

The Blank Swan

Dan Tudball talks to Elie Ayache

Elie Ayache has been away from these pages for some time now, working for the most part on fine-tuning a philosophical perspective that, if it catches on, will have far-reaching consequences for the way we think about finance. This fine-tuning has resulted in the recently published book, *The Blank Swan*, which is not so much a response to the argument put forward in Nassim Nicholas Taleb's feted work, but a reframing of the entire space in which discussion

of the financial markets, and particularly derivatives, takes place.

The thought behind the book is deeply challenging. Ayache himself says that he tends "to write only the things that will be as difficult to read as they were to write." This does not make his work incomprehensible, or illogical – every word has been very carefully chosen, and one has to be very careful about the baggage one brings to a reading. The reader has to be prepared to think about very specific definitions.



ELIE AYACHE



ELIE AYACHE

In the exchange that is reproduced in this article, I have attempted to deal with just the building blocks of Ayache's view. The author will be returning to the magazine with articles that will further explain his position and explore the consequences of his thesis. My hope is that, with this as a very basic introduction, this article will motivate readers to pick up *The Blank Swan* and pay the line of argument close attention.

If you do find yourself agreeing with Ayache, you will be falling in with a very controversial view that in essence means the end of probability as we know it.

We have a standardized view of the market; a view that rests upon our understanding of contingency and the relationship of probability to that concept. In this view, the following holds:

I. A derivative is based on an underlying.

II. The underlying is subject to the framework of the metaphysics of probability wherein it (the underlying) is going to find itself in several "states of the world" (i.e., manifest a certain state out of a possible range of states).

III. To each of these states, we assign a probability.

IV. The derivative is a function of these states – hence, it "derives" from those states. The derivative is not "absolute." In the Black–Scholes view, the option price is a product of the calculation of the probability of the underlying manifesting a possible state from a range of possible states.

V. Price is the expectation of some payoff. Price is computed after probability. The price of a derivative is just the mathematical expectation

of the payoff under the probabilistic distribution.

Ayache's criticism of this view is that, at some point, you will be able to completely hedge the derivative with other derivatives – thus, making the derivative redundant. Black–Scholes actually makes options redundant because you are hedging them perfectly with the underlying. The options do not "admit of a price" because the price is a function of the underlying and so brings nothing new to the table. Black–Scholes actually makes a market for options redundant.

This isn't how things really work in the market, says Ayache. In point of fact, the way the market actually operates points toward a solution to the quandary; that it should be admitted that the market itself should supplant probability as the medium of price discovery. There are great ironies at work in Ayache's view – for example, Black–Scholes, based on a probabilistic notion of the world, allows us to develop the notion of dynamic hedging; dynamic hedging is the process by which we act in the market, but at the same time destroy the model that has allowed us, as it were, to insert ourselves into market activity.

The problem with a probabilistic view is that it is random, but not random enough – hence the occurrence of Cygninae of every hue. The market is, according to Ayache, something that is very strongly random; a randomness that cannot be framed into any identifiable partition of states. It is infinitely differentiated – differentiation is a key notion, discussed later on. In the market, unlike the probabilistic notion we apply to it, all kinds of payoffs – no matter how complex – will never be redundant at any stage. The market is "absolute

contingency". It is truly stochastic, in that it may be analyzed statistically, but may not be predicted precisely.

Here, we reach the starting point for the discussion. Our view of "contingency" is a very tough one to shake. Our view is that contingency comes after probability; contingency is defined in terms of possible states of the world and, as such, is limited.

Derivatives, according to Ayache, should be renamed for what they are – "contingent claims" – invented to see what difference it makes today that a difference should occur later. Contingent claims, once written in the form of a contract, immediately have a value in the market – the market will price the contingent claim – bypassing any concept of probability entirely.

I wrote to Ayache after our talk, still trying to wrap my head around much of what we had discussed. Things that readers of this magazine, possessed of a much quicker intellect than I, will no doubt have picked up on in the course of the original discussion. I was trying to find some sort of metaphor that would capture the argument neatly. You will see that the metaphor is deeply flawed, but to its credit it elicited a response from Ayache that I feel stands as a perfect introduction to the entire exchange, which, aptly enough, preceded it. Ayache is, if anything, all about the inversion!

