Financial strategy and game theory

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Her field of action is the management and coverage of financial risks through the prisms of market finance, reinsurance, retail banking and corporates.
She began her career as Official Associate Professor of mathematics for the French Ministry of National Education. Since 2009, she has developed actuarial sciences in the industrial sector and joined the College of Associate Actuaries in 2017.
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The formalization of risk appeared in the fifteenth century, implying its quantification. The resulting financial strategy will be directly correlated with the transformation of knowledge and its speed of acquisition.
One of the latest applications to economics is game theory. Coming from the world of military strategy and specifically decisional mathematics, it has experienced considerable growth since the middle of the twentieth century.
This overview highlights several points of focus of the general framework in financial strategy. Among them:

- One must always be present on the market and/or in the field. This is necessary for the industrial tool (technological and armament) within our countries.
- When the limits of liability are poorly defined, theoretical tools (probability, statistics, and optimization) as well as technical tools (closed blockchain) introduce readability and reliability into the economic model.

• Introduction

"Intensity in combat: constants and changes, the challenge of meeting intensity shifts". What parallel can be drawn with what falls within the realm of a company's financial strategy and its adaptation to crises?

Lieutenant-Colonel Georges Housset was Chief of Research and History in the studies and foresight division of the Command Doctrine and Teaching Center. He defines: "the notion of risk is linked to a commitment in an action that can bring an advantage, but which also includes the possibility of a danger; thus, there is a notion that is akin to gambling, to a deliberate choice, but also to a calculated *'leap into the unknown'*, the repercussions of which can be positive as well as negative."

From an actuarial point of view, this definition is close to the concept of game theory and its latest developments.
Actuaries attribute the invention of game theory to the work of Luca Pacioli[1] in 1494. The story told is that of two knights who, having to go to war on the spot, interrupted a game. The debate was about: how to distribute the winnings fairly?
The latest developments in actuarial science[2] are moving us from a "binary" or earlier "binomial" aspect to quantum aspects of game theory.
The chronology shown later in Figures 1 and 2, offers a visualization of this evolution.

This article presents an overview of the situation linking financial strategy and risk perception. It focuses on actuarial sciences practiced by insurers.
The scope is limited to the strategic implementation and management of the impacts of financial risks on companies.

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[1]"*Summa de Arithmetica, Geometria Proportioni et Propotionalita*" Venice in 1494 presents the Venetian method for accounting (today known as double-entry accounting)
[2] Game theory is part of the insurance microeconomics (see Pierre André Chiappori, UECE Meetings in Game Theory and Applications, Lisbon (Portugal), November 2010 for example)

• The notion of risk

Insurance has two economical functions:
- it transforms "dormant" capital into available capital, reducing precautionary savings.
- it distributes financial impact of risks over time.

The insurer's job, whose financial cycle is inverse to a traditional production cycle, is to manage the financial impact of the risks transferred by its policyholders.

Risk is an ancient concept whose perception changes over time.
Among civilians, the link between the notions of risk and financial strategy has been established for several centuries. Methods and piloting tools vary depending on the surrounding complexity.
In the eighteenth century, the empiricist Etienne Bonnot de Condillac define the notion of risk as *"the chance to obtain a bad result, coupled with the hope, if we escape it, to obtain a good result"*.
The parallel evolution between mathematical concepts, information technology and risk perception stand out.
At the beginning of the twenty-first century, the notion of crisis is perceived in connection with risk management.
How then to introduce a reliable and readable economic model in a financial strategy?

<u>Non-exhaustive chronology presentation in the insurance field</u>
The following two diagrams present a non-exhaustive chronology of the evolution in actuarial science (insurance) to the present day. They cascade 3 sections in parallel: the emergence of concepts, the notions that have been developed, and risk management.
Note that the section on the twenty-first century gives a prospective vision.

First, strategy and games were mixed, so that we see the notion of "fair play" of Pacioli appear:
- on the one hand, game theory, i.e., a conceptualization of strategy and tactics;
- on the other hand, a principle of relativity since "fair" does not mean equality of sharing. But it means a theoretical projection of a present situation with an uncertain future (the interrupted game is conditioned by a due moment and a fixed position of the players).

We see here that from the fifteenth century, strategy and tactics fit into the conceptual system of risk as later defined by Etienne Bonnot de Condillac.

