The next question concerning technology

Part II: A World Inverted

The event and the significance of the October 1987 market crash, according to **Elie Ayache**

In the previous issue, I discussed the significance of *dynamic replication* and I argued that it is the "inaugural event" of derivatives markets. Dynamic replication institutes the *dynamic trader* and thereby accomplishes much more than a paradigm shift. It accomplishes an *ontological shift*. When seen from the point of view of the sociology and history of markets, the construction of option value on an abstract stochastic path and, what's even worse, on the minute act of re-hedging along that path, may look indeed like the evaporation of the underlying ontology in thin air (see Smith 2003). However, when seen from the point of view of the inceptive creature – the dynamic trader who wakes up to the world of dynamic replication and finds himself literally appended to his option: literally caught in the middle of the next stochastic tick and of the decision to re-hedge or not to re-hedge – the perspective looks very different. The world looks totally inverted.

The trader need no longer care about the hypothetical entrenchment of the option ontology in the world of economy. Having himself broken into being, his own position as implicated

trader will carry all the ontological weight. He no longer cares about option *valuation*. Instead, the option *price* will be floating all around him. It will be given by the market in which he is immersed. The price is zero because the market has become the *numeraire*. It is the zero mark of the marked-to-market procedure: the price equiv-

alent of sea level. All the option trader cares about now is how to compute the *hedging ratio* and re-compute it every time he re-hedges. With the capacity to dynamically replicate the option, he feels confident as *market-maker* of that option.

So long as the options market was contemplated from the outside, from the point of view

either of orthodox theory or of the history – even the sociology – of markets, we could talk of option value and of mechanisms, due to arbitrage or to sociological embeddedness, which tended, in the long run, to shape the market and bring it line with a given model or a given world. But as soon as dynamic replication and dynamic trading open the view from the inside, they occupy all the view. There is no "long run" anymore and no outside reference. Or rather, the option *price* itself becomes the only reference, and the model, which loses its prescriptive and shaping power, ends up inverted like everything else[1]. From now on, its only use will be to compute the hedge.

With options, or generally, with derivatives, the price process of the underlying becomes the only underlying ontology (it screens off the "deeper" ontology of economic value). The market prices of the underlying become the only states of the world. This is what Smith (2003) has already noted. However, with dynamic replication we get something more. A dynamic trader now gets appended to those states of the world, and trades them actively against the derivative. So highly prized is the dynamic hedge to his eyes – no wonder: it is the cause of his admittance in the options market – that he is willing to invert the model against the option price in order to compute it. So, when MacKenzie (2005) speaks of *implied volatility* becoming the common word in the market vernacular, what this means, really, is that all those market-makers are seeking this number in order to compute their delta hedge. Above all, what this means is that the options market prices have also become a *given* (against which to imply volatility). They've also become states of the world, which may imply different volatility numbers, at different times, and different hedging strategies. And when the market-maker realizes that both the underlying price and the option price are the given, yet that he, by his very implication-by-replication in the breathing interval of the market, *is-there* too and has got more *to do* than just surveying the states of the world from a distance with the eyes of an uncommitted representationalist, he will come to the conclusion that the "what-for" of his being-in-the-market (to speak like Heidegger) is *to make*

markets in those options. This is the exact "human" transposition of my slogan above: "From prices to prices, with technology caught in between." With "technology" now embracing the pricing engine, the racing car and the pilot, the slogan of the derivatives markets becomes: "From prices to prices, with the dynamic trader caught in between."

With this, we come to realize that the advent and growth of the derivatives markets have created a *new breed of market-makers*. By definition, derivatives are infinite in shapes and numbers: not only because the maturity dates or the strike prices of options are boundless, but because there is no limitation to the variety of derivative payoffs that can be structured (the successive generations of exotics) and because derivatives can be virtually written on anything, even on derivatives. Thus the derivatives market-maker often has to invent a price for the derivative he is in charge of trading. In the new world of derivatives, a market-maker is no a longer a market

The "destination" of derivatives

In the end, we may say that it all started with the "first" derivative. From the moment the first derivative contract was written, this whole new logic and whole new era unfolded.