I wrote:
So, probability theory:

- 1) Only exists for us to statistically analyze previous prices.
- 2) Allows us to make an educated guess (or at least a guess based on certain criteria) as to whether a bet is a good one or a bad one.
- 3) Metaphorically, it is like a chart of

an ocean route that allows us to devise a vessel (the contingent claim) which we then take to the sea of the market, hoping to arrive at a particular point on the map via a certain route, but we float on the sea fully expecting to respond to the constant need to trim the sails, adjust for currents and tides in the attempt to arrive as close to our proposed destination as possible. We will have to redraw the chart at every diversion caused by the winds, currents, and tides. We may, in the course of the journey, find that the vessel itself is entirely unseaworthy, based on the assumptions of the seachart we were originally given, and have to abandon the ship entirely.

The more complex the conditions of the route, the more complex the vessel needed to sail it. But we could still have created such a complex vessel without any presupposition of the complexity of the route. We could have created a complex vessel and just set it on the sea with the intention of reaching Utopia and based our judgment that such a place is possible to reach merely on the basis that the sea, indeed, exists and we had unknowingly misread the work of Thomas More.

Is it not ironic that, historically, probability theory has provided the means to ever-more complex contingent claims and so greater complexity of the market over conventional time, but once the complex claim is written, the theory becomes immediately superfluous?

In response, and by way of introduction to the interview that had preceded it, the author wrote:

I fully recognize the necessity of the paradigm of probability. As a matter of fact, I repeatedly argue in the book that the markets of contingent claims wouldn't have grown if dynamic hedging, which is based on stochastic process and probability, didn't introduce the dynamic trader to that market. And I fully agree that the quant culture, which has mainly evolved thanks to BSM and

its cognates, is what set the right mood and environment for the invention of new contingent claims.

As a matter of fact, an essential component of what I accept to call a contingent claim (worthy of market and price) is that it should be dynamically replicable. CDOs are not contingent claims to my mind, because you cannot dynamically replicate them; therefore they lack a dynamic trader and are ONLY based on naked probability theory and the faith in the corresponding copula functions, etc. In my logic, only if you dynamically replicate are you able to calibrate to the market and then to recalibrate.

Recalibration is what guarantees that the market-maker always sails on the surface of the market and never sinks below (here is your sailing metaphor). Recalibration of the model is trimming the sails and adjusting for new currents and tides, as you say. So, the complex vessel is the model (based on probability theory, no doubt), not the contingent claim. The contingent claims, whose other face are prices and the market, are just what constitute the sea, in my philosophy.

The main equation of my philosophy is that contingent claim = exchange = price. How I deduce the contingent claim is from the conversion of debt (which, in my philosophy, is as backward and as dead as probability and the static vision of states of the world – as a matter of fact, I argue that probability is just a metatasis of debt). And the contingent claim that I deduce from the conversion is not some complex nonlinear payoff such as call or put or barrier option. The strange thing is that I deduce $B + \delta t^S$, which is the replication strategy of the contingent claim (whatever this contingent claim may be).

The paradox is that the replication strategy is deduced before even probability or stochastic process is introduced. Why? Because this is dynamic replication in a market, not in a theory. We need the

trader to dynamically replicate the contingent claim (otherwise it is doomed like the CDO); however, dynamic replication shouldn't be framed in theory, otherwise it will entail the redundancy of the contingent claim, and the death of its market.

We need the theory, only we need to constantly break it. This is what is constantly achieved when you recalibrate your model, thus breaking its logic. And let's not forget that you are able to recalibrate, because you are first able to dynamically replicate. This is the "illogical" circle, which is not vicious but virtuous, because it just says, in a logic that is irreducible to theory, what the circle of the market is.

DT: Is "contingency" a cat-

So, the sad story of Black–Scholes is that although it is meant to price options, the theory of Black–Scholes makes options redundant because basically you are hedging them perfectly with the underlying

egory in a similar way to Kant's Noumenons – "things in themselves" – as far as your philosophy, which is not a transcendental one, can allow?

