three different phases:

- Mission Completion may be a point where the exercise is evaluated and reviewed fully.
- Execute and Gauge Risk involves managing change and risk while an exercise is current.
- Future Performance Improvements refers to preparing a "lessons learned" for the subsequent team that plans or executes a task.

Benefits

- a. Reduction of operational loss.**
- b. Lower compliance/auditing costs.**
- c. Early detection of unlawful activities.**
- d. Reduced exposure to future risks.**

Chief Operational Risk Officer

The role of the Chief Operational Risk Officer (CORO) continues to evolve and gain importance. Additionally to being chargeable for putting in a strong Operational Risk Management function at companies, the role also plays a vital part in increasing awareness of the advantages of sound operational risk management.

Most complex financial institutions have a Chief Operational Risk Officer. The position is additionally required for Banks that represent the Basel II Advanced Measurement Approach "mandatory" category.

9. Types of financial risks:

Market risk

The four standard market risk factors are equity risk, rate of interest risk, currency risk, and commodity risk:

Equity risk is that the danger that stock prices generally (not related to a particular company or industry) or the implied volatility will change. When it involves long-term investing, equities provide a return which is able to hopefully exceed the danger free rate of return [58] The difference between return and also the innocuous rate is assumed because the equity risk premium. When investing in equity, it's said that higher risk provides higher returns. Hypothetically, an investor are compensated for bearing more risk and thus will have more incentive to require a foothold in riskier stock. a serious portion of high risk/ high return investments come from emerging markets that are perceived as volatile.

Interest rate risk is that the chance that interest rates or the implied volatility will change. The change in market rates and their impact on the probability of a bank, end in rate of interest risk. [59] rate of interest risk can affect the financial position of a bank and may create unfavorable financial results. [59]The potential for the speed to vary at any given time can have either positive or negative effects for the bank and thus the patron. If a bank gives out a 30-year mortgage at a rate of 4% and also the charge per unit rises to 6, the bank loses and also the patron wins. this can be often an opportunity cost for the bank and a reason why the bank can be affected financially.

Currency risk is that the chance that interchange rates or the implied volatility will change, which affects, as an example, the price of an asset held during this currency. Currency fluctuations within the marketplace can have a drastic impact on a world firm's value because of the value effect on domestic and foreign goods, additionally because the worth of foreign currency denominates assets and liabilities. [60] When

a currency appreciates or depreciates, a firm is often at risk wishing on where they're operating and what currency denominations they're holding. The fluctuation in currency markets can have effects on both the imports and exports of a world firm. for example, if the euro depreciates against the dollar, the U.S. exporters take a loss while the U.S. importers gain. this can be actually because it takes less dollars to buy for a euro and contrariwise, meaning the U.S. wants to buy for goods and also the EU is willing to sell them; it's too expensive for the EU to import from U.S. at this time. Commodity risk is that the chance that commodity prices (e.g. corn, copper, crude oil) or implied volatility will change. there's an excessive amount of variation between the number of risks producers and consumers of commodities face so on own a helpful framework or guide. **[61]**

Model risk

Financial risk measurement, pricing of economic instruments, and portfolio selection are all supported statistical models. If the model is wrong, risk numbers, prices, or optimal portfolios are wrong. Model risk quantifies the results of using the inaccurate models in risk measurement, pricing, or portfolio selection.

The main element of a statistical model in finance may well be a risk factor distribution. Recent papers treat the factor distribution as unknown variable quantity and measuring risk of model misspecification. Jokhadze and Schmidt (2018) propose practical model risk measurement framework. **[62]** They introduce superposed risk measures that incorporate model risk and enables consistent market and model risk management. Further, they provide axioms of model risk measures and define several practical samples of superposed model risk measures within the context of economic risk management and contingent claim pricing.

Credit risk

Credit risk management is also a profession that focuses on reducing and preventing losses by understanding and measuring the probability of those losses. Credit risk management is utilized by banks, credit lenders, and other financial institutions to mitigate losses primarily associated with nonpayment of loans. A credit risk occurs when there's potential that a borrower may default or miss on an obligation as stated in an exceedingly very contract between the establishment and also the borrower. Attaining good customer data may be a necessary factor for managing credit risk. Gathering the right information and building the proper relationships with the chosen

customer base is crucial for business risk strategy. so on spot potential issues and risks that may arise within the long run, analyzing financial and nonfinancial information regarding the customer is critical. Risks like that in business, industry of investment, and management risks are to be evaluated. Credit risk management evaluates the company's financial statements and analyzes the company's deciding when it involves financial choices. Furthermore, credit risks management analyzes where and therefore the way the loan are utilized and when the expected repayment of the loan is additionally because the explanation behind the company's must borrow the loan.

Expected Loss (EL) may be an idea used for Credit Risk Management to measure the common potential rate of losses that a company accounts for over a particular period of some time. The expected credit loss is formulated using the formula: $\text{Expected Loss} = \text{Expected Exposure} \times \text{Expected Default} \times \text{Expected Severity}$ Expected Exposure refers to exposure expected during the credit event. Some factors impacting expected exposure include expected future events and also the sort of credit transaction. Expected Default can be a risk calculated for the amount of times a default will likely occur from the borrower. Expected Severity refers to the total cost incurred within the event a default occurs. This total loss includes loan principle and interests. Unlike Expected Loss, organizations have to hold capital for Unexpected Losses. Unexpected Losses represent losses where an organization will should predict a mean rate of loss. it's considered the foremost critical variety of losses because it represents the instability and unpredictability of true losses which can be encountered at a given timeframe. [63] [64] [65]

Liquidity risk

This is the risk that a given security or asset cannot be traded quickly enough in the market to prevent a loss (or make the required profit). There are two types of liquidity risk:

- **Asset liquidity** – An asset cannot be sold due to lack of liquidity in the market – essentially a sub-set of market risk. This can be accounted for by:
 - Widening bid-offer spread
 - Making explicit liquidity reserves
 - Lengthening holding period for VaR calculations
- **Funding liquidity** – Risk that liabilities:
 - Cannot be met when they fall due
 - Can only be met at an uneconomic price

- Can be name-specific or systemic

Operational risk

Operational risk means the risk that a company or individual has to face due their own operation and decisions made for the investment (more detailed above).

Example:

Fuel price risk management, a specialization of both financial risk management and oil price analysis and similar to conventional risk management practice, is a continual cyclic process that includes risk assessment, risk decision making and the implementation of risk controls. It focuses primarily on when and how an organization can best hedge against exposure to fuel price volatility. It is generally referred to as "bunker hedging" in marine and shipping contexts and "fuel hedging" in aviation and trucking contexts.

Fuel price risk management services are predominantly provided by specialist teams within fuel management companies, oil companies, financial institutions, utilities and trading companies.

10. The fuel price risk management process:

Similar to conventional risk management practice, [66] fuel price risk management is considered a continual cyclic process that includes the following:

a) Establishing the context

current and future business environment

financial position and budgets

objectives and needs

required fuel consumption, etc.

b) Risk assessment

fuel cost calculations

risk identification

the organization's attitude to risk

exposure analysis to fuel price fluctuations

scenarios of various hedging strategies

c) Risk treatment

Implementation of a fuel price risk strategy

d) Monitor and review

An alternative to the above described process is the following: **[67]**

- 1 Identify, analyze and quantify the fuel related risks
- 2 Determine tolerance for risk and develop a fuel price risk management policy
- 3 Develop fuel price risk management implementation strategies
- 4 Establish controls and procedures
- 5 Initial implementation of fuel price risk management strategies
- 6 Monitor, analyze and reporting
- 7 Repeat the process on as needed basis

VII. Forecasting the CO2 emissions impact after the health crisis: Priorities for a sustainable development model:

Policies for the ecological transition are at the forefront: because the impact of the Covid-19 pandemic on our societies has its origin in the human relationship with nature;-and because the realization of such an event is opposed to sustainable development. Indeed, at the origin of the concept of sustainable development is the recognition, that we must prevent the environmental and social risks to which our societies are exposed, whose potential impacts are long-term and large-scale. In order to achieve sustainable growth, regulations and public policies addressing market failures in these areas are necessary, offsetting the short-term biases of economic agents and making all the more responsible. If the magnitude of the shock experienced at the beginning of the year is conducive to an awareness in this respect, the economic and social emergency following the confinement may nevertheless lead to: once again, to sacrifice the long-term stakes in the end of the crisis. This leads to the two main questions posed by the mission letter:

- **How to anticipate and prepare the exit from the crisis to avoid this pitfall?**
- **What is the status of the European carbon market?**

1. Lessons to be learned from the crisis:

The health crisis is prompting a fundamental rethinking of the priorities of public action. As the report of the High Council for Climate Change of 21 April 2020 points out, the enlightenment of scientists is essential because the political decision is today, even more than yesterday, faced with complex issues and uncertainties. Anticipating and preparing for long-term risks, building resilience strategies require building on the best state of the art of knowledge, such as those produced by the IPCC for climate or, It is also important to ensure that research is mobilized to match the challenges that remain.

