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A nuanced perspective on *episteme* and *techne* in finance

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ABSTRACT

The debates on the Black and Scholes model shed light on the distinction between practices (i.e. inductive know-how or *techne*) and theory (i.e. deductive know-why or *episteme*) in finance. We revisit the classical distinction, still accepted widely in the literature, between *episteme* and *techne* and develop a nuanced view by introducing two other levels of knowledge we will call "commanding knowledge" (*epitaktike*) and "practical wisdom" (*phronesis*). The major contribution of this paper is to use these four levels of knowledge (*episteme*, *epitaktike*, *techne* and *phronesis*) in order to highlight how this model subtly influenced financial practices by shaping the microstructure of the emerging Chicago Board Options Exchange (CBOE). Our analysis will then be completed by a *re*-interpretation of the existing literature about the performativity of the BSM model to show how these levels of knowledge combined each other in the evolution post-crash (1987) financial practices.

1. Introduction

The Black-Scholes-Merton framework is a cornerstone of contemporary finance. This model which is nowadays well-known either practitioners or theoreticians, also generates a lot of debates between critics and supporters of the Black and Scholes model: while Kalotay (1995), Derman and Taleb (2005) or Haug and Taleb (2008) called the Black and Scholes model (BSM) into question, other authors tried "to save" the model (Duffie, 1998; Wilmott, 2008) by replying that the model is "correct on average" (Wilmott, 2008, p.2). These debates shed light on the distinction between practices (i.e. inductive know-how or *techne*) and theory (i.e. deductive know-why or *episteme*) in finance - Haug and Taleb (2011), for example, emphasized this distinction by suggesting that financial practices are essentially concerned with *techne*. In this perspective, these authors explained the BSM (*episteme*) did not contribute to financial *techne* because it appeared as a mere theoretical formulation of well-known practices. More precisely, these authors claimed on the one hand, that the BSM does not present new reasoning but it simply models an existing (and well-known) argument in terms common with those of the economic mainstream (Haug & Taleb, 2011, p.97); and on the other hand, that traders do not use this model but rather sophisticated heuristics. Because financial products have been created several centuries ago while financial theory has emerged in the 1960s, this duality between practices and theory in finance is an old story (Poitras, 2000).

This paper shows that this distinction between *techne* and *episteme* is not so clear in finance especially for the case of the Black and Scholes model. The first section presents the major argument used for justifying the distinction between practices and theory. Following this, we will illustrate this idea with the argument developed by Haug and Taleb (2011) by nuancing that classical distinction between *techne* and *episteme*. More precisely, we will nuance this opposition between *episteme* and *techne* by introducing two other levels of knowledge that we will call "commanding knowledge" (*epitaktike*) and "practical wisdom" (*phronesis*). The second section will illustrate these different levels of knowledge in finance by providing a case study related to the Black and Scholes model. While the influence of the BSM on the direction and shape of modern financial literature is well documented in the literature (Merhling, 2005; Schinckus, 2008), its impact on financial practices is not so clear (or even denied, see Haug & Taleb, 2011). In this context, the major contribution of this paper is to use four levels of knowledge in order to highlight how this model subtly influenced financial practices by shaping the microstructure of the emerging Chicago Board Options Exchange (CBOE, 1998). Our analysis about these four kinds of knowledge (*episteme*, *epitaktike*, *techne* and *phronesis*) will then be completed by a re-interpretation of the existing literature about the performativity of the BSM model to show how these levels of knowledge combined each other in the evolution post-crash (1987) financial practices.

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2. Black and Scholes model as *techne*

Haug and Taleb (2011, p.98) explained that the Black-Scholes-Merton formula was a marketing argument promoting the economic establishment[1] of that time. These authors presented the BSM model as a way of formulating (*episteme*) a practice (craft) already used by the practitioners (craftsmen). Several historical examples are convincingly provided by explaining that *episteme* and *techne* must be clearly distinguished. Basically, the authors justified their argument by evoking a "broken chain"[2] between the transmission of knowledge developed by options traders and the academic knowledge:

> "For us practitioners, theories about practices should arise from practice or at least avoid conflict with it [...] Options hedging, pricing and trading are neither philosophy nor mathematics, but an extremely rich craft rich with heuristics with traders learning from traders [...] It is a *techne*, not *episteme*" Haug and Taleb (2011,p.97).