EA: It's true that the philosopher on whose work I am leaning here, Meillassoux, the one I discuss in the philosophical paper "The Medium of Contingency," and I also discuss in Part II of my book – he is a metaphysician. His view is very original, in that he holds that contingency is actually the absolute; this is the ultimate category in the world. According to him, this should really be the "thing in itself;" we should think of the world as contingent. So, contingency for him is the primary thing; strangely

enough, for him contingency should come before existence and being. We should think first of all that things are contingent, meaning "they are what they are, but they could be something else," before we think that "they are." In his book, he guides you through a reasoning by which he shows that, given our position in the world as finite human beings, if you will, the only thing that we can know for sure is that everything is contingent. From that, you may actually think that it is a limitation in our knowledge, because you are basically saying "everything there is, is contingent; therefore everything I know could be different;" still, he says I

want to turn this limitation into an absolute. That's his philosophy.


What's interesting is that he wants to do two things at the same time; he is a speculative philosopher, a metaphysician who still wants to speculate on what is ultimately there, "in itself" in the world. So, they want to establish what exists in the world independently of the presence of man, and independently of man thinking about those things. This is the definition of speculative philosophy. However, he doesn't want to be a speculative philosopher of the dogmatic kind, who thinks that therefore something that exists absolutely is some kind of dogmatic

being. He wants to do speculation, to think of the absolute without thinking of a metaphysical being, a metaphysically necessary being.

DT: Which would be the way that Leibniz would think.

EA: Absolutely. He doesn't want to think like Leibniz, but he doesn't want to do what Kant did, which according to him is that he forgot about speculation altogether by saying that human thought is not meant to think about things absolutely. Human thought can only think about things relative to thought itself, which is transcendental philosophy. But Kant is kind of frustrating to thought, if you will, because Kant,

according to Meillassoux is limiting thought to the correlational circle. We want still to be able to think outside the circle of thought; however, we do not want to think of something that exists of necessity, therefore, and so there's a kind of twist here that says the only thing that we can think absolutely is contingency.

DT: Where somebody like Leibniz would think you basically go retrogressively through contingent states until you reach a necessary being, as it were, which thinks the contingency and makes it so, in this case contingency is the necessary category itself and it does not need some other intellect or mind to conceive of it, it just is. 

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EA: Leibniz' position is the principle of sufficient reason. Nothing is really the way it is without a reason ultimately. Whereas the new brand of speculative philosophy says, on the contrary, that nothing is by necessity, and really there could be absolutely no reason as to why things are the way they are, and this fact is actually the only absolute that I can hold on to.

DT: The next note that I have here is a flow of your conversion – contingency – price, and then I have a note that says “The market ‘actualizes’ contingency?” Is that a fair comment? Is that close to your thought? Is “actualize” an appropriate word?

EA: I would say that the market is the “medium” of contingency; it translates it, and it transmits it. How can I put this? What I like in this overturning of the categories, where contingency becomes absolute, is that somehow we have to think of contingency absolutely, no longer even think that contingency comes after probability or something like that. So, there is a shortcut there directly to contingency. For instance, the way that I apply this is saying that we should no longer think of derivatives as derivatives because if you call them derivatives – the received view of them – because we have something called the underlying upon which the derivatives are written, and the underlying according to the metaphysics of possibility and probability is going to find itself in several possible states of the world, to which we will assign several probabilities, and each of the states upon which the derivative depends is derivative from each of those states – the derivative is a function of those states, hence “deriving” from those states. However, the major driver here is the underlying



The Blank Swan (Elie Ayache) confronts the Black Swan (Nassim Taleb)

ing itself, which we partition into states, etc. So, in the end, the derivatives are not absolute because they depend on the underlying. If you do such a thing and you follow through the derivation of Black–Scholes, etc., you find that very quickly, because you are framing yourself in a framework where the world is partitioned according to the states of the underlying, no matter how complex you make the states of the world, if you decide that maybe

you are hedging them perfectly with the underlying. The options do not admit of prices because their price is a function of the underlying that brings nothing new to the table.