So, this is how I would narrate the story:

The derivative was born one day and it was *derivative*: it wasn't original and natural. An abstract model was thus needed to value it, based on states of the world completely disconnected from the traditional economic values. (This is what prompted Smith's (2003) doubts about the ontological status of options.) Yet because it was derivative *on an underlying* and the underlying was *traded*, somebody like Merton was able to show us how to dynamically replicate it *with the underlying*. This is what prompted the new breed of market-makers into existence, for both the reasons that it now took a dynamic trader to execute the dynamic hedging strategy and that it took a specialist to know how to use the model and quote a price for those new complex and unnatu-

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specialist quoting a bid-and-ask spread on a bunch of assets with a long trading history, and changing his price levels depending on supply and demand. Often, he is the initiator of the newly issued derivative (typically an exotic), and he commences its trading by calibrating his pricing model to the liquid prices of "older" derivatives which trade already. Even when he quotes the price of a vanilla option, based on the traded price of another, he invents that price. What relation there may exist a priori between the *values* of two vanillas of different strike prices or maturity dates is always *model-dependent* (no intrinsic arbitrage). That they should be *valued* using the same volatility number is only what Black-Scholes recommends. (Smile models imply different relative values.) As to the relation that will prevail in the end between their *prices* (as opposed to their values), it is always down to the market.

ral instruments. And now this new market-maker, who is thus *doubly* immersed in the market (on account of the market prices of the underlying *and* of the option, both of which he needs to imply volatility and compute his hedge), finds he has no other purpose in life than to make markets and trade the derivatives he is both pricing and hedging using his model.

In sum, it is the mere fact that derivatives are derivative that is here leading me, by an implacable logic, to pronouncing the *existence* of the derivatives trader (who embodies dynamic trading) and the *existence* of the derivatives market (which can see the light now, and proliferate, thanks to the replicating and pricing action of the dynamic traders). This is how I manage to deduce *being* (although of a new kind) from derivatives, when Smith (2003) could only deduce non-being and uncertain ontological status.

I can even argue my case much more concisely by completely reversing the onus of ontology on Smith (the inversion I announced earlier):

From the fact that derivatives have no connexion with the real world of value and the fact that their market exists nevertheless, even is material for sociological analysis, I shall not conclude, like Smith (2003), that their market must perforce be redefining value. Rather, I shall argue that the reason derivatives were written in the first place – the reason they were ever invented – is that they *may trade*. I would thus be deducing the necessity of the derivatives market from something even more original than the existence of derivatives – from their mere concept! – instead of standing amazed that such a thing as a derivatives market should exist and of puzzling over its implications.

And why is the mere idea of the derivative calling for a derivative market and for its own immersion, right here and right now, in the sea of the exchange? For exactly the same reasons that Smith (2003) was invoking in order to declare the nullity of the derivative. Smith (2003) is right and derivatives can indeed be characterized as running from nothing to nothing. True, they are created in terms of a possible future that may never be realized. True, they consequently have no place and they make no difference within the solid world of concrete value. The only difference they can presently make is that somebody may go ahead and "try" their value before somebody else: to see what trading would ensue. Because they *presently* have no existence, making a difference, in their case, *will be* their identity and existence. (What I am saying is that *to trade is to make a difference* – even, to earn a difference – and that to *presently* make a difference is how derivatives can exist. I wonder what Derrida would think of that.)

Just think about it. If derivatives are to be settled at a future time and only in a fraction of the state space (the portion of space above the strike price of a call, for instance), why should we be talking, or even thinking, of derivatives today if it were not to set a price on them today? If derivatives have no value today (according to Smith), what else can they have today except a *price*? (This, Smith (2003) calls: "redefining value.")