This distinction between *techne* and *episteme* can regularly be found in the literature (Poitras, 2000; Razgaitis, 2004; Houghton, Naastepad, & van Beers, 2015; La Berge, 2015) and it implicitly refers to the classical perspective of knowledge proposed by Artistotle in his discussion of prudence in the *Nicomachean Ethics*,

> "If science [*episteme*] involves demonstration, but there is2 no demonstration of anything whose principles admit of being otherwise (since every such thing itself admits of being otherwise); and if we cannot deliberate about things that are by necessity; it follows that prudence is not science nor yet craft knowledge [*techne*]. It is not science because what is achievable in action admits of being otherwise; and it is not a craft knowledge, because action and production belong to different kinds" (Book, VI, Chap.5 parag.3).

In other words, science is associated with things which can be demonstrated and deliberated before actions. In this perspective, *episteme* involves a reflexive knowledge implying a possible distinction between action and deliberation. We have an epistemic link between a deductive know-why and a post-deliberation action (idealistically, the latter should result from the first). At the opposite, craft (or *techne*) rather refers to practices where actions and productions are deeply embedded. Actions are not the result of a preliminary knowledge, they rather embody the production of knowledge leading to a broken epistemic chain between know-why and know-how.[3] In line with this Aristotelian dichotomy, Haug and Taleb (2011) explicitly associated BSM with a craft in which actions embody the production of a practical knowledge: the two levels of knowledge are therefore developed as illustrating in the following graph (Fig. 1),

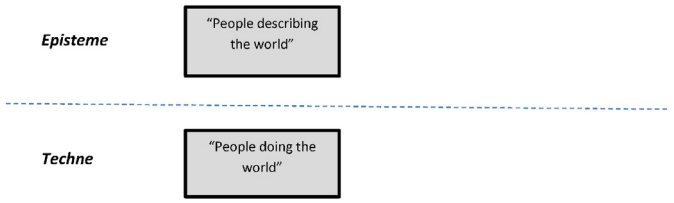

Fig. 1. *Episteme* and *Techne* are depicted as two distinctive levels of knowledge.

In this perspective, *Episteme* is generally associated with scientific knowledge in order to emphasize the certainty of its objects which do not change: scientific objects are supposed to be eternal and to exist by necessity. *Techne* rather concerns with the world of practices in the everyday contingencies. This is a well-known distinction used by Haug and Taleb (2011) as a justification for a distinction between heuristics used by traders (*techne*) and the option pricing theory developed in financial economics (*episteme*).

Although this distinction between *episteme* and *techne* makes sense, it is not so clear in epistemology.[4] In the Xenophon's Socratic dialogues, for example, *Episteme* and *techne* are interchangeable.[5] In *Protagoras*, Plato (1997) defined *episteme* as the role of reflective knowledge (i.e. way of illustrating discussions in philosophical conversations) while *techne* rather concerns with knowing how to do particular activities (piloting a ship, chariot-driving, carpenter, physicians etc) which indicates a theoretical component. This link between *techne* and *episteme* refers to the understanding (*gnosis*): the carpenter knows how to build a house because he knows how to use the right materials; the physician knows how to care for the sick because he recognized health through a specific *episteme*.[6] The only difference between these two levels of knowledge is just the context in which they are used: *Episteme* is a formulated knowledge about the world while *techne* is an applied (non-formulated) knowledge (craftsmen are not asked why they are doing their jobs).[7] In *Republic IV*, Plato nuanced this classical opposition between *episteme* and *techne* by introducing an intermediary level of knowledge: *epitaktike* which refers to "a commanding knowledge" (Parry, 2007, p.7). While the concept of *episteme* describes an abstract (mental) understanding of the world, *epitaktike* rather "gives commands whose effects are practical" (Parry, 2007, p.7). The best illustration of this sort of knowledge is architecture which is not a practical field since it does not directly produce anything in the way the carpentry does; however, architecture has direct and practical implications by shaping the work done by carpenters. Of course, *episteme* and *epitaktike* are interconnected since the former provides conceptual tools to the latter to define its structuring principles: architecture (*epitaktike*), for instance, uses a lot of mathematical notions (*episteme*) to define its commanding knowledge to the carpenter (*techne*).