If we take the opposite view, the one that deeply overturns all this and says that the first category is not “being,” it is not “states;” a state is something that exists, “the state of the world” is a category that is very close to “being;” if we say, that is not true, we don’t want to base a

We no longer call derivatives “derivatives” but “contingent claims”

the underlying is not the sole variable, that maybe you add volatility or whatever, you might be able at some point to completely hedge the derivatives with other derivatives and make them redundant. So, the sad story of Black–Scholes is that although it is meant to price options, the theory of Black–Scholes makes options redundant because basically

metaphysics on Leibniz' kind of view of possible worlds and possible states of the world because nothing really exists as an identifiable state of the world. If we say, well, no, contingency is what comes first, so instead of saying that derivatives are something which are written and derivative on existing states of the world and the underlying, we say that the

first thing is the contingent claim, so that’s why I say that we no longer call derivatives “derivatives” but “contingent claims;” so, we think of them directly, without thinking that they depend on some underlying. We are therefore in the world where the call option could pay this or could pay something else, so it’s contingent; however, this is the sure thing – if we make contingent claims, the first material of the world, if you will, you build into your whole metaphysical view the fact that they cannot be redundant because you have not even defined something on which they derive and which can make them redundant. Therefore, you want something to give value to those contingent claims without going through the intermediary of probability theory and of states of the world, and this thing I claim which translates the contingencies of those contingent claims directly into prices is the market. This is the definition of the market.

So, if you will, this is a metaphysical overturning of the picture, to say that contingent claims will never be redundant and they are the basic thing.

DT: This is part of the difficulty for me, but I’m trying to grasp it from various angles. One of the points that you made somewhere was that, essentially, tied into the fact that a valuation model like BS makes derivatives effectively redundant, in this view of things that you are putting forward, attempting to predict and pre-empt prices which have been generated from a sequence of historical data – so, as it were, thinking forward to think backwards in order to think forward again – is kind of pointless and what should be happening is that you have this event where there is a conver-

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sion of debt to equity, which creates the contingent claim.

DT: This is my discovery, if you will. Probability is a backward notion; it is associated with debt because probability is expressed either as zero or one; like debt, you either default or you don't default, so it's morbid, if you will – it's completely limited between zero and one. The new category is basically the category of price, and price is something that we do not think of as traditional financial theory thinks of it – as something that you compute from probability: “well, price is just the expectation of some payoff” – this is how financial theory puts it. It computes price after probability,

This thing which is infinitely differentiated and where all kinds of payoffs, no matter how complex they are, will never be redundant at any stage is the market

that the price of a derivative is just the mathematical expectation of the payoff under the probabilistic distribution. So, I think, on the contrary, that price and probability are actually opposed, so probability is actually backward and probability relates to debt, and probability is only what Bergson would call a fabrication – it is not real – possibility is not real according to Bergson. We have to reverse the current and think forward, so in that case price is the category that is forward, and what produces it – because I need

something to produce it; if I am in debt and completely stuck in the probabilistic, morbid framework, the operator that takes me from this framework to the framework where there is complete contingency is the conversion. This is what allows me to deduce contingency without saying whether the contingent claim is only derivative on some underlying state of possibility and assigned probabilities.

DT: You have debt and you have equity; conversion is the jump ...

EA: It's the magic, the transmutation or metamorphosis or “morph,” as I call it, that takes you from the backward framework or death of probability to the new framework

of market and price and contingent claims.

DT: The concept of differentiation is very important here; you are not talking about the differentiation between two separate entities, you are talking about differentiation which is within a single entity. An immanent thing, growth; it's not evolution.

DT: It's like evolution, except that it's not in a time frame, it's like an organism that first of all is completely homogeneous but then grows differential features.

DT: Perhaps the way we normally think of the market is that it is itself an entity which is evolving over time, and we don't see any end to it, just as we don't see any limit to the evolution of the human species, except for the end of the species itself. So, the market is itself evolving. The suggestion is that, in fact, the components of the market, these relational things, are actually going through a life cycle; it's more enclosed, more immediate, but the differentiation is the sort of thing you get from an organism developing from birth to death. There is a differentiation between the changes within an entity within a single life span, in comparison to the evolution of a total species, as it were. Is that what differentiation is?