Over time, mathematical tools were put in place, and we attained the concept of measure[3], particularly "probability measure" which, in the eighteenth century, facilitated the birth of financing risk.
We are then capable of funding "the bet" on the occurrence of an uncertain event considered as "the risk".
At that time, the link between political-economic strategy and risk exists, at least implicitly; especially with certain identified risks such as: fire, hail, epizootics, retirement, etc. This period sees the appearance of, on the one hand, royal loans[4] in the form of tontines, and on the other hand, fire mutuals, fixed-rate life annuities, compensation techniques by reciprocal insurance, etc.
It was Antoine Déparcieux who, between 1734 and 1746, structured the beginning of actuarial science in life insurance with mortality tables.
Let us recall here the definition of money "As a settlement instrument, money is a means of settlement or *a purchasing power* that allows the bearer to procure goods or services or repay a debt.[5]".

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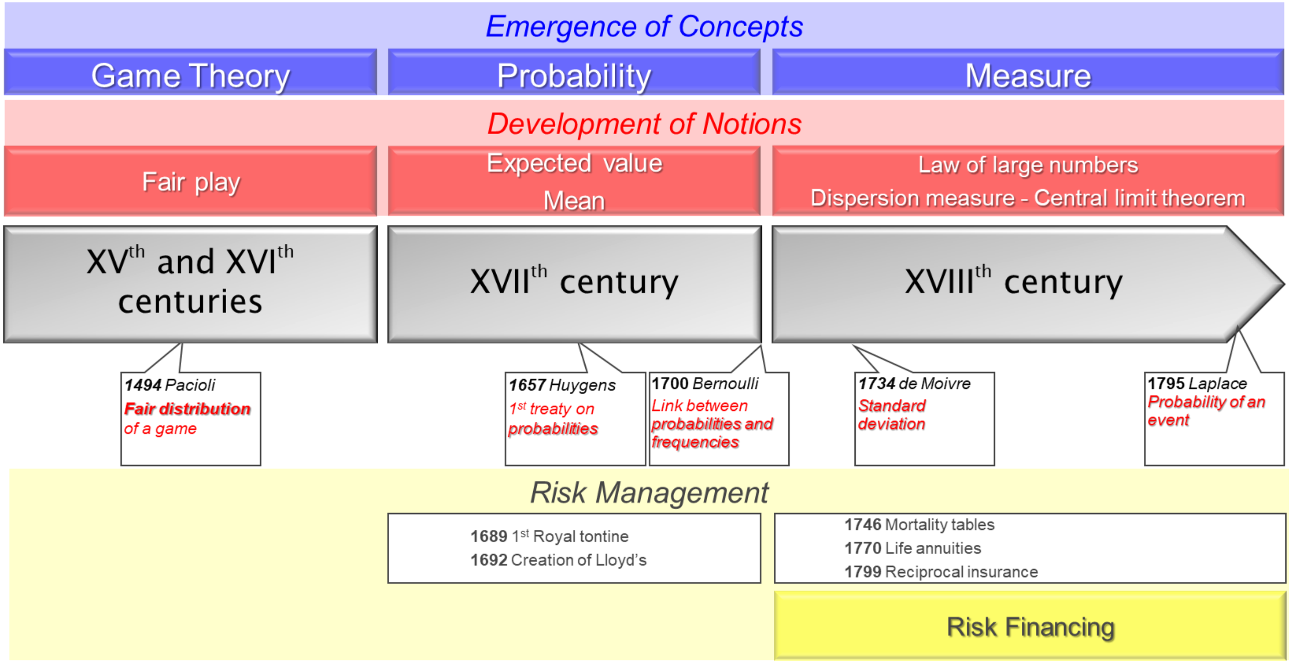
[3] For the record, the standard meter was established on December 10,1799.
[4] Tontine loans from 1689, 1696, under Louis XIV and composite tontine loan under Louis XV 1734
[5] Larousse dictionary

Figure 1: chronology of insurance from the XVth century to the XVIIIth century



In the continuation of the works of Laplace in the nineteenth century, we have learned how to find a price consensus "today" (on the date of commitment) in order to settle the financial consequences of an event that will occur later.
Actuarial science develops from the end of the nineteenth century in parallel with industrial statistics and computer science, and the evaluation principles put in place remain unchanged since.
With the aim to provide a price to a future settlement for the financial consequence of a potential event in the future, the principles can be summarized as follows:

1. the discount factor considers cycle reversal (as opposed to the production cycle),
2. the probability factor takes into account chance,
3. at commitment date, the "mathematical provision for contract risk[6]" is zero. Which means that the insurer and the insured agree on the same financial value of the risk at that precise moment.