[1] In the beginning of the 1970s, financial economics was at its origins and it was very important, for actors in this field, to emphasize its ability to provide scientific rigour to assertions and predictions regarding financial markets. The theoretical formulation proposed by the BSM model gave the opportunity to financial economics to establish its scientific authority (Bernstein, 1996).This model was, indeed, a marketing argument because it appears to be in line with the classical perception of knowledge evolution from unformulated knowledge (based on well-known practices) to formulated knowledge (based on theory). Philosophers of science usually deal with this kind of evolution between what they call proto-scientific and scientific knowledge. Basically, *proto-science* is often associated with a field based on a non-unified body of knowledge or founded on some practical evidences (Kuhn, 1970). In a sense, proto-science can be seen as a "practical wisdom" or "an object of perception dealing with the ultimate particular" (Jonsen and Toulmin, 1988) while science is rather based on conceptual knowledge providing general rules and basic principles unifying the description of a category of phenomena. For financial economists, the Black-Scholes-Merton model appeared to have the same epistemic properties than those usually associated with the development of a more scientific approach improving the understanding of pre-existing practices.

[2] "Options traders develop a chain of transmission of techne, like any professions. But the problem is that the chain is often broken as universities do not store the acquired skills by operators" (Haug and Taleb, 2011, p.98).

[3] In the Aristotle's quotation about prudence, prudence is not science neither craft because it refers to a no action which cannot be demonstrated neither associated with a specific production.

[4] Even for Aristotle himself since the distinction he proposed is not always observed elsewhere in his work. See Parry (2007) for further information about that point.

[5] The only difference emphasized by Xenophon is the way of learning: episteme is a knowledge acquired by teaching whereas techne is rather a knowledge acquired by training. However, Xenophon did not make distinction between theoretical instruction and learning by practice (Xenophon, 1979).

[6] A doctor cannot cure a patient's cough if he/she does not understand what a cough is.

[7] Nobody ask to a doctor why he/she is restoring someone's health since he is a doctor.

The classical opposition between *episteme* and *techne* can also be questioned through another concept called *phronesis* that Aristotle (1999) introduced in his *Book VI* for describing a practical knowledge implemented in accordance with a "practical wisdom" or a "particular ethics". In a sense, this *phronesis* can be seen as a practical knowledge (*techne*) guided by a morality or an ethical strength.

There is no knowledge without a knower and there is no knowledge without a use of it. In a sense, our lives are, by themselves, a sort of synthesis of these practical and theoretical intelligences we evoked here. However, in our way of living in the world, we can roughly identify four levels of knowledge as summarized in the following table (Table 1),

Table 1
Summary of the four levels of knowledge identified in the Greek philosophy.

Knowledge	Definition	Example
Episteme	Formulated or theoretical knowledge	Mathematics
Techne	Non-formulated or practical knowledge	Carpentry
Epitaktike	"Commanding knowledge"	Architecture
Phronesis	Practical wisdom	Ethics

In this article, we will use these two concepts of *epitaktike* and *phronesis* to nuance the classical opposition between *techne* and *episteme* in finance. More precisely, the following sections will illustrate how the knowledge provided by *episteme* (Black and Scholes model) has generated the creation of as an organizing principle (*epitaktike*) in the early organisation of the Chicago Board of Trade in the 1970s and how this configuration was justified through a particular practical wisdom (*phronesis*). The last section will complete our argumentation through a re-interpretation of the existing literature about the performative dimension of the BSM model in order to show how these different levels of knowledge combined each other in the evolution of the post-crash (1987) financial practices.

3. The design of the options market makers

This section presents how academic knowledge (*episteme*) influences financial practices (*techne*) and in doing so, the academic knowledge – the financial theory –undergoes changes. More precisely, we focus on the design of the options market makers and to show two reciprocal processes. First, how the BSM model directly shaped the original organisation of this market in the 1970s. In this context, we will explain how the implementation of the BSM model was presented with an organizing principle (or a commanding knowledge i.e. *epitaktike*) to justify a particular normative way of trading (*phronesis*). Second, how, following the crash of October 1987, BSM theory (embedded in applications) was altered. The understanding of this case-study showing the interaction between the academic model and the techno-social environment sheds a new light on the bridge between *techne* and *episteme* in finance.