The scientific work is sometimes contradictory or too fragmentary on new topics. But the vivacity of expert debate is also a symptom of the health of the scientific debate, since knowledge is the result of open and uncompromising discussions on the interpretation of the facts, themselves established with varying degrees of precision. On the other hand, it is important to improve the communication of scientific results and to make them more suitable for public decision making, without masking uncertainties. This must not lead to relativism, the need to reconstruct the interface between scientific knowledge of all kinds and political decision-making, and the need to strengthen research relevant to public policy design, are therefore two first lessons. The need for scientific expertise emerges from time to time as soon as its origin is considered. Indeed, the pandemic is not “attributable” to climate change and humans have been confronted with zoonoses since the Neolithic era. Certainly, the globalization of trade has changed the potential impacts of its contact with animal pathogens. But are we able to feed 8 billion people by eliminating international trade? The issues raised by confinement also highlighted the extent to which the trade-offs between health, economic and social issues needed to be approached modestly. Recognizing this complexity, however, does not prevent us from seeing that this crisis constitutes a major warning: we were not well prepared to suffer such a shock because we did not anticipate the emerging risks sufficiently, whether they were health risks, More specifically, the COVID-19 pandemic reminded us of the importance of health issues at the interface between humans, animals and the environment: almost two-thirds of human infectious diseases come from pathogens shared with wild or domestic animals; and the number of infectious outbreaks continues to grow.

In terms of the collapse of biodiversity, the circular economy, the health impacts of diffuse pollution, the health and environmental impacts of diets, the very qualification of the issues or the awareness of them-In the Netherlands, the Netherlands and the United Kingdom, the Netherlands and the United Kingdom are still more recent.

2. European Perspectives for green investment

Europe is directly involved at both levels, because the coordination of policies to revive activity and its financing is desirable, and because the harmonization of policies for ecological transition is necessary for public goods with a global dimension, especially when it is necessary to avoid distortions of competition. In addition, the evolution of agriculture, structured by changes in the common agricultural policy and trade agreements, is of major importance for the ecological transition. The European Green Pact, which puts the achievement of the carbon neutrality target in 2050 at the forefront, is therefore a unique opportunity. However, the ability to maintain this priority while economic and social emergencies have accumulated as a result of the health crisis is a major challenge and challenge for Europe, which must now build new solidarity, The European Green Pact must therefore be adopted to ensure its success and make it, in particular, the backbone of French climate policy. In this regard, a reformed European Emission Allowance System (ETS) is crucial to introducing the truth of ecological prices in Europe and France. Although the 2018 reform has improved the efficiency of the ETS, it is nevertheless urgent to continue consolidating it, by introducing mechanisms to protect our competitiveness vis-à-vis the extra-European (so-called carbon inclusion measures) and a price floor. Indeed, the success of the European Green Pact and a green recovery plan will not be possible without an effective and credible European carbon price, whereas, as it stands, the ETS covers only a limited number of sectors, The further strengthening of the European market (ETS) and its extension, at least to all sectors where national carbon pricing is a competitive barrier and, ideally, to all emissions, should therefore be the compass for European action in the short and long term. It is also in this way that the European example will be able to convince and thus contribute to the strengthening of international action.

3. How can we not sacrifice the ecological transition after the crisis?

EU must decarbonize the economy. It will be a long-term effort that requires a lot of investment, and it must be started immediately because we are slow to curb greenhouse gas emissions, particularly in energy-using sectors and agriculture. In these circumstances, a postponement of the effort to decarbonize the economy at the time of the resumption of activity could not be «corrected» later on would therefore be very costly for society. Whatever the post-crisis scenario.

Investing in the decarbonization of the economy and in climate change adaptation and biodiversity protection is therefore desirable. The exit from the crisis will also

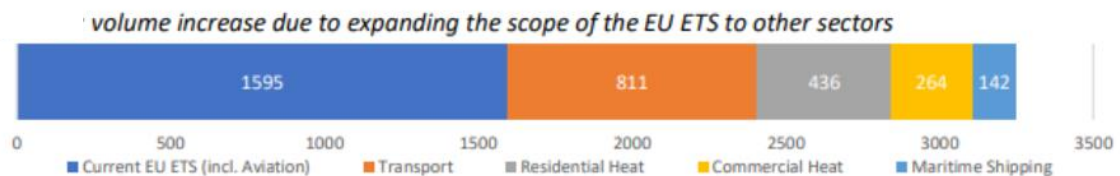
require strong public support for the activity, so the recovery plans are an opportunity to accelerate green investment. This is well recognized in European Commission projects and at national level. However, in a context of support for economic activity where, despite the easing of budgetary constraints, the needs will be immense, the proposed measures in the field of ecological transition will have to go through a double-fold. Effectiveness test: -in relation to their long-term effectiveness, to ensure that they do not exclude more useful measures. For emission reduction policies, the indicators for this are 'net costs per tone of carbon avoided'; -and their short-term impact on recovery, which implies mature projects, mobilizing available production capacity without the risk of bottlenecks. With this in mind, a number of recent reports have examined the lessons to be drawn from the recovery plans implemented to emerge from the 2008-09 financial crisis as regards the effectiveness of green fiscal measures. Although estimates of their macroeconomic impacts remain fragile, they argue in their favour, both in terms of short-term efficiency to boost activity, and to increase economic and societal returns on public spending. However, the value of the multiplier effects and the value of the return on investment appear to vary considerably depending on the type of investment made. -construction of low-emitting infrastructure (bicycles, public transport, charging networks, electricity networks to support the intermittence of renewable sources, public spaces...

4. The status of the European carbon market:

Although the 2018 reform has improved the efficiency of the European ETS system since 2019, it is nevertheless urgent to continue consolidating it to meet future challenges: Decarbonize and accelerate the transition to climate neutrality in a context of strong economic recession in 2020. Although showing a positive outcome in 2019, the strengthening of the ETS system presents (always) strong economic justifications: it concerns only a limited number of sectors, it signals insufficient price to reflect long-term European climate ambition and lacks the ability to be based on a short-term instrument to address a structural problem, which does not sufficiently inform the investment decisions of economic actors. From now on, the consolidation of this ETS system must be conducted in line with the political agenda for the implementation of the European Green Pact and the recovery plan. The success of the European Green Pact and a green recovery plan cannot be achieved without an effective and credible European carbon price. Indeed, the current economic crisis is expected to increase the quota surplus, due to the reduction in CO₂ emissions in 2020, and reduce the efficiency of the ETS with a lower expected carbon price. If the strategy to strengthen the ETS is to gradually align its emission cap with the ambition of carbon neutrality, it could also extend its scope and introduce a floor price, to make the ETS an “engine”.

Decarbonization in sectors where ETS would be the main policy and a 'safety net' in sectors where EU ETS would be a complementary policy. The European carbon

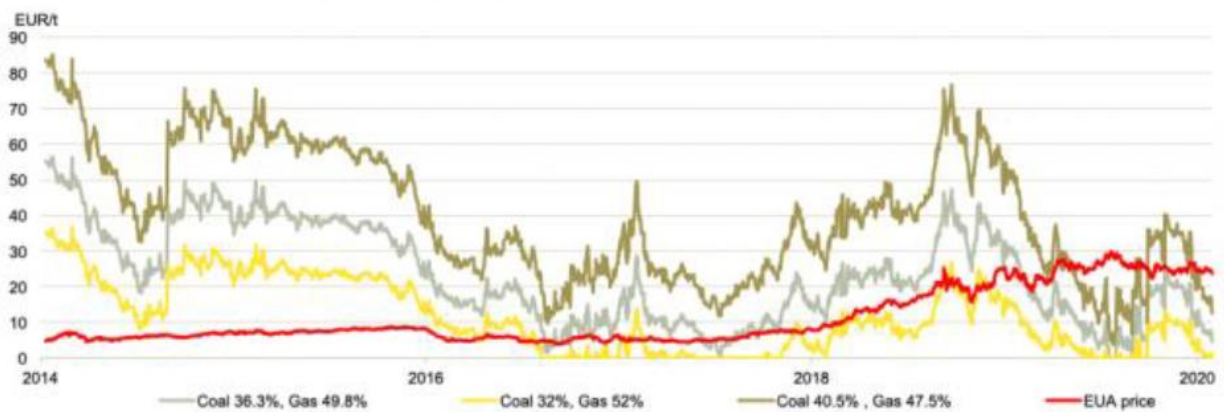
market (ETS) operates on the principle of cap and trade, with a global cap on emissions (cap) and the possibility for industrialists to exchange the quotas allocated when they have too much or not enough (trade). About 13,000 industrial sites in Europe, accounting for half of the area's CO₂ emissions, are affected by this mechanism (see diagram below).



Source: ERCST and BloombergNEF, data from the European Commission

Each year, ERCST, Wegener Center, ICIS, **I4CE** and **EcoAct35**, jointly produce an independent report on the status of HTA. While previous editions were marked by disappointments and questions about Europe's ability to put this instrument back on its feet, the 2019 edition showed that the ETS had regained its credibility. Following the 2018 reform implementing the "Market Stability Reserve (MSR)": thanks to this system, its price rose to around € 20-25/tCO₂, to a level unparalleled for eleven years. In fact, after 15 years of existence, this mechanism designed to limit greenhouse gas emissions generated by industrial activity in the region is working more as it was imagined, with the revision of its Phase 4 Directive (2021-2030), Emissions from the sectors covered by the ETS had decreased by 4% in 2018, almost twice as fast as the emission ceiling, the highest decrease since 2014; the sectors for which data are available show annual improvements in carbon intensity. price for economically efficient decarbonization by giving operators greater visibility on the future carbon constraint. With a CO₂ price in the range of €18/tCO₂ to €29/tCO₂, the EU ETS revealed in 2019 a carbon price level never seen in nearly a decade. In this context, CO₂ emissions from the EU ETS fell by 8.9% in 2019, a record decline since 2009, four times faster than the ceiling. In 2019, rising prices led to a historic decline in coal-based electricity generation, as the price of ETS steers coal-gas trade-offs in the electricity sector and the results are being felt. the price of CO₂ in the ETS is durably higher than the minimum price incentive to switch fuel - 'fuel-switching' between gas-fired coal plants -(cf. diagram).