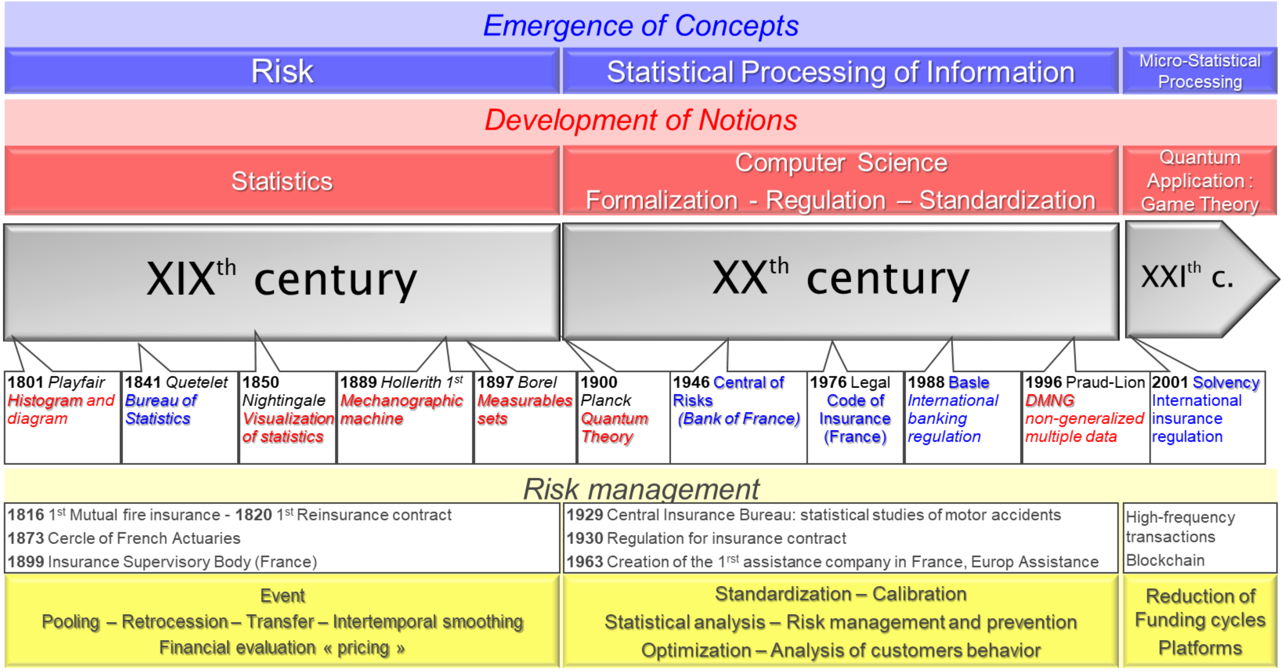
The advent of statistics and technologies to process information is key for the perception of risk and therefore for risk financing. This is achieved both by the contribution of visualization tools, therefore giving a cognitive approach to chance, and the accessibility to information and the computing capacity.

In the twentieth century, information technology came along with many developments of operational management of the impacts of financial risks.
This is particularly the case for the risk management of the credit granted to economic actors and the development of "trading" platforms. The speed by which transactions accelerates increases the speed of the money supply[7] circulation.
For statisticians and digitalizers (nuclear physics engineers), the quality of financial market data is an inexhaustible source: the data is numerous, reliable, standard, their costs are low, the cost of the experience appears to be negligible, and its implication seems limited, etc. Researchers in econometrics, in numerical analysis develop and adapt many models that will in turn be adapted, calibrated, utilized, etc.
It was between 1995 and 1996 the non-generalized multiple data (DMNG) [8] were developed based on a real-time trading experience of European debts. This tool proposed, by means of a directional vector (gradient), a representation of the instantaneous kinetic analysis of the data so that the decision is instantaneously taken thanks to outcome measures of theoretical scenarios chosen according to the "observed" direction and kinetics. This work questions the analysis by statistical sampling. In 1996, pressure coming from the

[6] The mathematical provision for risk is measured by the difference between the probable present value of the insurer and that of the insured at a given point in time.
[7] *"The money supply is an instantaneous notion, but it is obvious that it makes it possible to settle in a given period a much higher amount of transactions depending on whether it circulates more or less quickly (speed of circulation or coefficient of rotation)" (Larousse)*
[8] "Protocoles de décision sur les marchés financiers à terme" thesis in mathematics I. Praud-Lion Oct. 1996

ENSAE[9] let to the abandonment of DMNG. At the same time, INSEE was delaying its entry into work related to "big data".

Figure 2: chronology of insurance from the XIXth century to the XXIth century (prospective)



DMNG's early beginnings of new risk measures techniques has its origin in the movement accompanying the negotiation of the convergence of European debts. These kinetic results from the monetary policy choice decided at the time: that of the paragon design for country debts.
The question already being asked was twofold:

- operational: once the risk premium[10] was measured, which mode of action should be preferred (buy, sell, nothing, capacity, etc.)?
- strategic: how to predict the impact on prices due to the other stakeholders' manipulations, from incoming flow of information? As for example the communication of central banks, and what communication to give to the market?