Because derivatives were invented today and thought about today when everybody knew they only existed in the future and only in a fraction of space, the *only thing we could have in mind for them today* is to trade them today! What else? Derivatives are all about trading. They are meant for trading: this is the only plain – not fractional, not conditional – fact that is of concern to them today. They are the trading. They are the market. Instead of saying: "There is and there always has been a market, only this market is redefining value today because it is trading objects that are written and derivative and sent away (instead of allocating objects all filled up with plain and unambiguous and self-evident intrinsic value)," better to say: "If those objects were ever conceived and thought of, it is for the purpose of present trading. This, by the way, is what trading is all about: to lend existence to objects of such kind. This is the best introduction to the market. This is the *implicit definition* of the market. This is what the markets are for, as technology of the future. Instead of thinking that derivatives are introduced on the market, better to think that the derivatives themselves introduce the market: they call for it, they justify it."

Non-closure

If the mere *thought* of the derivatives – what the derivatives imply and what they are meant for – entails the *trading* of the derivatives, then Black-Scholes-Merton is ultimately invalid. In order to derive their result, Black-Scholes-Merton assume that the derivative value $V(S,t)$ is a function solely of time to maturity and of the underlying stock price. This is how the Ito expansion of the hedged portfolio can be written and the hedge executed in precisely the ratio that cancels the risk. With the trading of derivatives being now the first thing in our mind, we can no longer interpret $V(S,t)$ as a value but as a market price, and, as such, it can no longer be assumed to depend only on time and the stock price. Surely enough, it depends only on the underlying at maturity, however, what now takes place before maturity is not only time but also *trading* (by the theta-gamma equivalence principle noted in Part I).

To trade the derivative is precisely to make room, that is, to make *space*, for that *other* determinant of its value, beside the underlying price: in this case, volatility. Indeed, there would be no point in trading derivatives if varying with the underlying was all there was to their prices. $V(S,t)$ should really write: $V(S,\sigma,t)$.

From this, we see that Black-Scholes-Merton or any generalization thereof, complete as they may be on paper, will always be *philosophically* incomplete[2]. The purpose of any derivative pricing model, advanced as it may be, is to value a given derivative after due calibration of the model parameters to the market prices of the reference derivatives. Those parameters are then assumed to be constant and this is how the dynamic replication of the derivative (which can involve as many hedging instruments as there are underlying risk factors) is set into place. Then again, reflecting on the meaning of the derivative and on the difference that *it* makes (for instance, the reason why barrier options were created over and above the vanillas) will lead to the thought that it was written in order to trade: more specifically, in order to play the variability of precisely *that* which was assumed to be constant in the setting up of its dynamic replication.

Derivatives and derivative pricing models are fine when considered as pure, detached inventions. But when it is realized that the derivative was invented in order to trade and that the derivative pricing formula was derived in order to price and replicate the derivative in a trading environment, *as* the specifically trading object that it is[3], when, in other words, the *market* is summoned back inside the pricing technology (the model) and inside the derivative itself *as technology* – and the only technology the derivative is good for and is meant for, the essence of the derivative *as* technology, is the technology of trading –, the thought is back upon us of that for which this whole technology and whole history of being were destined. And what they were destined for is the *other beginning* of the derivatives market[4], the beginning that holds the truth of the market: the October 1987 crash and what it meant to options markets. Or, more specifically, what this meant for options markets and for the technology to *traverse* the 1987 crash.

Value vs. price

The October 1987 crash is the beginning of derivatives markets because it marks the return to derivatives *prices* (and to derivative *pricing* – in the enlarged sense that I will explain later) as opposed to derivatives values (and derivative valuation). It is the return to derivatives prices *through* derivatives values. So let me first elaborate the distinction between value and price.