3.1. Early organisation of the CBOE

To understand the particular path through which finance theory affected practices, we resort to a historical analysis of Chicago Board Options Exchange. In the historical case below we show how BSM was used not merely to calculate option prices, but, as part of the evolving practices around financial theory, where it served as a form of a 'technological character witness' (in line with what we call a "commanding knowledge") for market makers. This, we argue, illustrates a process underpinning the shift from *episteme* to *techne*. To stress, the fact that BSM could be proposed to test and justify the normative character (echoing to the concept of *phronesis*) of market makers is due to significant embeddedness of BSM into option trading practices.

In April 1973, when trading in CBOE began, stock options were an unknown 'beast' to most in the securities world as well as to commodities traders and thus recruitment of new members to the options exchange was a challenging task. Additionally, in late 1973 the agricultural commodities market showed signs of recovery and as futures trading volumes started to grow significantly, the interest expressed by commodities traders in options markets diminished (Markham, 1987). On its first year, CBOE's founding members encountered difficulties in selling trading rights (known as 'seats') at the new exchange. As a result, many of those who bought seats in the first year of CBOE's trading were assisted by funds from relatives or friends. Therefore, by the time that new member traders paid their fees and started trading, they usually had little working capital. Since market makers were chosen from among the members, unlike the established NYSE where specialists were supported by investment firms, the young and relatively unknown CBOE began its operations with a population of market makers who were relatively strapped for cash. Due to the pilot program status, which demanded detailed reporting of CBOE data to the SEC, it was also widely known that CBOE's market makers had inferior financial resources in comparison to specialists in other exchanges, such as the NYSE.

The funding challenge was compounded by the fact that the market makers, according to the design agreed upon by the exchange's founding team and the SEC, competed with one another. That is, for each stock option there would be several designed market makers who were to compete by offering bid and ask quotes and the best combination would be quoted by the exchange. The CBOSE wished to demonstrate, in effect, that the role of the market makers complied with the FRB's perception of a markets operating smoothly, and, in essence, to embody a particular theoretical view of competitive agents in a market. These factors exacerbated the situation and turned the function of a CBOE market maker in its early into a risky financial endeavour. This is the main practice of the market makers which, in accordance with what Haug and Taleb (2011) claimed, implement hedging practices. However, these practices did not solve the main challenge market markers faced: they needed a way of funding their activity. In the first 3 years to CBOE's existence, for example, annual bankruptcy rate among market makers stood at about 10% (Millo, 2003). The difficulties that the individual market makers faced also signaled problems for the exchange as a whole. The performance indicators set for the market makers demanded that they would be available for trading as and when needed. Indeed, the reputation and future success of the fledgling exchange were determined by its responsiveness to trade orders from the public, which depended, especially in times of volatility, on the performance of the market makers. Therefore, it was imperative for the exchange to ensure that the operation of its liquidity supply subunit would be as smooth and as trouble-free as possible and securing a source of funding for the market makers was crucial.

A possible solution for the market makers' funding problem, suggested by the exchange's legal team, was to demonstrate that the function that the market makers filled in the options exchange made them eligible for the special extensions of credit under the Federal Reserve Board (FRB) credit extension rules. This set of rules known as regulation T (US Congress, 2002), included definitions of situations ('provisions') where special extensions of credit were granted to individuals or organisations that contributed directly to the smooth operation of financial markets. The special extensions of credit provided relatively comfortable conditions under which short-term loans could be given, allowing options for market makers to use borrowed funds to replenish their working capital under more favourable conditions than were available otherwise (e.g. lower collateral would be required, longer periods for return of the loan would be allowed). To bring about a change in the FRB's regulation,[8] CBOE wished to demonstrate, in effect, that the role of the market makers complied with the FRB's perception of a markets operating smoothly. In turn, the line of argument that the CBOE's legal team employed to support and promote its cause was based on the risk that competitive market makers take regularly as they supply liquidity. The

[8] Strictly, to include an additional 'interpretation' to the provisions of the rule.

rationale was that normative market makers who aim to provide liquidity through their trading were taking such risks on behalf of the exchange, and by proxy, on behalf of the investing public, it would only be fair that they would be compensated for it by the public – via the funds supplied by the FRB.