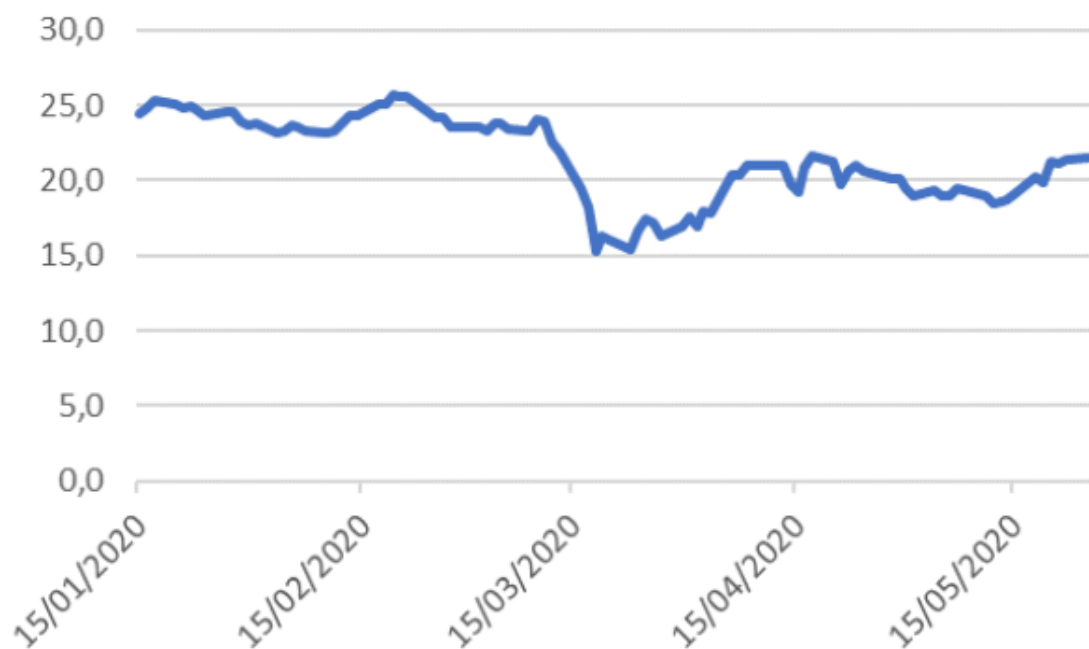
Switching price for different thermal efficiencies, compared to the EUA price



Source: BloombergLP, BloombergNEF

This found robustness was confirmed during the health crisis, which did not have a measured effect on the price of ETS, after a transitional fall in prices in mid-March.

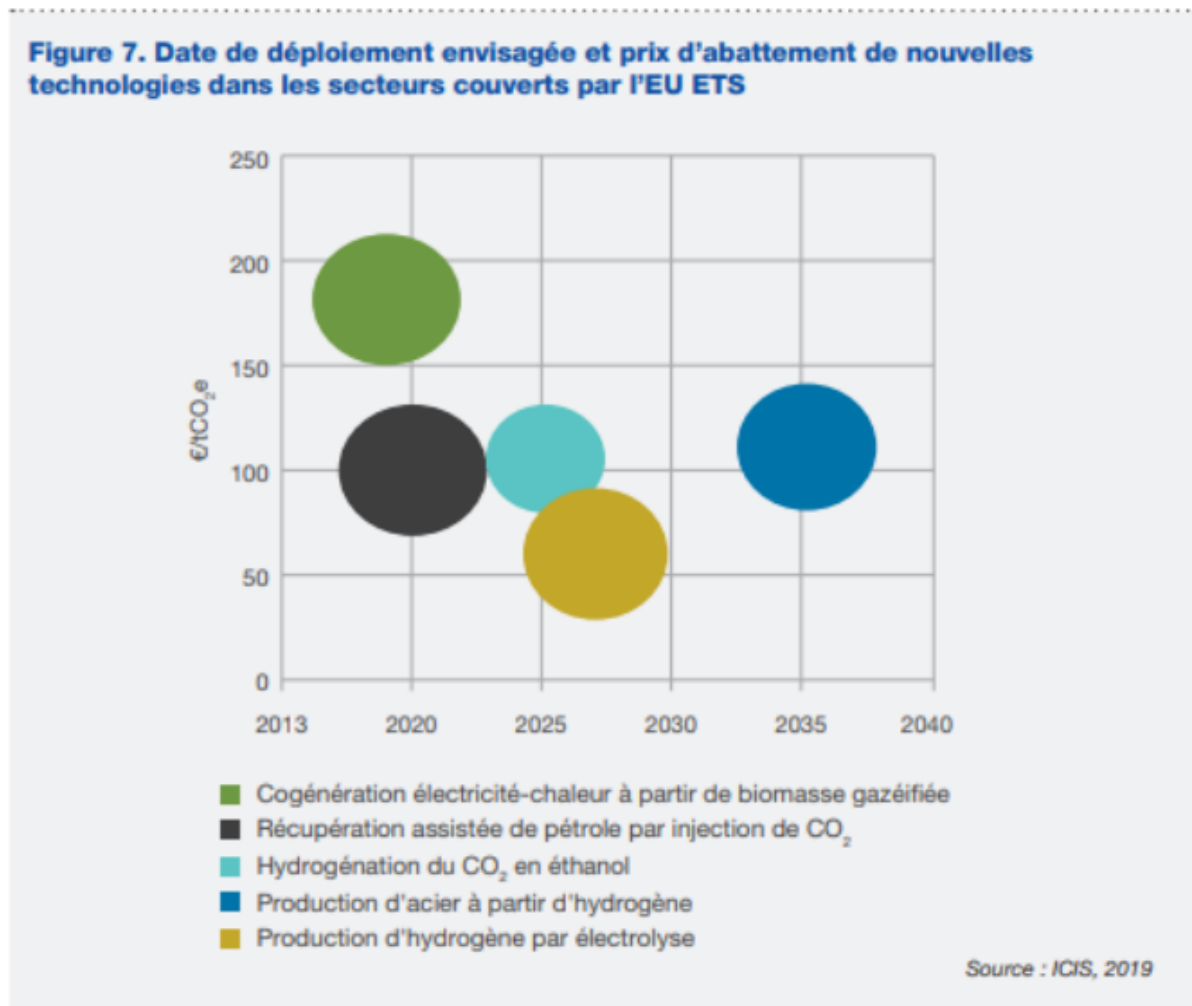
Prix de l'EU ETS (€/tCO2)



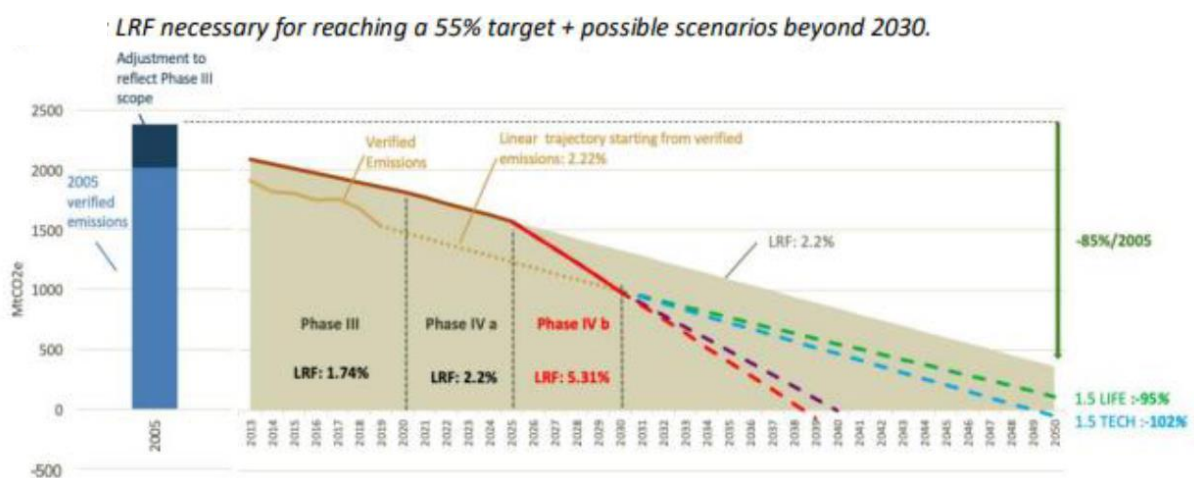
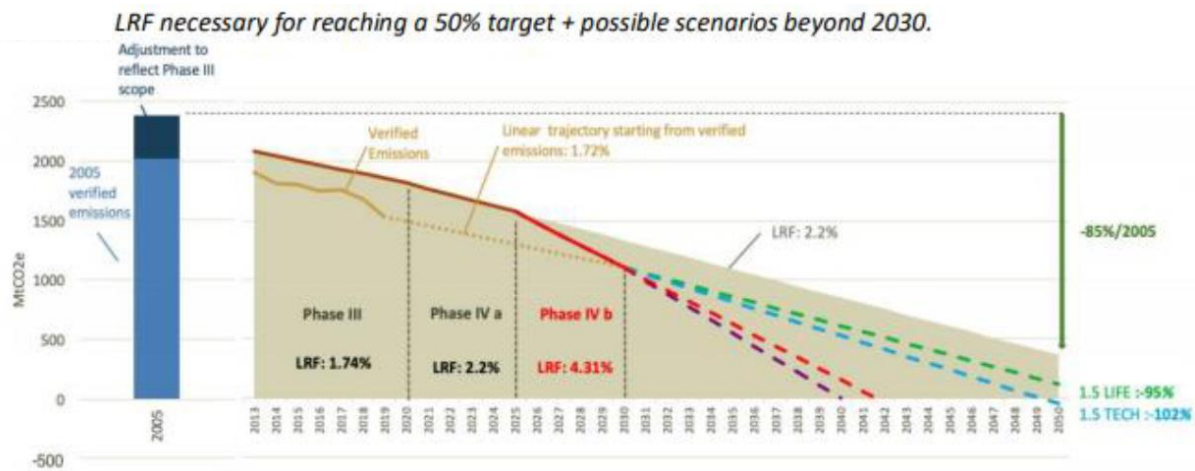
Source : EEX

However, the current economic crisis confirms the weaknesses of the ETS, which were only partially resolved by the 2018 reform. Indeed, because of its impact on emissions, the crisis will generate a new quota surplus, while the surplus accumulated since 2009 is still not resolved. In order to avoid the risk of a further depreciation of its price and contain the risks of volatility, a strengthening of the parameters of the MSR during the review scheduled for 2021 is therefore necessary.