From the end of the twentieth century and the beginning of the twenty-first century, the State returns in force in the game of company's financial strategy. Financial and insurance models measuring risk and solvency, consider that the State is a "risk-free" creditor but above all, they assume that the State is the "final reinsurer". This fact is established at all levels of companies: from the sales department, through operations, and from the senior management to the board of directors.
Until today, it clearly appears that the risk taken by companies has been analyzed and covered in a political way. The resolution of the so-called "subprime" crisis of 2007-2008 demonstrates this about credit risk where the State is the creditor of last resort.
In the field of insurance and reinsurance for natural disasters or extreme situations, the State rests as the final reinsurer. The successive interventions of the Army can regularly establish it: in an extreme situation or during natural disasters on the national territory and recently in the case of Operation Resilience[11] demonstrates this.

• What constants and changes appear?

Constants remain within the general framework of action in financial strategy:

- information processing is an important resource
- materialization of strategic gains is achieved through short-term "fait accompli".

Constants remain in the capacity for action to manage risks, and that is regardless of the situation:

- the follow-up needs to be practiced continuously:

[9] École nationale de la statistique et de l'administration économique (dependent of the Institut National de la Statistique et des Études Économiques)
[10] The risk premium is the difference at a given moment t between the price observed by the market and the theoretical actuarial value considered to be known because it is deterministic.
[11] Military operation launched in March 2002 dedicated to support the public services and the French people in the fields of health, logistics and protection

  - data entry does not tolerate any delay, they must be analyzed in real time (any retransmission allowing a possible "censoring or mutation")[12],
  - operational continuous presence in the market is necessary to carry out tests and corroborate (or even complete) the calculations developed on the basis of data alone;
- information must be developed efficiently: transparency and sorting of useful/useless information;
- decision criteria must be defined (bounded) and intangible before any operation to translate the principle of subsidiarity in an operational way.

Shifts intervene in the general framework,
- as the State role is modified, the companies' risk profile and consequently their financial strategy changes;
- funding cycle impacts time of transactions and materialization of strategic gains;
  - it requires to adapt ex-ante the limits (strategic and operational) to change course or stop the operation.

• Developments in game theory

Stemming from military strategy, game theory is one of the components of decision theory in the field of mathematics. In economics, game theory applies to risk conceptualization. **It aims to analyze the decision-making of individuals in a situation of interdependence**.
Scientific and computer evolutions constitute game theory from the following three bases:
- *probabilities* provide it with a conceptual tool;
- *statistics* feed it with data and thus provide experiences and illustrations;
- optimization *techniques* and calculation algorithms provide it with results (possible outcomes of the game).

Let us now first specify the perimeter on which game theory relates.
- Excluded from the perimeter are situations of games against a *nature* devoid of goals, without plans (these are in fact situations where there is only one player).
- Are included in the scope of the so-called game situations:
  - "**cooperative**" or "related": in which players determine their game while they have partially antagonistic goals
  - "**uncooperative**" or "unrelated": before engaging, players cannot enter into an irrevocable agreement between themselves (it is also said that they do not communicate with each other).

The economic sector strengthened its interest in game theory at the end of the twentieth century.
Between the year 1994, when the Nobel Prize awarded the pioneering notion of "Nash equilibrium" and the year 2020, with the enhancement of "auction theory" by the work of Wilson and Milgrom, 10 other Nobel prize winners crowned the subject (see Appendix).
As a result of Borel's work, John von Neumann and Oskar Morgenstenn[13] developed as early as 1944 what is still considered the foundations in economics of modern game theory. This applies when the "agents" are few (for example in the case of duopoly or oligopoly supply).

<u>Defining Modern Game Theory in Economics</u>
Game theory in economics is "*the study of economic games engaged in by individuals, companies and nations…. It analyzes how at least two players or parties choose the actions or the strategies that concern each time and simultaneously, each participant"* [14]
"*Game theory is an application to the economic analysis of strategic game theory.... [It] aims to enlighten the economic actor, placed in given situations, on the possibilities they open for him and help him to build all the possible strategies for him and his playing partners.*" [15]

Economists rest on game theory for topics over strategic decisions but also tactical when the environment is uncertain. Even more, game theory supports economic formalization and helps to define the *economic and financial model* as is the case in auction theory. It also allows building up quantitative strategies of investment under constraint over various time horizons; strategies that consider the behavior and actions of economic agents, the market, or the regulator, etc.
As illustrated below regarding simple cases, modeling helps to conceive and visualize the situation.