Speaking of the economic *value* of options, Smith (2003) says it is "defined and calculated in terms of various statistical/mathematical formulas applied to past price movements of the underlying financial instruments and equities." From this, as we recall, he deduced the uncertainty and insubstantiality of their ontological status. Along came dynamic replication and it taught us, first, that option value is defined in terms of future, not past, price movements of the underlying (for surely, Smith (2003) did not have a dynamic picture in mind: historical volatility came the closest to his idea of a statistical variable to stick in a mathematical formula and show all round as an illustration of how ethereal this whole valuation process has become!), and, second, that those underlying prices are *prices*, and by this I mean that they are actively traded in a *market*, by a dynamic hedger who finds himself implicated in the price process, by his own replicating action. Then an elaboration followed, whose only purpose was to re-centre the ontology of the market on dynamic trading and the essence of the derivative on its trading destination. It can be summed up in one play on words: derivative *pricing*, not derivative *valuation*. And by this I mean that, given what we now know of the derivative and of dynamic trading – both of which are essentially pointing back to the market –, the purpose of this whole process cannot be to produce a derivative value but a derivative *price*. When you think *through* the first beginning in terms of what it really implies (the dynamic trader, the derivatives markets), you find that the derivatives are not merely valued, but should really be priced. The derivative is valued with a view to trading. Only in the other beginning does this become a reality.

The derivative pricing model will always be incomplete and the theoretical value it produces will always be *wrong*. It is wrong because the derivative shall trade, contrary to the assumption of the model. What is right, however, is the only "fixed" and "complete" thing that the derivative technology has produced: the nerve of the model, dynamic replication. Through here, the dynamic trader gets tied to his option and to his market; so how can this be wrong?

The summer of 1987

Thus my reading of the period just preceding the 1987 crash can proceed as follows:

By 1987, options markets had indeed matured, as the majority of sociologists recognizes. However, my interpretation of that "plateau" is not the same as MacKenzie's, namely, that the Black-Scholes-Merton model had, by then, completed the process of shaping the market and of driving the patterns of options prices towards its prediction. How I'd rather describe the situation is that, by October 1987, the options market had finished "filling up" with market-makers of the new breed: those who are appended to the options they trade by the tie of dynamic replication. If the pre-1987 situation had been one of convergence to the Black-Scholes-Merton values, like MacKenzie (2006a) says, then my guess is that that would have ultimately driven the market-makers away from the market, instead of gathering them. (What margin could there be left in a market where everybody uses the same formula?) Rather, I contend that the pre-1987 situation was one of convergence and increased concentration of *market-makers* inside the options pits because the dynamic replication algorithm had, by then, bought everyone of them a ticket into dynamic trading, regardless of the agreement between option theoretical value and option price.

Now of course, something exogenous did happen: the October 1987 crash. Something always, eventually, happens. Yet I think that the question of the dynamics that was prevailing before the crash (whether the underlying was following Brownian motion and all of sudden stopped following it, or whether it had ever followed it) is beside the point. I don't think the idea has crossed the mind of the sociologists of finance to go check whether Black-Scholes-Merton had ever enacted itself in the arena of the underlying. (Rubinstein's empirical study of the period between August 1976 and August 1978 concerned only options prices and their agreement with the flat implied volatility line (Rubinstein 1985, MacKenzie 2006a 165).) I'd say

The purpose of this whole process cannot be to produce a derivative value but a derivative price

the underlying was following whatever motion it was following, as it always did and always will. Likewise, the question that is presently torturing the sociology of finance: "What model are the post-1987 option prices performing?" is unrelated to the question of the motion that the underlying has been following since.

Nor is it interesting to speculate that the market-markers *believed* the underlying was following Brownian motion before the crash and no longer believed so after the crash. The beliefs, the psychology or indeed the knowledge of the market-makers are totally irrelevant (and negligible) considering the vast question that I am waving here, the one concerning their very being-there, namely, whether those market-makers will-be-in-the-market or not, whether they will be tied to their options with the string of dynamic replication or not.

As far as options *prices* are concerned, the Black-Scholes-Merton model is, to my mind, an episode of minor importance: options prices were not aligned with it before 1973 and haven't been aligned with it since October 1987. Where

Black-Scholes-Merton is of crucial importance, I think, is with respect to *locking in* the market-makers in the dynamic replication process. Once this is granted, it will only make sense that options prices got aligned with the model during the "docking" period.