EU ETS price levels have never been high enough for manufacturers to have enough confidence to invest in low-carbon energy (see diagram below).



Thus, the price on ETS remains far from being in line with the net «zero emissions» target, which is that of the European Green Pact. The increase in the 2030 emission reduction target to 50% or 55% compared to 1990 therefore requires a significant tightening of the «course» and the continuation of reforms to ensure the effectiveness of this instrument. The report published in 2020 explores different possible reinforcement scenarios (cf. diagrams).



Source: ERCST

5. EU ETS environmental efficiency

EU ETS CO₂ emissions decreased by 8.9% in 2019. More specifically, they decreased by 13.9% in the electricity sector, while they were reduced by only 1.8% in industry.

- In 2019, CO₂ emissions fell almost four times faster than required by regulation by meeting the emissions cap, compared to twice as fast in 2018, the highest decline since 2009.
- This decrease can be attributed to the substitution of coal fuels by gas in the electricity sector, under the influence of a higher carbon price combined with historically low gas prices; a continued penetration of renewable energy into the EU's energy mix, and finally at relatively hot temperatures that have limited energy demand.

- Sectors for which data are available have shown limited annual carbon intensity improvements, such as glass, metals, refining and paper sectors with a largely stable trend during Phase 3. •EU ETS has achieved its 2020 emission reduction target by 2014. However, there remains significant uncertainty on 2020 emissions due to COVID-19: official figures from the European Environment Agency (EEA) show that at the end of 2018, Emissions from fixed facilities were already 29% lower than in 2005. Official EEA data are not yet available for 2019. In a COVID-19 scenario, EU ETS CO₂ emissions could be reduced by 20% in 2020, with a 95% recovery starting in 2021.
- Beyond 2020, the EU ETS target of -43% CO₂ emissions by 2030 would not be sufficient for the EU to achieve its long-term climate ambition of carbon neutrality by 2050, with several review scenarios to be considered in 2020.

6. Economic efficiency

For 2019, the European Carbon Price (EUA) was higher than the minimum incentive price for the substitution of electricity-generating fuels between low- and medium-efficiency coal and gas-fired power plants. In addition, for part of the year, the EUA price was higher than the minimum price incentive to switch from coal to gas for high efficiency power plants. Thus, much of the electricity sector's CO₂ emissions reductions in 2019 can be attributed to this 'coal-gas' substitution, confirming the efficiency of the EUA's high price.

- The market sentiment survey showed increased confidence that the EU ETS provides a stable and predictable framework for an investment signal.
- In terms of protecting industrial sectors at risk of carbon leakage, 2019 was the third consecutive year that all industrial facilities had a net direct cost of 2,5% of their CO₂ emissions receiving a free allocation covering 97.5% of their emissions, compared to 96.8% in 2018 and 98.8% in 2017.
- In terms of auction revenue in 2019, auction volume decreased due to the start of the market stability reserve (which absorbed 397 million allowances) and the fact that any quota has been auctioned. With the increase in the price of the quota, total auction revenues amounted to €14.6 billion in 2019, compared to €14.2 billion in 2018. Member States declare that they have spent 80 % of their auctioning revenues for climate and energy purposes for the period 2013-2018.

VIII. Conclusion

Implications of the Green Deal and its 2050 carbon neutrality target for the EU ETS: the increase of the 2030 and 2050 climate target, the border carbon tax, the integration of new sectors in the EU ETS are among the issues to be examined in 2020.

- Consequences of COVID-19 on the EU ETS: in 2020, Europe will experience a deep recession due to the severe economic consequences of the coronavirus health crisis. The major challenge for the European Commission will be to demonstrate the ability of this European carbon market to pursue its objectives to support and contribute to the recovery towards a greener European economy.

- EU ETS developments to follow: Brexit and the definition of the UK's future carbon pricing scheme (UK ETS linked to EU ETS ?), the implementation of CORSIA within the EU ETS and the revision of the market stability reserve are among the challenges to be followed in 2020.

products that are more polluting on the second-hand market («Gruenspecht» effect»); and are only just a carbon tax. In addition, it should be noted that the diffuse sectors include, in particular in transport, activities for which the stakes of competition are very high, as for the road transport of goods, This leads national mitigation policies to exempt them from any effort when they are significant emitters of CO₂. Finally, the architecture of mitigation policies is fragmented, with no consistency between the efforts requested in the SWE sector and in diffuse sectors, and with dilemmas between equity and efficiency poorly resolved to allocate the ESR quota, any policy aimed at maintaining a global emissions quota is confronted with an acute conflict in order to allocate it between:

The objective of achieving the reductions where they are least costly; -and that of fairly allocating the cost of efforts in order to reconcile the two objectives, an instrument of flexibility must be introduced to allow efforts to be reallocated between countries, against compensation. each time, very complicated given: the relatively high costs of efforts requested from countries that are already emitting little; and the very strong opposition of countries with the most significant reduction potential to any increase in the overall target, However, they have to bear disproportionate costs since they concentrate the fields to be mobilized as a priority (coal extraction, in particular). The repetition of this negotiation also leads to wait-and-see.

Promises and conditions for success of the European Green Pact:

The Commission's "von der Leyen" perspective of structuring European action around a global "Green Deal" is an opportunity not to be missed to respond to the ecological emergency. Its project is structured along four axes: -the setting of objectives and framework measures. This is the purpose of the climate law, which aims to make them binding. In this area, the critical step will be the definition, which should take place in September 2020, of new targets by 2030 and their declination by country, the overall target going from -40% currently to -50% or -55%.

The Commission will then be able to monitor its application in a manner comparable to that existing in the budgetary field, with, in particular, the issuing of recommendations to States in default. The five-year monitoring process would start in 2023. The idea of the Commission is then, for the period 2030-2050, to be able to adjust the trajectory by simple delegated acts; -the investment plan for the Green Pact, corresponding to an additional effort estimated by the Commission in a range of between €175 and €290 billion per year. The implementation of the «Just Transition Fund» also aims to facilitate the transition for the most affected regions and sectors, In the first place, coal-related measures;

The reform of the main existing mitigation instruments; (ETS and ESR quota market; regulations on land use and forestry, energy efficiency and renewable, vehicle emission standards...). Proposals in this area, which will be established to ensure the achievement of the new 2030 targets, are announced by June 2021. The establishment of a border adjustment mechanism to prevent this increased effort from weighing on European competitiveness would go hand in hand,

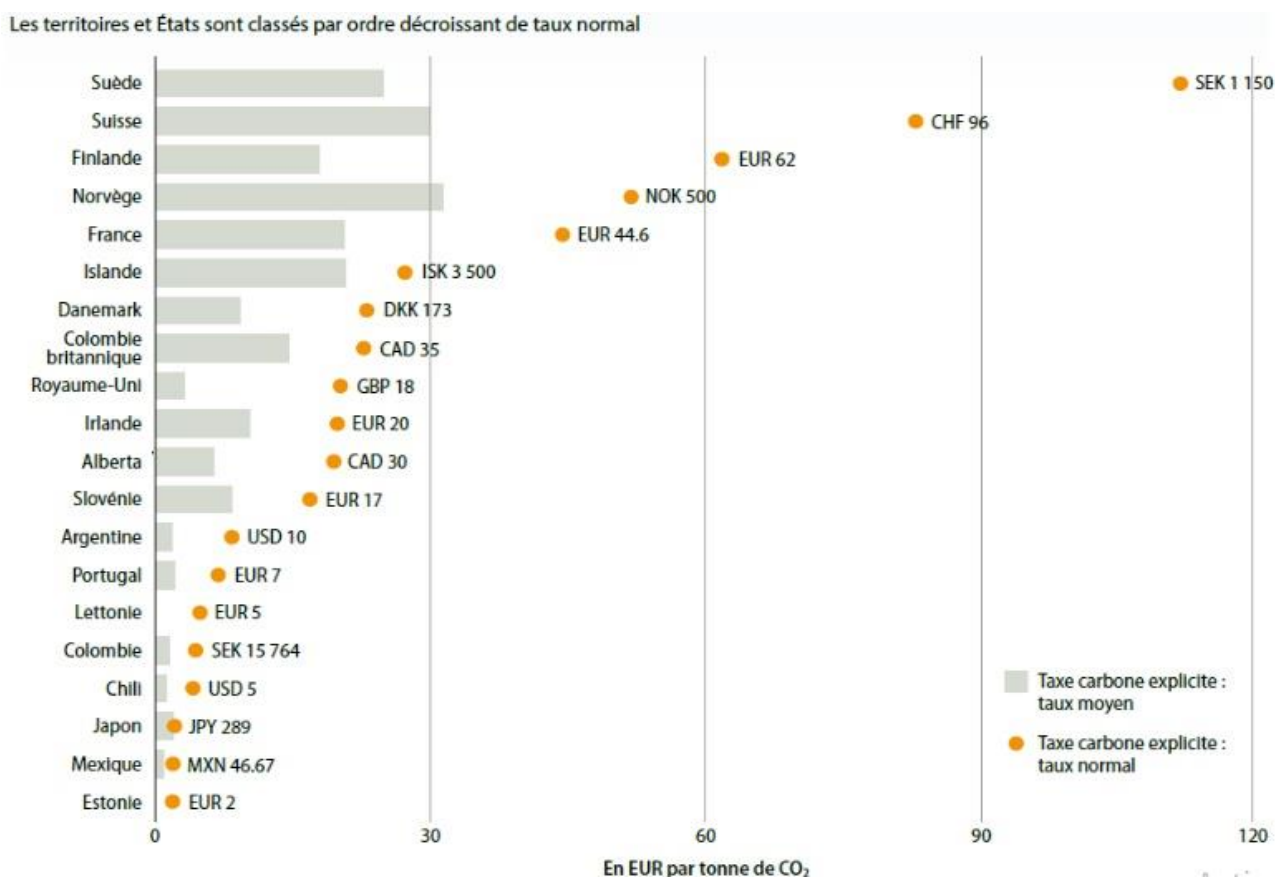
The progressive coherence and alignment of the objectives of all European Union programs and policies, so as to integrate carbon neutrality and the constraints of adaptation to climate change, The proposed strengthening of the European level is questioned indirectly by those who question the possibility of the Commission being given the desired prerogatives. Others question the choice of the supervisory mechanism, as the Commission may find itself at the forefront of national debates, while the latter could mobilize other instruments: Rather than transposing existing fiscal mechanisms into the climate, should we not rather be inspired by what has been done for monetary policy with the ECB? In terms of economic principles.