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[12] Recurring criticism of sampling
[13] "Theory of games and economic behavior", John von Neumann and Oskar Morgenstern, 1944, Princeton University Press
[14] Samuelson Nordhaus "*Economics", 1998*
[15] Larousse dictionary

Illustration analysis of a "price confrontation" in a duopoly situation

First, let us remember at this stage that modeling means giving a synthetic representation of reality and that the aim is not to give an accurate reflection of this reality neither to simulate it.

Game theory translates with mathematical concepts into a model, the options taken by players placed in a particular situation, thus it makes possible to predict the probability of possible outcomes to the game (set of possible strategies). The two strategies considered in this case are confrontation or relationship.

- If the players compete, they take the risk of losing everything (Pyrrhic victory[16]).
- If players are in contact, they optimize their loss "function" (reduce their risk of loss).

In a classic and simplified way, the graph below illustrates the result (ruin) of a price clash (only on the fall in prices, or the lowest tax rate between two countries for example) between two companies that are assumed to have the same cost and demand structure.

Figure 3: diagram representing the interaction in case of clash on prices in a duopoly

The other strategy studied by game theory indicates that both companies A and B will, in the development of their respective strategies, consider reciprocal reactions and anticipate them.

The basic concept of tactic approach is as follows: A chooses its strategy by optimizing its profit (wondering what is best for it) assuming that B, who analyzes A's strategy, acts to optimize B's profit (in its best interest).

Two tactical games are then modeled:

- the dominant tactic, whose result is the dominant equilibrium and
- the tactic (or game) of rivalry, whose result is the uncooperative equilibrium (or Nash equilibrium)

The *dominant tactic* is the simplest: it appears when one tactical choice is better for one player than any other, regardless of the tactical choice made by the opponent.

In the case of the above duopoly, A and B are symmetric. When both opt for a dominant tactic, the result is the **dominant equilibrium**.

We illustrate these two tactics in Figures 4 and 5 below.

As economic patterns are sometimes deliberately confused, let us try to clarify the presentation.

To understand this a priori simple situation, let us note before all that it is an **economic analysis on a duopoly** situation. This allows economists to adopt a representation of the game's gains/losses within a matrix. The results may very quickly seem counterintuitive because they lose. Indeed, the strategy is based on prices and the whole theory aims to demonstrate the interest of adopting a price qualified as "normal" (cost of production increased by a consensus margin in the sector). But let us see in detail this matrix representing gains/losses.

Take for example a two-drawings game[17] (or *n* drawings but always a finite number) between ***two players***.

The possible combinations of the game result are represented by the *win/loss matrix*.

[16] Tactical victory achieved at the cost of losses so heavy that they jeopardize his chances of final victory
[17] Strategies

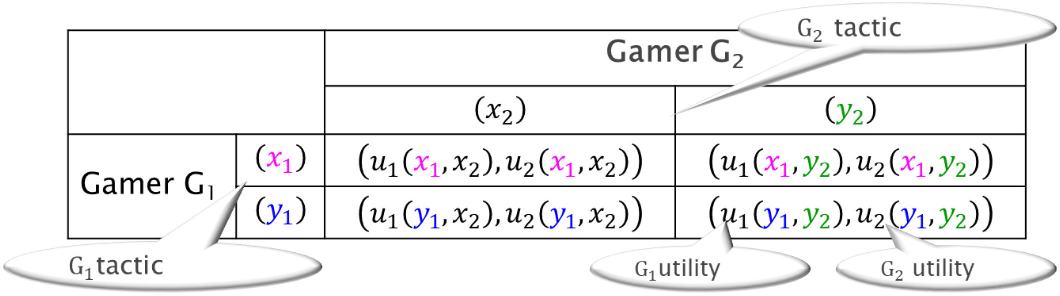
The components of the matrix list:

- on line the strategies of the first player and
- on column that of the second player.

The value of each component is a couple (or an *n-uple*) representing for the first term, the win/loss function of the first player, and for the second term, the gain/loss function of the second player. The whole matrix presents the result by possible tactical combinations of game strategy (actually, not possible but considered).
Note also that in economics we speak of the **utility function of the player** (a pricing strategy) to evoke the win/loss function.

Specifically, the game's win/loss matrix is represented as follows:
name, $\{N = \{1,\ 2\},\ G_1\{x_1, y_1\}, u_1(\cdot),\ G_2\{x_2, y_2\}, u_2(\cdot)\}$, the set of strategies.

Each player of the two-drawings game, G_1 and G_2 has a tactic and a function u_i (respective) of calculation of gain/loss (*utility* of the *player i tactic*). This set defines its strategy.