How I would describe the departure of options prices from the flat implied volatility line of Black-Scholes-Merton is then simply that those prices just had to break free again one day (after filling up with market-makers). As a matter of fact, what caused the birth of the implied volatility smile wasn't the sudden, unusual deviation of a certain option price (as you would think). What caused it was something simpler and more original: the question of the mere *possibility* and the mere right of being of a certain price. The emergence of unsuspected ontology, yet again.

The birth of the volatility skew

In the summer of 1987, I had just been hired as an apprentice option market-maker by a major French bank. My underlying market was the 10 year French government bond future. Although the future contract was listed on the MATIF, options on futures were still over-the-counter. Volatility of long term interest rates is much lower than the volatility of equity indices, so the largest single-day bond-price swings I have witnessed during the crash were "only" four per cent down on October 19th and five per cent up on the 20th, and the highest level that at-the-money implied volatility had traded in my options market was "only" 25 per cent. However, this isn't how the volatility smile was born. In reality, it had started to materialize a couple of months earlier.

That summer, an obscure trader, who was employed at the time by a small Parisian brokerage firm, started calling all the banks that made markets in the options, including mine, asking for quotes on the 95 per cent out-of-the-money December put. With at-the-money volatility trading roughly at 4 per cent in the summer of 1987 and absolutely no sign of volatility skew, the theoretical value that the market-makers would compute for that put was exactly zero! So, not only did this put have uncertain ontological status, like all

the other options, on account of the "usual" insubstantiality of the statistical/mathematical formula underlying all options values (Smith 2003), but even worse, it didn't have *any value*, that is to say, any existence, even relatively to that peculiar ontology of options! Yet because our dark trader was expecting a *transaction*, because a market transaction occurs at a *price*, and because a traded *price* – something quite distinct from a value, in my ontology – *cannot* be zero, the market-makers had to blow that put into existence and sell it for at least a cent, which translated into an implied volatility of 4.60 per cent.

Our doomsday trader would buy all the puts he could at that price, from all the market-makers he could reach, and the next day, he would ask for a quote on the next put, the 94 per cent out-of-the-money strike! The market-makers would answer him: "0.00 bid; 0.02 offered; nothing in the middle." So his next question to them was: "What is the nearest put that you could sell me for one cent?" (This was simply asking: "What is the next put that you care to trial into existence?"). The most daring market-makers would answer: "The 93 per cent put," and selling this put for a cent would already imply a volatility of six per cent.

Thus the birth of the volatility skew had nothing to do with theoretical valuation or with theoretical modeling. It was simply a matter of a market transaction, and the most elementary one at that! Not a matter of finding a price, but more originally, of finding the option such that it may admit of the smallest possible price and thus enter, only just, the realm of the tradable.

Having argued, at the time I was discussing standard option theory and dynamic replication, that option value reflected the ontology of dynamic trading (see the previous issue of *Wilmott*), I may start to wonder now what second-level ontology might be reflected in the limiting, recurring question of our ominous trader: "What is the nearest put I can buy next, for next to nothing?" Note that there will always exist such a put when the underlying is the long-term interest rate future contract. Obviously, such an extreme question doesn't take place within the bounds of a quantitative model. It is a *qualitative* question raising the incalculable, incommensurable, pos-

sibility of failure of any previously adopted quantitative model. Never before has a price (the price of that one cent put) been so immeasurable and so initial. (How I must disagree with Smith (2003) here, who speaks of prices as the "numerical measures of values"!)

If, having established that a given put is theoretically worthless, you end up buying it nevertheless because "*you never know*!", this can only mean that you are factoring in the possibility that, literally, "you may never know," in other words, essential uncertainty. What I am saying is that kurtosis, or fat tails, belongs in the domain of the meta-model, not of the model (the domain of the critique of knowledge, not of knowledge itself).

So does the lesson of the 1987 crash.