CBOE presented to the FRB a model of the normative, well-performing market makers as competing economic actors that aim, through their practices to facilitate transactions. The practice to which that CBOE's argument was referring specifically is known as 'hedging' – buying or selling of securities as a measure against price movements that would have an adverse effect on the options position. Market makers who hedge their positions and try to avoid risk do not use their market role to speculate and try making profits for themselves, but, instead, fill their designated organizational function. The aggregate effect of this improved performance, the argument continued, would be that the exchange as a whole will maintain a more liquid market and become more receptive to orders from the investing public. This argument could be made because by that time practically all traders, as well as other market participants were accustomed to BSM-related practices. For example, the BMS model was used for predicting prices, developing trading tactics and assessing intra- and inter-day risks (Millo & MacKenzie, 2009).

The conceptual simplicity of the proposal does not abolish the practical complexities related to determining the performance of market makers and their inherent difficulties. The main difficulty comes from the fact that the market makers' actions themselves, buying securities, for example, can be done either as part of hedging or as part of a speculative trading activity. Consequently, the application of regulation T's provisions to options market makers, as the argument that CBOE was promoting, needed to present a way to distinguish between the hedging-related and speculative securities transactions. Specifically, the exchange and the market makers had to demonstrate to the FRB that risks were taken, but at the same time that the market makers did maintain a trading behaviour that contributes to the supply of liquidity. This set of demands demonstrates how deeply embedded in the function of liquidity supply is the exposure to market risk and, consequently, how this exposure played a role in shaping and re-shaping the market makers subunit. The market making subunit was designed on the premise that the market makers were held accountable according to their level of performance, which, in turn, this indicated the value of responsible service provided to the exchange and, ultimately, to the investing public (indeed, the regulatory approval for the entire exchange relied on this premise). However, the very nature of the liquidity supply function was based on personal risk-taking (e.g. buying when prices are falling and selling when they rise), a fact that was emphasized by the competitive setting in which the responsibility centre was placed.

This T-regulation acknowledges the existence of a "structuring principle" combined with a "practical wisdom": risks taken by market makers do not aim at making profit but rather to ensure the liquidity (and thus the existence) of the market. In this context, the *episteme* (the BSM model) combined with the T-regulation provided a "commanding knowledge" (*epitaktike*) in order to justify and define the hedging positions taken by market markers whose decisions do not aim at making money (in line with a practical wisdom, *phronesis*).

To understand the difficulties in the creation of a performance management system that would distinguish between hedging and speculating, it is necessary to look at the practicalities of options trading. Let us assume that a market maker bought stocks and sold call options: this position implies a potential obligation by the market maker to sell the stocks if the call options are exercised by their buyers. Hypothetically, the market maker could buy a number of stocks that would cover exactly all of the market maker's potential future obligations. This would eliminate all market risk from the position, but would make it practically impossible for the market maker to trade profitably.[9] However, any position of less than complete coverage of the obligations would entail a certain degree of risk. Underpinning this conclusion is a question of what degree of risk (or performance level) would be accepted as hedging, allowing the market makers to be eligible for the provisions of regulation T? After all, even if risk can be measured in a valid manner, there still exists the challenge of subjectivity. Each market maker evaluated differently the risk involved in holding market positions and may choose to hedge these differently. How can the exchange choose a degree of risk that would be applicable to all?

3.2. From episteme to epitaktike: the BSM model and the design of the market

First initiated in 1975, the CBOE's proposed solution for determining the market makers' performance was to use an options pricing model to assess the risk involved in holding the stock-option positions (Joyce interview). The pricing model, known as the Black-Scholes model (Black and Scholes 1972, 1973), can be used to calculate a ratio between the number of stocks and number of options contracts in a position that would, together, make up a model-generated risk-free portfolio (known as 'delta neutral', Haug & Taleb, 2011). The rationale behind the methodology was that a market maker's portfolio that is deemed risk-free by the model represents an attempt to hedge market positions and indicates beneficial genuine market making activity. This application of the Black-Scholes model was presented to the CBOE staff by a trader who had been using the methodology for measuring the risk of his portfolio (Millo & MacKenzie, 2009). The idea was presented, in an initial form, to a joint committee of CBOE's staff and members that decided to develop it into a detailed plan. During the following months, various departments in CBOE's staff developed the regulatory and technical aspects of the model-based distinction method. In November 1976, Joseph Sullivan sent a letter to Robert Plotkin of the Federal Reserve Board in which he explained the proposed method:

> [According to the proposal] [T]he Board [the Federal Reserve Board] would either issue an interpretation of, or adapt an amendment, to the specialist account provisions of regulations T and [let us] know that credit may be extended to options market makers with specialist accounts with respect to certain exercise and hedging transactions in the underlying securities. […] [A] […]definition that we believe merits consideration is the one which would incorporate an options pricing model formula by reference. Under a formula of this type, it is possible to estimate the rate of change in the price of an option with respect to small changes in price in the underlying stock. The estimate of the amount by which an option price would change upon a change of $1 in the stock price is commonly called the 'dollar delta' and, thus, determines the amount of stock that would theoretically hedge an […] option position against small changes in the price of the stock.

[9] A more technical explanation of this point: First, options usually cost much less than the stocks for which they are written, especially when they were 'out of the money'. An options contract is 'out of the money' when the market price for the stock on which the options is written is traded is lower than the price indicated on the option (call option) strike price or higher than that price (put option). During such times, it would not be profitable to exercise the option and therefore its price would be relatively low. Second, each options contract was written for 100 stocks, so that many (relatively expensive) stocks would be needed to cover fully each options position. Third, market makers usually sold not just one series of options contracts, but instead several ones with different strike prices at the same time. Strike price is the price stated on the option contract and at which, (when the stock reaches that price in the market) the option becomes exercisable. For example, a market maker may sell call options on IBM's stock with the same expiration date but with strike prices of $120, $125, $130 and $135. If IBM's current market price is $85 then there is a higher chance that the price would reach $120, and thus make the $120 options exercisable, than the chance for the $130 or the $135 options to become exercisable. Consequently even if, from a hypothetical perspective, one might expect a market maker to own enough IBM stocks to cover the $120 strike price options, it would be far less reasonable to expect the market maker to have bought enough stocks so as to cover the whole range of options up to the $135 ones.

> […] The principle advantage of the dollar delta formula is that it provided good mathematical test of a bona fide hedge. (Letter, Sullivan to Plotkin, November 19, 1976).[10]

The distinction methodology that CBOE used calculated a theoretically-driven representation of risk-taking as an indication of market maker's risk taking. Market makers who were deemed as risk takers were regarded as one who were not performing their economics-organizational role properly of helping the exchange to facilitate trading. In other words, if by taking risks market makers were promoting their own goals at the expense of the exchange then risk-taking corresponds with the lack of accountability and poor performance – in this context, the BSM model provided the guiding conceptual framework (*epitaktike*) in order to define and justify an acceptable risk taking. This situation illustrates the complexity related to the constitution of market makers across the multiple discursive arenas: market makers *do* need to take risks to play their role successfully and provide liquidity to the exchange. However, to secure funding from the FRB, which was critical to its success, the CBOE had to demonstrate, by applying economic theory, that the market makers were not *seeking* risks. In other words, risk taking is not considered as a speculative activity but rather as a necessary evil allowing market markers to wisely ensure the liquidity (and therefore the existence) of the market.

The FRB began to examine the proposal in late 1976 and over the following 2 years periodic discussions about this issue were held between the FRB and CBOE.[11] In late 1978, as part of a broader examination of options markets, the FRB sent its final decision about the proposal, where it was rejected:

> The staff is also concerned that the use of the "delta model" as a formalized part of regulation T would sharpen the conflict which the staff believes currently exists between a marketmaker's [sic] obligation to the market he serves and his desire to become "delta neutral" in order to minimize his risk. […] Incorporation of the "delta model" into the specialist credit provisions of regulation T would appear to discourage a marketmaker [sic] from assuming these risks [involved in making a market] since if he did so, he might break his "delta neutrality"[12][…] (Plotkin, letter to Teberg, December 5, 1978).[13]

In spite of the rejection in 1978, the FRB's decision illustrates how option pricing theory was embedded into the design and practices of the exchange. The episode we analyzed shows that the influence of the BSM model was not limited only to justifying the opening of an options exchange, but that it also shaped the on the techno-social environment of the market. This particular organisation has not been implemented because of the regulator's decision but actors (practitioners) wanted it. That case-study shows how, by offering a justification to risk taking for market makers, the BSM model implied a "commanding knowledge" (*epitaktike*) whose effects on financial practices were real. In a sense, our analysis confirmed what Mackenzie (2006) wrote,