EA: To me, what strikes me in the market is the actual generativity of payouts. For instance, we have the call options, barrier options, and variance options, and we have payoffs which are more and more sophisticated, if you will, and this is what I mean by differentiation, that there is no limit to the complexity of the payoffs that could be invented on the market. The whole idea of breaking free outside of the framework of the probability (and that's why I call it the end of probability) is to actually say at any point in time, independently, not like an evolution in time, it's not like at some point we had invented vanilla options and the barrier options 10 years after that and then variance options and so on, even though historically this is what happened. But now, independently of history, and if you want to think logically about what I define to be the market, my idea is that instantly you should be able to think of as many differentiated or different payoff structures,

like vanillas, barriers, all that, and none of those things should actually be redundant. All of these things should admit of prices instantly; what I mean by price, almost by definition, is that it is a price independent of other prices and cannot be reduced to being just a function of other things. Go back to the probabilistic thinking, the way that all the quants and my company do things. Let's say you devise a stochastic volatility model; in a stochastic volatility model, vanilla options are not redundant with the underlying, they are redundant in Black-Scholes. However, they won't be redundant in a stochastic vol. model because a stochastic vol. model is to say, basically, that options themselves are trading in the market. However, we find that another payoff structure, like barrier options, will be redundant because barrier options will in that case – simply due to the limitations of the model and of the states of the world of the model – be replicable perfectly by combinations of the vanillas, and they will be redundant. So, therefore, you have come to a stage, a certain stage of differentiation of the market, where you have basically stopped it from existing; you are saying it doesn't exist because it is redundant. So, if you want the whole thing to exist as such, it's like the fractal – you know the fractal curves? The fractal curve, at any scale on which you see it, always differentiates, because on any scale it will never end up being predictable and smooth; on any scale of complexity with which you look at the payoffs of the derivative, you should never fall on redundancy, if you will.

DT: The moment of conversion, or the conversion event from debt to equity. Equity is about differentiation ...

EA: To me, the moment of conversion produces the contingent claim, even before equity.

DT: So, the contingent claim ... the reason why this can admit of price is because it is a differentiating thing, it is not something that is destined for death or redundancy. Debt is passive, share is active; it is about the conversion of the past into the future.

EA: Absolutely. So, debt is passive; you can only redeem a debt or go into default, there is no growth in debt – there is only death (i.e., default), or you just go back and redeem the amount, so it's very boring. There is no differentiation, in that it's like degeneration. On the other hand, the active or *action* in French, which is the word for "share" and means "activity," is the price, and because it is the price of the contingent claim, and because potentially all contingent claims should admit of prices and none of them should be redundant, if I were to think of contingent claim in the backward framework of probability and possibility, this would be trying to fall back into the passive sort of picture, because to me, in the end, possibility and probability are no different from debt, as, even though you may have partitioned the world into states, and, as such, assigned different probabilities to them, you have the impression that your world is richer than just default or redemption. Because debt is very simple, either you default or you redeem the debt, meaning that you go back to "one," so, even though you might be under the impression that, by devising a tree of possibilities (like when we price options), this is richer than just zero or one because you think that you have different possibilities open to your option, ultimately the

replication argument will make your option redundant, therefore killing it and turning it as boring as dead debt. This is why probability and the metaphysical representation of the world in terms of states of the world are as passive as debt. What we need is a framework for something that is basically random, like prices; however, it's random in a very strong way, random in such a way that it can never be framed under probability or under states of the world, because whenever you frame something within that you are dead because you can replicate it. It is something that is random; it's a new category of randomness that is never frameable into any kind of identifiable partition into states, and this thing which is infinitely differentiated and where all kinds of payoffs, no matter how complex they are, will never be redundant at any stage *is the market*. I don't know how to deduce the market; I don't deduce it, it's given – that's my postulate, that's absolute contingency.

This should be the ground, this should be the beginning, and this is what happens in practice. In practice, even though you might have developed, as we have in my company, very sophisticated models that include jumps and stochastic volatility or whatever, you are going to calibrate the model to the market prices of the derivatives, and the next day you are going to recalibrate; by definition, the next day you are going to completely change the parameters of the model that you have recalibrated the day before, and therefore you are going to make the model stochastic again. You are yourself enacting the fact and validating the fact that no model, no matter how complex it is – because you are going to use it and calibrate it to the market – no

model is going to be the last word and frame completely the market. The next day, it's going to become itself stochastic and to differentiate again. And it's even stronger than this because even if you don't recalibrate even the previous day, the only reason why you are using this model is to trade options with it, so it's you yourself who intends it to vary from what you devised it for because you want to trade with it; therefore, you want to trade those options at variance with their theoretical value. So, it's almost built in with any pricing model that any prices that it generates should vary and should diverge from the theory because otherwise, like I said, there won't be a market

My shortcut is that as soon as there is a contingent outcome in the future, the only thing that it can have today is a price, via the market

for the derivatives because they would be redundant.