So does the lesson of the *prices* of options (as opposed to their values).

So does, in the end, the lesson of the market.

The October 1987 crash, like I said, is simply the lesson of the return of the market. It is the *other* beginning.

The completed technology

For all that, options markets did not return to their pre-Black-Scholes-Merton wild nature. For the first beginning (dynamic replication) was *also* here to stay! The practice of dynamic replication survived the market crash, and this is something the sociology of finance duly recognizes: "Today," writes MacKenzie, "it would be unusual to find the Black-Scholes-Merton model being used directly as a guide to trading options: in options exchanges, bank's trading rooms, and hedge funds, the model has been adapted and altered in many ways. However, the model's 'replicating portfolio' methodology remains fundamental" (MacKenzie 2006a 20).

What this means is that, although the main parameter of Black-Scholes-Merton (or of any adaptation or generalization thereof), implied volatility, is recognized to become stochastic by the rule of its very usage, traders would nevertheless recalibrate the model every time, imply a different volatility number every time and re-compute their hedging ratio every time, rather than reject the model. When the trader realizes that both the calibration inputs and the theoretical outputs of his

model are market prices and, as such, are free-floating, when, in other words, he realizes that the given model will always be incomplete, he will have no choice but to hold on firmly to that part of the model which is of direct concern to him and will remain meaningful so long as he himself remains-in-the-market, namely the hedge.

True, the lesson of the October 1987 crash may have been: "At the beginning will always be the market!" but the upshot of my argument is that this beginning will now have to always include the implicated market-maker, i.e. the first beginning. The number of dynamic hedgers didn't decrease after the crash. Quite the contrary! And the fact that dynamic replication remained fundamental is not an accident. It is as if the market's abyssal fall had secured the hook of dynamic replication even more strongly in the trader's flesh. This is *also* the lesson of the October 1987 crash. Perhaps its main lesson.

Like I said, the net result of the whole Black-Scholes-Merton period was the institution of dynamic replication and the rising of the dynamic hedgers. But with the market now flanking the technology on both sides: on the side of the calibration to traded prices of derivatives and the side of the trading of the newly priced derivative, the net result for the co-constitutive relation of the market and the technology can only be something unusual, something unsettling and almost paradoxical. (This is probably the fate of the technology of the future.) This is captured by the following equation: "Only because a new brand of derivatives is dynamically replicable by the existing stock of derivatives does its market rise and grow. Only because it is *not* ultimately replicable by the existing stock of derivatives should its market ever rise and grow." I shall call it the *market equation*.

The goal of the technology is to produce a theoretical value and a replicating strategy for the derivative, in order that it may be safely and liquidly traded. Its goal, we may say, is to *produce* (not shape) the derivatives market. However, it will not reach its goal (this market) in the hope of finding the validation of its product. Strangely, its only hope and goal (this market) is that its product may be *invalidated* and that the market price may soon *diverge* from the theoretical value it is prescribing. (The market, I said, takes place in the displacement.)

Philosophically speaking, we may, therefore, say that the technology produces the derivatives market – it *gives* the derivatives markets – only insofar as this market is *thereby* considered as given. As soon as the derivatives market-maker derives a derivative price (using his hedging algorithm and formula) and posts it in the market, the price is traded and exchanged and it becomes a market-given. It becomes a datum and is no longer a result. Hence our chance to finally appreciate the virtue of the market *as exchange*: the market doesn't just exchange the *result* of the theoretical derivation against the prices that other market-makers are showing. More fundamentally, it exchanges the (category of) result *for* the (category of) premise: something I have called a "context-changing engine" (Ayache 2007a) .

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Thus the October 1987 crash completes the technology that Black-Scholes-Merton has initiated. Black-Scholes-Merton doesn't need the 1987 crash, as MacKenzie says, in order that we may not mistake its performativity for its truth (MacKenzie 2006a 33). It needs the crash because the derivatives market it has created only begins – that is to say, *it becomes a given through its being produced* – with the crash. So in a sense, the Black-Scholes-Merton model and the 1987 crash are respectively the beginning and the end (the destination) of the technology.