> "Broad features of the Black-Scholes-Merton model were indeed already present in the patterns of prices in options markets prior to the formulation of the model […], however, the Black-Scholes-Merton model did more than simply express price patterns that were already there […] the model also provided capacities for coordinated action that did not exist prior its development" (Mackenzie, 2006, p.65)

This section illustrates the kind of capacities the BSM model provided for structuring the financial world. The following section will propose a re-interpretation of the existing literature about the performative dimension of the BSM model in order to show how these different levels of knowledge combined each other in the evolution of the post-crash (1987) financial practices.

4. From *techne* to *phronesis*: The BSM model as a "counter-benchmark"

The financial climate in the 1980s and more precisely the 1987 crash had an important influence on the financial practices. More precisely, that event showed in what extent the existing *techne* was not totally adapted to the complexity of the market. Practitioners adapted their practices (*techne*) and that evolution progressively transformed the epistemic role of the BSM model (*episteme*). Mackenzie (2005) explained how the traders' use of the model can be described through three historical steps. In the early months of trading (i.e. in 1973), some traders already used the model (MacKenzie & Millo, 2003) which has been really implementing in the financial practices when Black himself, in 1975, provided a "subscription service selling sheets containing option's calculated prices for the weeks in each month" (Millo & MacKenzie, 2009, p.642). Although this first application was a case by case implementation, these Black's sheets had an impact on the first practices related to the emergence of the Chicago Board Options Exchange. The use of these sheets had even been recognized by the Securities and Exchange Commission in 1978 when it legitimize the spreading practices consisting in a comparison between the option's market prices with the model-generated prices provided by these sheets (SEC's Historical Society, 2002). This first step showed the implementation of the BSM model progressively provided "structuring principles" (in terms of pricing strategy) to the practitioners.

However, the second phase of this "empirical history of options pricing" (Mackenzie, 2005, p.38) refers to the computerization of the arenas that favoured a more general implementation of the Black-Scholes-Merton model. Indeed, the computer technology allowed all traders to generalise the pricing principles offered by the model. This growing use of the Black-Scholes-Merton model led to what Mackenzie (2005) called a "Barnesian performativity" in which "the claim that the market practices informed by the model altered economic processes towards conformity with the model" (Mackenzie, 2005, p.23).[14] That is, because the model provided a useful benchmark, an increasing number of traders used it leading to its performativity dimension emphasized by Mackenzie (2005). From an epistemological point of view, the BSM model played, at that period, the role of formulated knowledge (commanding knowledge or *epitaktike*) for the traders.

Signalling dramatically this second phase was the one-day fall of the US stock market in October 1987, which called the BSM model into question. This financial crash was an unlikely even and it appeared as totally unpredictable in a log-normal description (use in the BSM model) of the financial markets. Following the crash, traders realised that the BSM model did not produce an

[10] All the quotes from the November 19, 1976 letter are taken from a letter sent by Joseph Sullivan, President, CBOE to Robert Plotkin, Assistant Director, Division of Savers and Consumers Affairs, Federal Reserve Board, November 19, 1976 (Federal Reserve Board's library archive)

[11] Documents related to these discussions are protected under confidentiality rules and are not available.

[12] "Delta neutrality" refers to the ratio between the quantities of stocks and options at which, at a given price, the position would be free of risk.

[13] Letter from Robert Plotkin, Assistant Director, Division of Banking Supervision and Regulation, FRB to Richard L. Teberg, Director, Special Study of the Options Market, SEC, December 5, 1978. (SEC library, filed under 'Options Special Study', Exhibit 7).

[14] Black-Scholes-Merton model also influenced the "techno-spatial nature" of options markets by changing the knowledge-related power relations in the trading firms. For further information, see Millo and Mackenzie (2009)

accurate description of market movements, but still they kept using its applications. To stress, market participants continued to use the model as a practical tool, since it provides another reference point for trading decision-making process. To clarify, after the 1987 crash, economist proposed several alternatives to the statistical distribution at the heart of the BSM model (stochastic volatility models, jump diffusion models, non-Gaussian options pricing models etc). In so doing, the theoretical framework itself did not change,[15] but the way practitioners employed BSM-knowledge has altered remarkably: instead of a directive, it has now provided a counter-benchmark – an inaccurate but useful piece of theoretically-driven information.