In terms of economic principles, there is no debate about the need to strengthen the European level of climate policy. Climate risk mitigation is a "global public good," efforts to reduce emissions that benefit everyone regardless of their location. The consequence is that everyone has an interest in relying on the efforts of others, and has little, if any, interest in taking action, since the associated abatement costs do not provide any significant return to the person who commits them. To deal with such a problem, it would ideally be necessary to have a mitigation policy defined by a «World Authority», without any loophole. Unfortunately, it does not exist. The aim of

international cooperation is to supplement, but with difficulty, the concern to involve all countries, resulting in very inadequate levels of ambition. There is an interest in defining mitigation policies at the highest possible institutional level. In this respect, the European lever should naturally be favored over the national level. Thus, intra-European distortions of competition can be avoided. With regard to extra-European competitiveness issues, carbon inclusion mechanisms are indeed necessary if our climate ambition is significantly higher than that of our trading partners, to ensure that European industry is not penalized in relation to more polluting products, both on the import side and on the export side. The design of these devices must anticipate their compatibility with WTO rules and threats of retaliation. Since the commitment of -40% was made without conditions; it is likely that their implementation will only apply to a strengthening of efforts, with a level of carbon inclusion referring to the effective price on ETS. Indeed, Europe will not be able to defend these adjustments at the WTO on the basis of a non-discriminatory «level playing field». In addition, they should be designed to foster greater collective ambition and not only to enable Europe to pursue its own ambitious targets, with less than 10% of CO₂ global emissions.

Carbon pricing Strengthening the European level is not an objective in itself: the objective is to enable more ambitious and effective climate policies. With this in mind, the Economic Analysis Council and the German Council of Economic Experts had drawn up a joint proposal "A Single Price for Carbon for the Single Market⁴⁰". It pointed out that a single carbon price within the EU would be more effective in achieving the targets set in the Paris Agreement than a set of different national measures. Due to the free movement of goods and services within the single market, a single carbon price would also prevent carbon leakage and distortions of competition within the EU. If necessary to reach an agreement, a redistribution of funds between countries could be part of the shared effort to extend the carbon price to all Member States to regulate emission allowance trading (ETS) in other sectors. The European Commission and Member States are encouraged to take this path, in particular because a homogeneous treatment of CO₂ emissions would be an important element in the completion of the European single market. Furthermore, it was stressed that the implementation of such a uniform carbon price will necessarily have redistributive impacts between and within Member States. The former must be dealt with at European level. Specifically, the initial issuance of certificates could favor poorer and historically more carbon-intensive countries to facilitate their transition. In addition, EU regional and structural funds could provide additional support for low-emission investments. Redistributive impacts within countries can best be addressed at the national level. Suggestion that a significant share of national revenues collected through carbon pricing be returned to households and businesses in order to increase public acceptance and limit the effects of loss of purchasing power, while preserving incentives for behavioural change. As regards the criteria for redistribution to households, the geographical situation and the level of income are two parameters that Member States could take into account. ' The rise of

green investment and, more generally, the achievement of a "climate-neutral Europe", require an effective carbon price, giving private profitability to the reduction of emissions. In this respect, the establishment of the Market stability reserve requires effective carbon pricing, giving private profitability to emissions reduction. In this respect, the establishment of the Market Stability Reserve was a major step forward for the ETS, but it has not yet been possible, for example, to establish a price floor mechanism, which is very useful and effective where it has been implemented. Moreover, the expansion of the ETS is a priority to fill the existing 'holes' in carbon pricing. These are highlighted by OECD (carbon pricing gaps) reviews, which show that the differences between nominal and effective carbon pricing affect the same sectors in all European countries, the critical sectors in transport and agriculture; suggesting the inability of national frameworks to address them, due to the associated competitive problems.



European Central Carbon Bank?

Drawing lessons from the ECB's success and recalling that the performance of a quota market is judged by its ability to produce the appropriate carbon price in relation to the decarbonization targets targeted, J.Delpa and C.Gollier propose to go beyond incremental ETS governance adjustments by establishing a "Central Carbon Bank" (BCC) to manage the European carbon budget. Such an approach deserves

even more attention, since the costs and difficulties of alternative measures are not negligible. The proposal would be to have the evolution of the carbon price in Europe controlled by an independent institution, the BCC, which: that not only any source of direct emissions on European territory should acquire (against payment), but also any importer of “carbon” products, which is the mandate to achieve, by this means, the climate objectives set by the EU, This proposal is not entirely new. Noting the difficulties in reforming EU-ETS, C.de Perthuis had already proposed this type of institution.

On the basis of the observation that the monitoring and effective management of the European carbon market required extensive harmonisation and centralisation, with implementation decisions to be taken rapidly, which is incompatible with the European institutional context, which proposed to create an independent body based on the model of a central bank and sufficient credibility to change the expectations of industrialists so that they can make the necessary investments today to put the European economy on the decarbonization".

Of course, this proposal needs to be clarified on different points, in particular: by a more in-depth analysis of the measures to be taken between credibility and flexibility in the management of the overall quota, -the use of revenue, which must begin by ensuring adequate compensation so that pricing is fair. However, the framework established in relation to the objective -40% establishes a benchmark against which the perennial rules could be built, and the legal aspects, to avoid a requalification as a tax if the price trajectory is too rigid, This would preclude delegating steering to a non-political authority, and would require unanimity for any reform. EU-ETS was established precisely because it was recognized as falling under environmental policy.

This is also an element to emphasize the flexibility dimension of the system to manage the carbon budget, marked by over-allocation within the ETS, and excessive price volatility, consistent with its governance. It also adds that, since climate risk is associated with the concentration of greenhouse gases accumulated in the atmosphere, which remain there for decades or hundreds of years depending on the gases, it is an externality of 'stock'. It is therefore in terms of the “global” carbon budget by 2050 that policies must be built, and no longer in short periods that sustain the “slow race”, where urgency calls for a long-term vision. While the current situation remains marked by volatility and regulatory risk, it finally incorporates the need for long-term credibility. The term of carbon pricing and the legibility of pricing trajectories to ensure the effectiveness of climate policies and encourage private investment decisions to decarbonize the economy.

References:

Part 1: Introduction Corporate Finance:

- [1] See [Corporate Finance: First Principles](#), Aswath Damodaran, [New York University's Stern School of Business](#)
- [2] Katz, Jeffrey; Zimmerman, Scott. "Recent Developments in Acquisition Finance". *Transaction Advisors*. ISSN 2329-9134. Freedman, Roy S.: *Introduction to Financial Technology*. (Academic Press, 2006, ISBN 0123704782)
- [3] Jim McMenamain (11 September 2002). *Financial Management: An Introduction*. Routledge. pp. 23–. ISBN 978-1-134-67624-8.
- [4] Carlos Correia; David K. Flynn; Enrico Uliana; Michael Wormald (15 January 2007). *Financial Management*. Juta and Company Ltd. pp. 5–. ISBN 978-0-7021-7157-4.
- [5] *Financial Management; Principles and Practice*. *Freeload Press, Inc.* 1968. pp. 265–. ISBN 978-1-930789-02-9.
- [6] [Investment Decisions and Capital Budgeting](#), Prof. Campbell R. Harvey; [The Investment Decision of the Corporation](#), Prof. Don M. Chance
- [7] Myers, Stewart C. "Interactions of corporate financing and investment decisions—implications for capital budgeting." *The Journal of finance* 29.1 (1974): 1-25.
- [8] [The Financing Decision of the Corporation](#), Prof. Don M. Chance; [Capital Structure](#), Prof. Aswath Damodaran
- [9] Drinkard, T., A Primer On Preferred Stocks., [Investopedia](#)
- [10] "Preferred Stock ... generally carries no voting rights unless scheduled dividends have been omitted." – [Quantum Online Archived 2012-06-23 at the Wayback Machine](#)
- [11] Kieso, Donald E.; Weygandt, Jerry J. & Warfield, Terry D. (2007). *Intermediate Accounting (12th ed.)*. New York: John Wiley & Sons. p. 738. ISBN 978-0-471-74955-4.
- [12] [Capital Structure: Implications Archived 2012-01-21 at the Wayback Machine](#), Prof. John C. Groth, [Texas A&M University](#); [A Generalised Procedure for Locating the Optimal Capital Structure](#), Ruben D. Cohen, [Citigroup](#)
- [13] See: [Optimal Balance of Financial Instruments: Long-Term Management, Market Volatility & Proposed Changes](#), Nishant Choudhary, LL.M. 2011 (Business & finance), George Washington University Law School
- [14] See: [Valuation](#), Prof. Aswath Damodaran; [Equity Valuation](#), Prof. Campbell R. Harvey
- [15] See for example [Campbell R. Harvey's Hypertextual Finance Glossary](#) or [investopedia.com](#)
- [16] Prof. Aswath Damodaran: [Estimating Hurdle Rates](#)