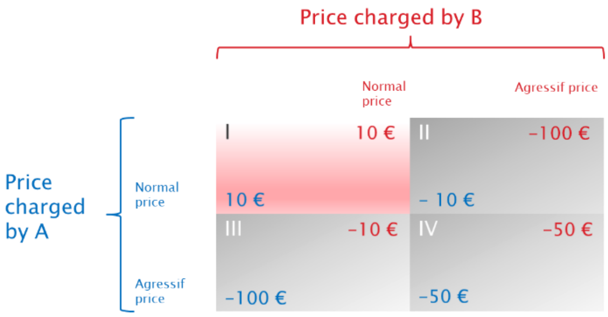


As we will see in two examples, the matrix representation appears to be paradoxical because the "weapon" used by the economic world is the lowering of the price to capture the market. The loss is all the greater as the pricing strategy is aggressive as shown in Figure 3 and as we will see in Figure 4.
The purpose of *game theory in a regulated economic world* is to justify that the gamers (economic agents) have interest to charge a *normal price,* even if the gain seems small.

Let us look at the classic example shown below. Normal price generates a profit of 10 €.
As soon as the first player practices a very aggressive price to enter the market, he loses 100 € if his competitor does not change his strategy; on the other hand, he takes a larger market share. He loses less, 50 €, if his competitor adjusts his strategy and follows him.

Matrix representing the static profit[18] ***transposition of a Pyrrhic victory***

Figure 4: charging the normal price is the best tactic for both companies



In a situation of price opposition, the profit matrix enclosed illustrates the result obtained when two symmetrical players apply the *dominant tactic*.
In this example, regardless of the tactic adopted by B, A's best choice is to opt for a normal price.
Indeed, in this case:

- if B opts for a normal price, A wins 10 €
- if B opts for an aggressive price, A loses10 €

On the other hand, if A chooses a rivalry price:

- if B opts for a normal price, A loses 100 €
- if B opts for an aggressive price, A loses 50 €

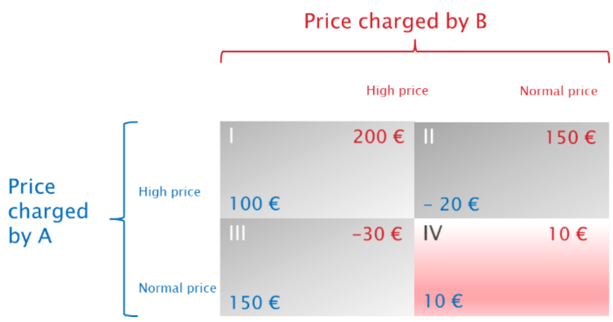
The reasoning is the same for B.

The *rivalry tactic* is the most practiced: each company examines whether it must charge a normal price or increase the price towards the monopoly price, to obtain profits. The examination depends on what each believes the other will do.
In the case of the duopoly, if A has a dominant tactic and there is no agreement between A and B, the result is the **uncooperative equilibrium or Nash equilibrium**.
The example below justifies the competition law regulation. Indeed, in this game, the two companies would benefit from price agreement.

[18] Samuelson Nordhaus *"Economics"*, 1998

Profit (static) matrix[19]

Figure 5: no company improves its gain given the tactical choice of the other



If companies agree on the price, they have interest to charge high (so-called monopoly) prices. Game theory assumes that in this case, one of the companies breaks the cartel. Therefore, the equilibrium price converges on the normal price.

Nash equilibrium is defined by tactical choice (Tactic_A; Tactic_B). The couple is constituted in such a way that neither of them can find a better action under the assumption that both remain loyal to their initial choice.

As Figure 5 shows, A's tactic is dominant and if B were to charge a higher price, it would lose. So, B chooses the normal price.
Equilibrium price is reached when neither A nor B can improve their earnings as long as, the other does not change action.

Nash equilibrium is called "uncooperative" because the behavior of each player is exclusively based on his own optimality (without understanding, cooperation, social well-being, etc.).

The trickiest here is that the players' choice depends on what each believes the other will do.

Of the importance of information processing in modelling

Each modeling in game theory poses the following strong underlying assumption:
- each player has a rational behavior[20];
- this rational behavior is independent of other players' behavior for *a given game situation* (or just before a stage of engagement in the game).

Information that the player has at the time of his commitment, *information he believes the other player has*, become major attributes in the development of the theory.
For example, in financial markets where IT investments have been substantial, agents reacted, based on this theory, by accelerating information flows, calculation time, transactions, etc.
What is more, some investment strategies are based on what institutional players will do given the current regulations. Some others are also based on the models[21] used to determine the price consensus. It is also a question of processing large volumes of information at a very high speed, etc.