We can spell out the program of the *completed technology* – this "next technology" I was urging for the derivatives markets, in the previous Wilmott issue – as the technology that *produces the market as a given, not as a result* (paradoxical as this may sound). I have argued, in a recent paper (Ayache 2007a), that such a pricing "model" can no longer belong to the object domain and remain confined in a fixed context. It is not really a model, but a *meta-contextual pricing tool*, a plausible implementation of which is the regime-switching model.

Heideggerian performativity

Reciprocally, the October 1987 crash "completes" the market. And by this I mean that only with the 1987 crash does the derivatives market acquire its final truth, namely, that it shall always trade outside the given model and away from the reductive power of replication. The insertion of the living trader inside the very mechanism of the market is both the consequence of dynamic hedging and the guarantee that the market will always be displaced and taken somewhere else. Thus the trader holds the market at both ends. His being-there is the *site of being* of the market. The market acquires its complete meaning and its complete significance only when it is realized that it will remain structurally "incomplete" (in the sense of financial theory, this time).

The Black-Scholes-Merton model and the 1987 crash are the two inseparable sides, or stages, of the derivatives market. The two always work in conjunction. There always occurs a stage where a derivative is replicated and its market is shaped by a model and a stage where it breaks free from the model. The cycle repeats itself and the next thing to do is not to look for the model that the post-1987 options prices will be performing; it is to watch for the moment when a new pair, composed of a model and its breakdown, will repeat the *market equation*.

The story of the 1987 crash can be retold as the story of liberation and literal explosion of the out-of-the-money puts: the market-inscription of model risk, in this case, stochastic volatility. The chain of one-cent puts that our dark trader has awakened did not break into existence from the side of the first beginning – the side of the model and its predictable dynamic replication. They entered the market from the other side of the *market equation*. As their price was "next to nothing," they literally *were* next to nothing: qualitative, not quantitative; ontologically inceptual, not replicable; the market equation pushed to the limit.

Thus the 1987 crash is the extreme form of the inversion which, I said, was typical of the ontology of the market. We can invert the quantitative model to compute the implied volatility of those one-cent puts (thus constructing the

volatility skew), but the extremity here is such, and the price is such (one cent) that no dynamic replication can follow. Like I said, the emergence of those puts had nothing to do with the *dynamics* of the underlying. The ontology here is of a totally different nature and is irreversible. This is the reason why the volatility skew has persisted to the present day.

With the presence of the market-maker now meaning (constant) "trouble," the question will no longer be to note the performance of a given model by the patterns of prices or to wonder what model the patterns of prices might be performing. That which is performed, through the implication-by-replication of the living trader, and at precisely the moment when he *trades away* the derivative he has valued last by the replication methodology, that which is performed in a movement that cannot be re-covered by the model or even by representation, is simply the market.

Whether it is called the return to the market, the other beginning of the market, or the extreme form of the *market equation* which teaches us that a model can be performed only up to the limit where the market itself has to exist, the 1987 crash is, to my mind, a necessary stage in the market's maturing process. We owe it to the ultimate form of performativity, not to a form of counterperformativity as MacKenzie contends (MacKenzie 2006b).

This kind of performativity, I would like to call "Heideggerian performativity." It is intransitive in essence. No model is performed here, for the market is always essentially *what happens next*; it is always what takes place in the displacement: always outside the model. Nothing can be the object of this kind of performance. By simultaneously replicating the derivative, implicating himself, and trading the derivative, the trader enacts his "being-there" and enacts the truth, or the being, of the market. For the reason that the trader's "being-there" is a site of being and comes before any doing or result of doing, and for the reason that the being of the market is the primary "what-for," the initial event that cannot be produced unless it is "produced-as-given," neither the "being-there" nor the being of the market can be the direct objects of a verb or of a performance. What is performed here is performativity itself.

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