[17] "Capital Budgeting Under Risk". Ch.9 in Schaum's outline of theory and problems of financial management, Jae K. Shim and Joel G. Siegel. See Probabilistic Approaches: Scenario Analysis, Decision Trees and Simulations, Prof. Aswath Damodaran

[18] I. Ballington, E. Bondi, J. Hudson, G. Lane and J. Symanowitz (2004). "A Practical Application of an Economic Optimisation Model in an Underground Mining Environment"

[19] Virginia Clark, Margaret Reed, Jens Stephan (2010). Using Monte Carlo simulation for a capital budgeting project, Management Accounting Quarterly, Fall, 2010

[20] Quantifying Corporate Financial Risk Archived 2010-07-17 at the Wayback Machine,

[21] David Shimko. The Flaw of Averages Archived 2011-12-07 at the Wayback Machine, Prof. Sam Savage, Stanford University.

[22] Dividend Policy, Prof. Aswath Damodaran.

Part 2: Evaluation of the financial risks with the Monte Carlo mounted simulation:

[1] . Nicholas Metropolis, « *The Beginning of the Monte Carlo Method* », *Los Alamos Science*, n° 15, 1987, p. 125-130

[2] . Nicholas Metropolis et Stanislaw Ulam, « *The Monte Carlo Method* », *Journal of the American Statistical Association*, vol. 44, n° 247, septembre 1949, p. 335-341

[3] Kroese, D. P.; Brereton, T.; Taimre, T.; Botev, Z. I. (2014). "Why the Monte Carlo method is so important today". *WIREs Comput Stat.* **6** (6): 386–392.

[4] . Carmona, René; Del Moral, Pierre; Hu, Peng; Oudjane, Nadia (2012). Carmona, René A.; Moral, Pierre Del; Hu, Peng; et al. (eds.). *An Introduction to Particle Methods with Financial Applications. Numerical Methods in Finance. Springer Proceedings in Mathematics.*

[5] . Carmona, René; Del Moral, Pierre; Hu, Peng; Oudjane, Nadia (2012). Numerical Methods in Finance. Springer Proceedings in Mathematics.

[6] . Kroese, D. P.; Taimre, T.; Botev, Z. I. (2011). *Handbook of Monte Carlo Methods. John Wiley & Sons.*

[7] . Arenas, Daniel J.; Lett, Lanair A.; Klusaritz, Heather; Teitelman, Anne M. (2017). "A Monte Carlo simulation approach for estimating the health and economic impact of interventions provided at a student-run clinic

[8] "Real Options with Monte Carlo Simulation". Archived from the original on 2010-03-18. Retrieved 2010-09-24.

[9] "Monte Carlo Simulation". Palisade Corporation. 2010. Retrieved 2010-09-24

- [10] "Risk Analysis in Capital Investment". *Harvard Business Review*. Sep 1, 1979. p. 12. Retrieved 2010-09-24.
- [11] Boyle, Phelim P. (1977). "Options: A Monte Carlo approach". *Journal of Financial Economics*. *Journal of Financial Economics*, Volume (Year): 4 (1977)
- [12] "Monte Carlo Simulation : Financial Mathematics Glossary K-O". *Global Derivatives*. 2009. Retrieved 2010-09-24.
- [13] The Flaw of Averages Archived 2011-12-07 at the Wayback Machine, Prof. Sam Savage, Stanford University.
- [14] "FAQ Number 4 : Does Risk-Neutral Valuation Mean that Investors Are Risk-Neutral? What Is the Difference Between Real Simulation and Risk-Neutral Simulation?". Archived from the original on 2010-07-16. Retrieved 2010-09-24.
- [15] Savvakis C. Savvides, *Cyprus Development Bank - Project Financing Division (1994)*. "Risk Analysis in Investment Appraisal". *Project Appraisal Journal*, Vol. 9, No. 1, March 1994. SSRN 265905.
- [16] David Shimko, President, Asset Deployment, USA. "Quantifying Corporate Financial Risk". *qfinance.com*. Archived from the original on 2010-07-17. Retrieved 2011-01-14.
- [17] Marius Holtan; *Onward Inc.* (2002-05-31). "Using simulation to calculate the NPV of a project"
- [18] Peter Carr; *Guang Yang* (February 26, 1998). "Simulating American Bond Options in an HJM Framework" (PDF). Retrieved 2010-09-24.
- [19] Carlos Blanco, Josh Gray & Marc Hazzard. "Alternative Valuation Methods for Swaptions: The Devil is in the Details" (PDF). Archived from the original (PDF) on 2007-12-02. Retrieved 2010-09-24.
- [20] Ammann, Manuel; Kind, Axel; Wilde, Christian (2007). "Simulation-Based Pricing of Convertible Bonds" (PDF). *Journal of Empirical Finance*. doi:10.2139/ssrn.762804.
Frank J. Fabozzi: Valuation of fixed income securities and derivatives, pg. 138
- [21] Donald R. van Deventer (Kamakura Corporation): Pitfalls in Asset and Liability Management: One Factor Term Structure Models
- [22] Martin Haugh (Fall 2004). "The Monte Carlo Framework, Examples from Finance and Generating Correlated Random Variables" (PDF). Archived from the original (PDF) on 2012-01-05. Retrieved 2010-09-24.
- [23] "Monte Carlo Value-at-Risk". *Contingency Analysis*. 2004. Retrieved 2010-09-24.
David Harper, CFA, FRM. "An Introduction To Value at Risk (VAR)". *Investopedia*. Retrieved 2010-09-24.

- [24] Christopher Farrell (January 22, 2001). *"A Better Way to Size Up Your Nest Egg : Monte Carlo models simulate all kinds of scenarios"*. *Bloomberg Businessweek*. Retrieved 2010-09-24.
- [25] John Norstad (February 2, 2005). *"Financial Planning Using Random Walks"* (PDF). Retrieved 2010-09-24.
- [26] Edouard Petit, « *PRÉVOIR LA BOURSE ET VOTRE PATRIMOINE GRÂCE AUX SIMULATIONS DE MONTE-CARLO* » [archive], sur Epargnant 3.0, 8 avril 2018 (consulté le 16 janvier 2020)
- [27] Marco Dias: [Real Options with Monte Carlo Simulation](#)
- [28] Marco Dias: [Real Options with Monte Carlo Simulation](#)
- [29] Don Chance: [Teaching Note 96-03: Monte Carlo Simulation](#)
- [30] Peter Carr and Guang Yang: [Simulating American Bond Options in an HJM Framework](#)
- [31] Carlos Blanco, Josh Gray and Marc Hazzard: [Alternative Valuation Methods for Swaptions: The Devil is in the Details Archived 2007-12-02 at the Wayback Machine](#)
- [32] Frank J. Fabozzi: *Valuation of fixed income securities and derivatives*, pg. 138
- [33] Donald R. van Deventer (Kamakura Corporation): [Pitfalls in Asset and Liability Management: One Factor Term Structure Models](#)
- [34] Gonzalo Cortazar, Miguel Gravet and Jorge Urzua: [The valuation of multidimensional American real options using the LSM simulation method](#)
- [35] global-derivatives.com: [Basket Options – Simulation](#)
- [36] Rich Tanenbaum: [Battle of the Pricing Models: Trees vs Monte Carlo](#)
- [37] Les Clewlow, Chris Strickland and Vince Kaminski: [Extending mean-reversion jump diffusion](#)
- [38] Peter F. Christoffersen (22 November 2011). *Elements of Financial Risk Management*. Academic Press. ISBN 978-0-12-374448-7.
- [39] Allan M. Malz (13 September 2011). *Financial Risk Management: Models, History, and Institutions*. John Wiley & Sons. ISBN 978-1-118-02291-7.
- [40] Van Deventer, Donald R., and Kenji Imai. *Credit risk models and the Basel Accords*. Singapore: John Wiley & Sons (Asia), 2003.
- [41] Drumond, Ines. "Bank capital requirements, business cycle fluctuations and the Basel Accords: a synthesis." *Journal of Economic Surveys* 23.5 (2009): 798-830.
- [42] EMMANUEL ATTAH KUMAH. *COST OF CAPITAL (A FINANCIAL TOOL TO CREATE AND MAXIMIZE SHAREHOLDER VALUE)*. Lulu.com. pp. 39–. ISBN 978-1-304-26045-1. ^[self-published source]