Mackenzie (2005) presented this empirical contradiction between the BSM model and the 1987 crash as a better evidence of the Barnesian performativity of the model before this his extreme event. After October 1987, the BSM model has been used in a counter-performativity sense that Mackenzie (2005, p.11) called an "effective performativity" in which an aspect of economics [reject of log-normality] must be used in a way that has effects on the economic practices in question.

In other words, the 1987 crash called for the development of more complex theoretical models or heuristics. In this context, the BSM model appear to be a common theoretical knowledge shared by all traders who know that they must "make a difference" with this knowledge by using more sophisticated techniques. Starting from this period, the BSM model did not inform traders on what is the right price but rather on what is not the right price. In this perspective, traders integrated this information in their practices (*techne*) by developing a practical wisdom (*phronesis*) concerning the implementation of the model.

This progressive reconfiguration of the role played by the BSM model had an impact on the theoretical perception (*episteme*) of this model: before 1987, this model offered pricing principles providing the "right" method for options pricing while, after 1987, this model in its original form rather became a "counter-benchmark" whose results cannot be seen as the "right ones" anymore. Although the role played by the model changed during the eighties, its conceptual important did not change since the model still offered a "commanding knowledge" both before (follow its results) and after (use its results as a counter-benchmark) the 1987 crash. The difference between the pre and the post crash period mainly refers to the progressive development of a practical wisdom (*phronesis*) in the use of the BSM model. It is also worth mentioning that this shift in the role played by the model also paved the way to a new way of thinking the model since new theoretical development such as microstructure of financial markets emerged as a consequence of the failure of BSM based-practices (Bake & Kiymaz, 2013).

5. Conclusion

Through the production of different levels of knowledge, scientific practices directly influence the social practices (Golinski, 2005): by emphasizing the interactions between the BSM model and the techno-social environment of finance in the 1970s, this paper nuances the Aristotelian distinction bewteem *episteme* and *techne* that Haug and Taleb (2011) used in their reflection on the BSM model. More precisely, we provide empirical evidence about the emergence of the CBOT in the 1970s to improve our understanding of the diffusion of scientific knowledge from academic department to practices in finance. In the case of the BSM model, this diffusion process took different forms: we explained how the model (*episteme*) provided the conceptual framework in order to justify a specific organisation of the CBOT market. This contextualized knowledge has been associated with what Plato called a commanding knowledge (*epitaktike*). In this configuration, market makers used this knowledge to justify their position on the market by claiming they did not seek for profit but rather for the liquidity of the market in accordance with a specific practical wisdom (*phronesis*). Finally, the last section proposed a *re*-interpretation of the literature on the performativity of the BSM model in order to show that the four levels of knowledge we identified in this article (*episteme*, *epitaktike*, *techne* and *phronesis*) can also be found in the evolution of financial practices before and after the 1987 crash. This financial event, led market participants to adjust their implementation of the BSM model. So doing, they developed a specific practical wisdom (*phronesis*) by using this model as a counter-benchmark rather than as a directive framework. In the light of the case-study presented in this article, the strict distinction between *episteme* and *techne* regarding the use of the BSM model is not an easy task simply because we identify two other additional levels of knowledge that can be associated with this model. The following table (Table 2) summarized these four levels of knowledge concerning the BSM model,

Table 2
Summary of the four levels of knowledge regarding the BSM model.

Knowledge	Example
Episteme	BSM model as defined in the modern financial theory
Techne	Option pricing method used by market participants.
Epitaktike	BSM model as structuring principle for the early organisation of the CBOT
Phronesis	Option pricing method integrating the BSM model as counter-benchmark

These four levels of knowledge suggests that the strict distinction between practices and theory is so clear, contrasting with the opposition proposed by Haug and Taleb (2011) in their analysis of the BSM. The interdependence between each level of expertise also shows the existence of high level of embeddedness between knowledge and knowers.

[15] The original Black-Scholes-Merton model is still presented in textbook and taught in business school as a cornerstone of the modern financial theory.

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