In the example illustrated earlier of the uncooperative Nash equilibrium we have a simultaneous "normal" game with full information (each player has a complete view of the available information).
In practice, and in current developments of game theory applications, economists consider time and information in games in "developed" form. For example, they consider *a set of strategies as a trajectory broken down into elementary sequences* respecting conditional optimum states (thus returning to the "normal" case).

Game theory is part of insurance and actuarial science. Moreover, the insurer and the insured are often in a situation of asymmetry regarding the information that each of them has. Added to this is the relationship between the insurer, the regulator, and the State. In micro-economics of insurance these are so-called "moral hazard[22]" games and "anti-selection[23]" games.

Game theory main stages

- In 1944 John von Neumann and Oskar Morgenstern, introduce game theory through **time-invariant choices** ("zero-sum" game) where the gain of one player constitutes the loss of the other (the algebraic sum of all players is constant).
- The negotiation theory articulated in "non-zero-sum" games. Instead of a confrontation tending to make the interlocutor concede on his opposition line, the negotiator seeks arrangements external to this line. The goal is to bring gain to one without costing too much to the other (so-called "win-win"

[19] Samuelson Nordhaus *"Economics"*, 1998
[20] A "rational" player seeks to maximize his utility function (interpreted by his payment for example)
[21] Models presented in scientific research seminars (mathematics, finance, etc.)
[22] In insurance it would be the fact that the policyholder increases his share of risk because he has insurance. Similarly, a company takes disproportionate risks if it assumes that the State will intervene in the risk of ruin.
[23] Hidden information that the insured may have about his own risks and that is not accessible to insurers.

strategies). For example, two competing companies whose research services cooperate. These games consider **time and information**.

- Combinatorial game theory is now part of graph theory or artificial intelligence. Choice arises in different terms at each stage. The main tool here, is Bayesian **probability theory. Complemented by experimental economics**, it can give good results.

Quantum theory's contribution
The concept of the "advisor" or "negotiator"[24] emerging from negotiation theory and the latest advances in game theory bring mathematics closer to quantum physics[25]. This opens a new field in economic theory. The parallel in the military field would be, for example, to complete the simulations of current enemy strategies on the basis that the enemy would act with a "different brain" from the expected, than what we could have imagined. In addition, Philippe Duluc, in charge at ATOS of the program on quantum information and in particular the quantum learning machine (QLM)[26] confirms the pre-eminence of this computing technique in the fields of combinatorics and optimization.

Two topics remain at the heart of current developments in economics: rationality (in the sense of rational behavior) and the use of information (the correlation between the use of information and the behavior of the player concerned). However, economic theory is represented through models. This representation remains schematic especially on aspects such as cognitive biases and individual/collective utility. Above all, *it does not always differentiate information from information elaboration (out of step with the operational practice that distinguishes them well)*.

Nevertheless, these considerable advances complement the constants and changes already presented
Constants remain within the general framework of action in financial strategy:

- The research for determining factors in the balance of forces with the corollary of:
    - the importance of information processing (whether through experience or simulation)
    - feedback (return on experience), only the feedback grants the implementation of achievements in the real environment.

Shifts intervene in the general framework:

- Balance between stakeholders is changing, including regarding knowledge and information:
    - role of the State: regulation, its responsibility, stability mechanism/intervention;
    - accountability requirements (boards of directors, etc.);
    - standardization measures for amounts calculated such as capital/returns - required/acquired (taxation, reserves, risk coverage, etc.);
    - principle of "neutrality of information" to strengthen the reliability and readability of the economic model (determine a price consensus, etc.);
    - influence of technological and scientific progress: by imposing a standard it brings economic superiority. That is reached both in the interest of the company and, through the trust/capacity generated within the market and the ecosystem).
- The surge of blockchain technology and computer platforms modifies the sharing of the quadruplet: investment, information, risk, return. Changes occur on:
    - the role as "agent" information neutrality is now delegated to the platform manager;
    - the standardization of trades, contracts and exchanges;
    - the price consensus defined by an approved and public algorithm and also the governance of this tool;
    - the marginal cost (new player or acquisition cost for a new customer, etc.).

• Conclusion

Operationally, companies' financial strategy generates case studies that we can use.

- Broadening the spectrum of crisis scenarios by using the "footprint" methodology. Projection of the past to, for example, imagine the extension of conflict fields.
- Adopt platforms whose marginal cost of acquisition is negligible or even to aid in transforming traditional business.
- Implement a governance system between players through real-time interoperability monitoring (including via platforms) to, for example, use and maintain an operational reserve on national territory.