- [43] KRISHNAMURTI CHANDRASEKHAR; Krishnamurti & Viswanath (eds.) "; Vishwanath S. R. (2010-01-30). *Advanced Corporate Finance*. PHI Learning Pvt. Ltd. pp. 178–. ISBN 978-81-203-3611-7.
- [44] John J. Hampton (1982). *Modern Financial Theory: Perfect and Imperfect Markets*. Reston Publishing Company. ISBN 978-0-8359-4553-0.
- [45] Zahirul Hoque (2005). *Handbook of Cost and Management Accounting*. Spiramus Press Ltd. pp. 201–. ISBN 978-1-904905-01-1.
- [46] Kirt C. Butler (28 August 2012). *Multinational Finance: Evaluating Opportunities, Costs, and Risks of Operations*. John Wiley & Sons. pp. 37–. ISBN 978-1-118-28276-2.
- [47] Dietmar Franzen (6 December 2012). *Design of Master Agreements for OTC Derivatives*. Springer Science & Business Media. pp. 7–. ISBN 978-3-642-56932-6.
- [48] *Corporate Finance: Part I*. Bookboon. pp. 32–. ISBN 978-87-7681-568-4.
- [49].<http://www.emeraldinsight.com/Insight/viewContentItem.do?jsessionid=EFA8D4FB63329F2C94F48279646551BF?contentType=Article&contentId=1649008> (contrary to conventional wisdom it may be rational to hedge translation exposure. Empirical evidence of agency costs and the managerial tendency to report higher levels of translated income, based on the early adoption of Financial Accounting Standard No. 52).
- [50]"Committee Draft of ISO 31000 Risk management" (PDF). International Organization for Standardization. 2007-06-15. Archived from [the original](#) (PDF) on 2009-03-25.
- [51] "*Operational Risk Management - Time-Critical Risk Management*". U.S. Navy. Retrieved 12 July 2009.
- [52]"*Financial Risk: Definition*". Investopedia. 2018-03-22. Retrieved 1 October 2011.
- [53]"*In Wall Street Words*". Credo Reference. 2003. Retrieved 1 October 2011.
- [54]McNeil, Alexander J.; Frey, Rüdiger; Embrechts, Paul (2005). *Quantitative risk management: concepts, techniques and tools*. Princeton University Press. pp. 2–3. ISBN 978-0-691-12255-7.
- [55] Horcher, Karen A. (2005). *Essentials of financial risk management*. John Wiley and Sons. pp. 1–3. ISBN 978-0-471-70616-8.
- [56] Markowitz, H.M. (March 1952). "Portfolio Selection". *The Journal of Finance*. **7** (1): 77–91. doi:10.2307/2975974. JSTOR 2975974.
- [57]Salomons, Roelof; Grootveld, Henk (2003-06-01). "The equity risk premium: emerging vs. developed markets". *Emerging Markets Review*. **4** (2): 121–144. doi:10.1016/S1566-0141(03)00024-4. ISSN 1566-0141.
- [58]Oberoi, Jaideep (2018). "*Interest rate risk management and the mix of fixed and floating rate debt*" (PDF). *Journal of Banking & Finance*. **86**: 70–86. doi:10.1016/j.jbankfin.2017.09.001.

[59] Shin, Hyun-Han; Soenen, Luc (1999-03-01). "Exposure to currency risk by US multinational corporations". *Journal of Multinational Financial Management*. **9** (2): 195–207. doi:10.1016/S1042-444X(98)00051-6. ISSN 1042-444X.

[60] Poitras, Geoffrey (2013). *Commodity Risk Management Theory and Application*. New York: Routledge. ISBN 978-0-415-87929-3.

[61] Jokhadze, Valeriane; Schmidt, Wolfgang M. (2018). "Measuring model risk in financial risk management and pricing". SSRN. doi:10.2139/ssrn.3113139.

[62] "credit-risk-management-best-practices-techniques".

[63] "The Fed - Supervisory Policy and Guidance Topics - Credit Risk Management". www.federalreserve.gov. Retrieved 2018-12-13.

[64] "Credit risk management: What it is and why it matters". www.sas.com. Retrieved 2018-12-13.

[65] **Credit Risk Management** <https://www.rmahq.org/credit-risk/>

[66] "Committee Draft of ISO 31000 Risk management" (PDF). International Organization for Standardization. 15 June 2007. Archived from the original (PDF) on 25 March 2009. Retrieved 12 September 2009.

[67] "The Basic Building Blocks of A De Novo Fuel Hedging Program". The Mercatus Energy Pipeline. Mercatus Energy Advisors. 7 November 2011. Retrieved 9 December 2015.

Part 2: Evaluation of the financial risks with the Monte Carlo mounted simulation:

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Director of Publications Dominique Bureau

Priorities for a green recovery a model of sustainable development.

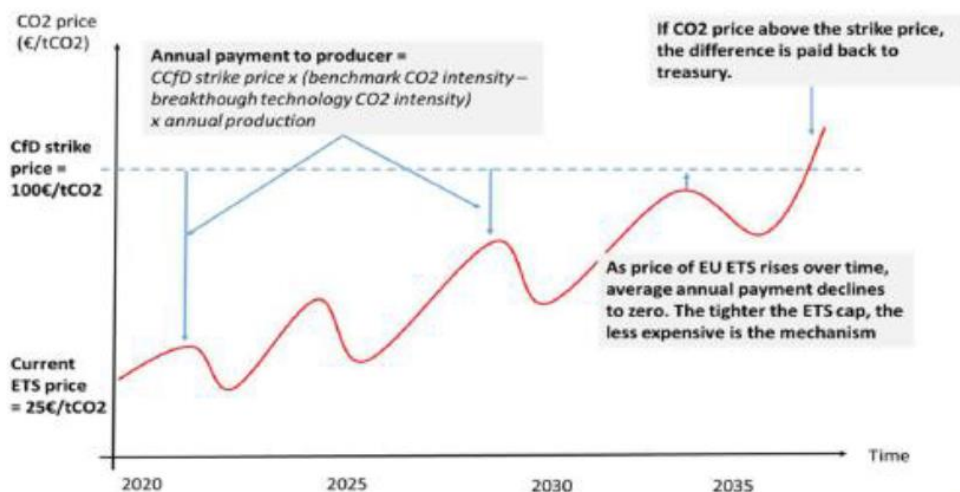
- Les enjeux et priorités identifiées par le Haut Conseil pour le Climat Riyad Abbas et Timothée Asensio-Frery SEVS, Commissariat général au développement durable.
- Quelle place pour l'investissement vert dans les scénarios macroéconomiques de reprise? Katheline Schubert
- L'investissement vert: quels multiplicateurs keynésiens? Riyad Abbas et Timothée Asensio-Frery SEVS, Commissariat général au développement durable
- Hepburn, C., O' Callaghan, B., Stern, N., Stiglitz, J., and Zenghelis, D. (2020), «Will COVID-19 fiscal recovery packages accelerate or retard progress on climate change?», Smith School

Working Paper 20-02.6 Agrawala, S., Dussaux, D., and Monti, N. (2020) «What policies for greening the crisis response and economic recovery?»

- Comment réaliser des programmes d'investissement vert avec des moyens budgétaires inévitablement limités? Alain Quinet.
- La valeur de l'action pour le climat –France Stratégie –2019.
- Le rapport Canfin-Zaouati pour la création de France Transition de 2018.
- TSE-Debate du site de la Toulouse School of Economics.
- «La fiscalité environnementale au défi de l'urgence climatique », Conseil des prélèvements obligatoires, 2019.
- <https://cgedd.documentation.developpement-durable.gouv.fr/notice?id=Affaires-0011438>
- <http://www.compta-durable.com/comptabilite-environnementale-sociale/modele-care>
- Où en est le marché européen du carbone? Emilie Alberola.
- Alberola E. et alii (2020) «L'état du marché carbone européen. Edition 2019»; pour 2020: ERCT, Wegener center, Bloomberg et Eco-Act.
- Comment renforcer la politique climatique au niveau européen? Dominique Bureau
- «The cost of avoiding the carbon tax with standards », TSE-Debates.
- Pourquoi l'Europe a besoin d'une banque centrale du carbone», Revue de l'OFCE, 2011. • A.Quinet «Comment relancer les investissements verts lorsque les moyens budgétaires sont limités?», qui rappelle la faisabilité d'une telle démarche

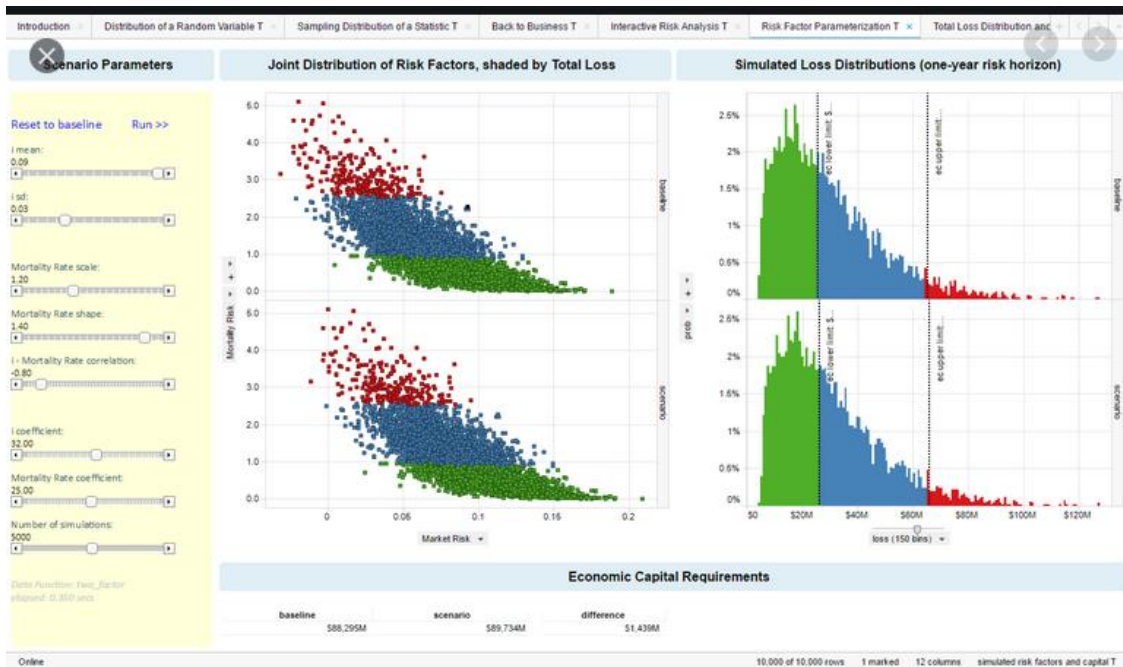
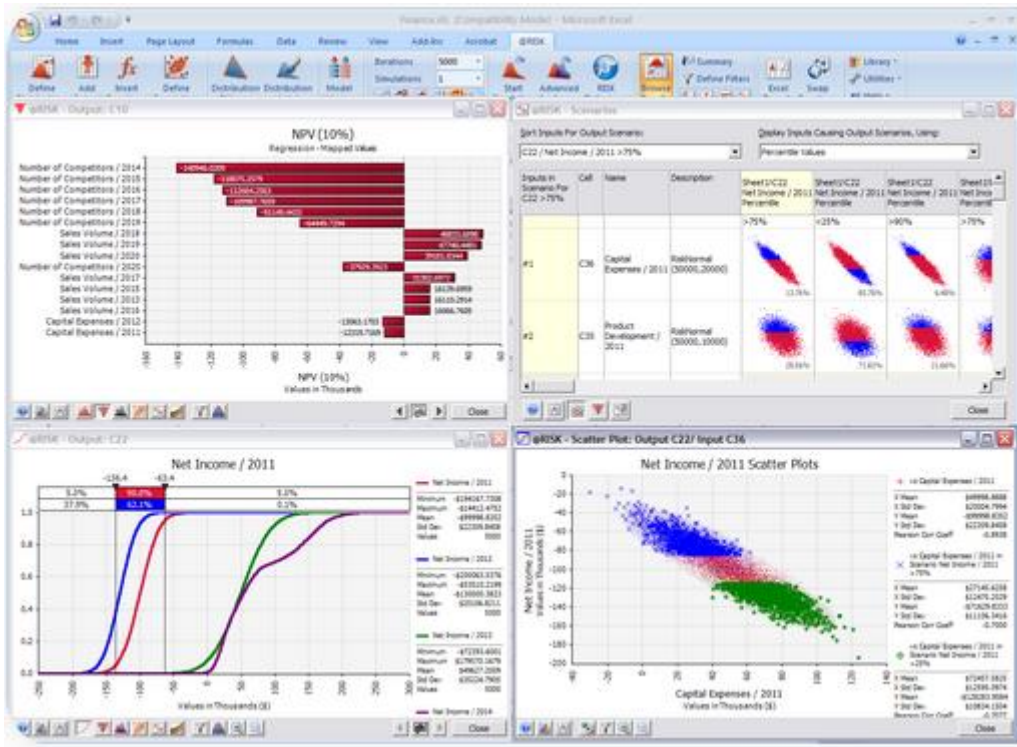
Appendix

Many of the support measures are actually aimed at alleviating the lack of sufficient carbon pricing to ensure its profitability. Subsidies for renewables, clean vehicles, or tax credits for building retrofits fit this pattern. Unfortunately, subsidizing equipment is generally an imperfect substitute for carbon pricing because, since they do not guide user behaviour, their impact is reduced by bounce-back effects, with less-emitting vehicles being used more, for example. Often the technological biases and risks of 'lock-in' are also important; and the redistributive effects are very regressive because subsidies are used only by the richest. Conditional subsidies to secure carbon price trajectories for investors make sense, to set price expectations and limit risk premiums required by investors on green projects. This is the logic of “contracts for differences”.



Source: Agora Energiewende

Risk Analysis using Monte Carlo Simulation Dash boards:



What conditions for carbon adjustments at borders?

The objective of the Border carbon adjustments (BCAs) is to limit carbon leakage (or leakage), resulting from the relocation of industries that emit greenhouse gases or from the transfer of production to countries with less ambitious climate policies. The introduction of tariffs based on the carbon content of imported products; or the obligation to purchase CO₂ emission allowances by importers of these goods, including them in the EU-ETS and thus restoring conditions equivalent to those to which European industries producing carbon intensive goods are subject. By these means, it is possible to limit the deterioration of the competitiveness of European industry if Europe pursues climate policies of significantly higher ambition than those of our partners, other industrialized or emerging countries. Such a system exists, for example, in California, for electricity imported from neighbouring states. At European level, importers would be required to acquire CO₂ emission allowances, based on the same technical standards as those already used by the European Commission for the initial allocation of allowances to European ETS producers. As Europe cannot engage in a 'net zero emissions' strategy without ensuring that it does not unduly or unnecessarily jeopardize its competitiveness, the challenge is now recognised by the new European Commission, after changes have been made at company level (Eurofer, Business Europe...). Long viewed with suspicion by many economists who feared that their real object was protectionist, the BCAs raise fewer objections in principle today. For example, U.S. economists call for carbon taxation (2019) states, "To prevent carbon leakage and to protect U.S. competitiveness, a border carbon adjustment system should be established. This system would enhance the competitiveness of American firms that are more energy-efficient than their global competitors. It would also create an incentive for other nations to adopt similar carbon pricing." Similarly, the recent call by European environmental economists (eaere.org, 2019) for carbon pricing states, "A border carbon adjustment system could be considered in a multilateral context.

The transfer of activities to more lax countries associated with carbon leakage resulting in persistence or even increased greenhouse gas emissions, it is possible to justify such instruments under the exceptions of Article XX of GATT for environmental protection, provided, however, that they are not applied to constitute a means of discrimination between countries where the same conditions exist or a disguised restriction on international trade. Moreover, threats of retaliation must not be ignored. In these circumstances, it is important not only to work from the outset to develop a project that is perfectly compatible with the rules of trade so that it has some chance of success, but also, as suggested by Mehling et al. that the entire design and implementation process (see conditions below) is fully transparent to all potentially affected parties.

Moving Forward: A Balanced BCA Design

Based on an analysis of legal and economic literature as well as existing case studies and proposals, we propose a BCA design that strikes a balance between legal durability, ease of implementation, and environmental performance. Its main parameters are outlined in the following subsections.

Scope and Coverage

Scope and coverage relates to products and trade flows, affected countries, and types of carbon constraints to adjust for. The BCA should:

- Apply only to imports to hedge against classification as a prohibited export subsidy under the WTO Agreement on Subsidies and Countervailing Measures, and to avoid incentivising domestic producers to increase the carbon intensity of exports;
- Cover only primary goods, i.e. commodities from sectors with high carbon cost and trade exposure, and limited ability to pass the cost through to consumers. This reduces the administrative and technical burden while delivering a majority of environmental benefits;
- Have a sectoral focus to observe the Most Favoured Nation principle and prevent avoidance ('trans-shipment') strategies by which importers channel goods through exempted countries;
- Exempt Least Developed Countries to respect differentiation provisions in the climate and trade regimes without undermining environmental objectives;
- Determine policies for which to adjust differences in ambition. This is easiest with policies that create an explicit carbon price, a natural starting point for a BCA, although additional carbon constraints may be included in its scope.

Calculating the Embedded Carbon

Determining the amount of carbon emitted during production of a good depends on the scope of emissions that are included and the methodology used to calculate those emissions. This should consider:

- Direct emissions from production plus indirect emissions from energy and heat inputs, as these cover the majority of product-related emissions without unduly adding technical complexity;
- Global average sectoral benchmarks for direct emissions (multiple benchmarks may be needed in some sectors to reflect different production technologies) to strike a balance between legal concerns, fairness, and incentives to emission reductions;
- Regional or local factors for indirect emissions to avoid a legally problematic link to country-specific characteristics and more accurately reflect real world energy markets;
- Average carbon intensity of domestic goods as a fall back or transitional approach when relevant emissions data is unavailable or of insufficient quality;
- A transparent, accessible process, allowing foreign producers to document actual emissions and improved performance using third-party-verified data.

Adjustment Level

Once embedded emissions have been calculated, the level of the BCA needs to be determined. As a default, the adjustment will be based on the sectoral benchmark multiplied by an explicit carbon price and the amount of product, which, in the case of a variable carbon price (e.g. in an emissions trading system), may have to be averaged out across a specified period.

The BCA is only meant to adjust for the differential between the foreign and domestic climate policy cost in the covered sectors. Accordingly, the level of the BCA has to reflect any exemptions, rebates or free allocation in the importing country, as well as carbon constraints applied to imports in their country of origin, all of which are then deducted from the determined level.

Revenue Use

Rather than accrue to the general budget or be recycled to the public, any revenue collected through a BCA should be used to further its environmental objective and benefit developing countries affected by it.

Expiration

A BCA should be temporary in nature and contain a sunset clause prescribing its periodic review and expiration once the leakage rate falls below a certain level. Doing so averts the risk that instruments that generate revenue become entrenched even after their primary objective has been achieved,

Process

Throughout the design and implementation of a BCA, a process should apply that ensures fairness, transparency and predictability. It should also provide sufficient lead-time, opportunities for participation by affected countries, as well as appeal and review procedures. In parallel, good faith negotiations with affected trade partners and the exploration of potential steps within the trade regime to facilitate BCA implementation should begin.