[24] Could be an expert model
[25] In 2013 Nicolas Brunner (Department of Theoretical Physics at the University of Geneva) and Noah Linden (Department of Theoretical Physics at the University of Bristol) established a link between non-locality in quantum physics and game theory.
[26] Conference 2021 May 6th at Institut of actuaries

- Value, keep and acquire knowledge by requiring everyone to be vigilant in real time and in continuous time. Ensure a rotation of functions so that everyone can keep an open mind on the objects to be treated: observation, negotiations, maintenance of models[27].
- Adapt and make reliable the scenarios on a multi-year basis without forgetting to integrate all levels and processes.

Within the overall strategic framework, three ideas stand out.
First, on the ground presence is necessary.
Second, the complexity of stakes requires to increase the efficiency of allies (in number and quality). It imposes too, to isolate weak links (when a complex economic system fails, rupture occurs on weak links).
Thirdly, an economic model is all the more readable and reliable if its monitoring has the elements to take into account the financial impact as a last resort. And note that the companies' strategy depends directly on the ultimate actors who cover the financial impact of their risks (the State, hedge funds).

Nash equilibrium theory and cooperative games (see Illustrations 3, 4 and 5) is currently used to manage the balance between GAFAs[28]. To illustrate this point, the current theoretical corpus (the volume of the Nobel investment is explicit) prohibits us from thinking about the creation of a Franco-German GAFA.

To conclude, regardless of the current developments we will have to evolve towards an update of Colbert's theories. Indeed, they alone will allow us to overcome the situations established. Remember that insurance was historically the main key[29].
Quantum physics theory applications will be essential here because they will lead to systems integration. In a way, the completion of a successful RETEX (return on experience).

[27] Organisation that Jean Paul Bailly, chairman, implemented at La Poste during the bank subsidiary creation (La Banque Postale).
[28] Google, Apple, Facebook et Amazon
[29] In the Assyrian world, without the establishment of these systems (syndication, commercial loans to the big adventure, international treaties) there would not have been, given the risks involved of great trade and therefore enrichment of the City-State.

List of Nobel Prizes awarded in fields related to game theory: general equilibrium, contract theory, uncertain decision, behavior or information processing

1. 1970: Paul Samuelson
   Theory of general and partial equilibrium. “For the scientific work by which he developed static and dynamic economic theory and helped raise the level of analysis in economics.”
2. 1972: Kenneth Arrow and John Hicks
   General equilibrium theory and well-being theorems. “For their pioneering contributions to general equilibrium theory and welfare theory.”
3. 1983: Gérard Debreu
   General equilibrium theory. “For integrating new analytical methods into economic theory and for its rigorous reformulation of general equilibrium theory.”
4. 1988: Maurice Allais
   Theory of general and partial equilibrium. “For his pioneering contributions to market theory and resource efficiency.”
5. 1994: John F. Nash, John C. Harsanyi and Reinart Selten
   Game theory. “For their pioneering analysis of balance in non-cooperative game theory.”
6. 1996: James Mirrlees and William Vickrey
   Information economics. “For their fundamental contributions to the economic theory of incentives in an asymmetric information environment.”
7. 2001: George Akerlof, Michael Spence, Joseph Stiglitz
   Information economics. “For their work on markets with information asymmetry.”
8. 2002: Vernon Smith and Daniel Kahneman experimental games
   Experimental economics. Kahneman: “For integrating the contributions of psychological research into economics, particularly regarding human judgment and decision-making processes in uncertain environments.”
   Smith: “For establishing laboratory experiments as a tool for empirical economic analysis, in particular for the study of alternative market mechanisms.”
9. 2005: Robert J. Aumann and Thomas C. Schelling
   Game theory. “For advancing our understanding of conflict and cooperation through analyses using game theory.”
10. 2006: Edmund Phelps
    Macroeconomics. “For his analysis of intertemporal trade-offs in macroeconomic policy.”
11. 2007: Leonid Hurwicz, Eric Maskin et Roger Myerson incentive mechanisms
    Microeconomics. “For laying the foundation for the theory of incentive mechanisms.”
12. 2012: Alvin Roth et Lloyd Shapley, supply and demand adjustment on the markets
    Game theory. “For their theory of stable allocations and the practice of market design.”
13. 2014: Jean Tirole analysis of market power and its regulation
    Industrial organization. “For his analysis of market power and regulation.”
14. 2016: Oliver Hart and Bengt Holmström
    Contract theory. “For their contributions to contract theory.”
15. 2017: Richard Thaler
    Behavioral economics. “For his contributions to behavioral economics.” economic effects of cognitive biases.
16. 2020: Paul Milgrom and Robert Wilson for their work in game theory, in general and for their contributions to auction theory more specifically.
    Game theory. “For improving auction theory and inventing new auction formats.”

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