DT: The valuation tool is a way of inserting ourselves into the market. It doesn't necessarily represent the market or represent the particular derivative you are working on.

EA: When I think about it I think the metaphysics of probability and possibility is only a pretext that allows me to price options and to think that I will be able to hedge them in the market continuously, like Black-Scholes says or any more evolved model would say, but it is simply an excuse, a very good excuse, for me, the dynamic trader,

to get inserted and implicated in this market. It's only because I'm going to adjust my hedging to be a dynamic hedger. So, this is basically what pins me to the floor on the market. When I find myself on the market hedging those options, the only thing that I have left is to trade those options because to trade them is to take them away from the prediction of my model – if they were to really follow the prediction of the model, there won't be any meaning in trading them. So, the good thing about dynamic hedging is that it is ultimately designed to be wrong, you see? It's only an excuse to let me be inserted in the market.

DT: So then dynamic hedging and

the use of the valuation tool is merely a means to insert yourself in the market, recalibrate against the market, and then repeat the procedure ...

EA: Absolutely, this is my belief. It is only because the dynamic trader has to be hedging continuously his position in the option and therefore is following the option continuously; it is only because of this that he is basically entitled to compute something we call implied volatility – and implied volatility is the simplest instance of recalibration because I'm basically recalibrating the Black-Scholes model to the option market price, that's implying volatil- >

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ity, if you will. You are able to imply volatility only because you are there to hedge continuously the option. That's my belief, and if you imply volatility – by definition of what you are doing by implying volatility – you are going to re-imply volatility the next minute or the next day, you are going to recalibrate; therefore, you are basically going to contradict the model that brings you here in the first place because by recalibrating you are making volatility stochastic, you are killing the very assumptions of Black–Scholes. This is precisely the idea, that's the good thing about it, that is what you are supposed to do. You need the model to insert the trader on the floor, and you need the

You are basically going to contradict the model that brings you here in the first place because by recalibrating you are making volatility stochastic

trader, of course, to go and address the contingency of the contingent claim and take it outside the frame of possibility and probability and redundancy.

DT: Derivatives are contingent claims. They were invented to see what difference it makes today that a difference should occur later. So, is the contingent claim a tool in much the same way as the valuation model?

EA: What I like about the contingent claim is that it is material, it is not like possible states of the world or probabilities which are only metaphysical abstractions. Contingent claim is something

material; in fact, it's a piece of paper – a contract – on which it is materially written that it will pay off 100 if the underlying is above a certain strike, or zero if not. You see something material, and because it is written with the difference on it, what I call the payoff of the derivative, you can see that it is something differential, because it's not boring, it's not like one all the time. It is something that is zero or something that is different to zero when you are above the strike. There is a differential feature in the payoff, so here you go, something is differentiated because it has a differential feature and it is materially written. So now, the thing that we need to

understand, this is where the movement in thought says that actually the only reason why it is written and available materially at present on the contingent claim, even though it is pointing to a difference that will have to occur later in time, and that it is later in time that we are going to open the box and see if the stock is above the strike or below the strike at maturity, is that it *may admit of a price today*. That's the whole trick; because it is written, the only reason why we are writing is to exchange it, and by exchanging it we mean assigning a price to it, and automatically, just by dint of being written,

the contingent claim is going to exchange, and therefore is going to admit of a price, and this is the shortcut that you get from contingent claim to price, without even going through the category of possibility or probability or expectation or what-have-you. So, writing is the major operative idea here. Writing creates the contingent claim and the exchange.

DT: For an exchange to occur, you need two parties ...

EA: This is what I deduce the next second. My first idea is that, even before thinking of two parties, we think of something that is the exchange place. There is always an inversion of the hierarchy of the logic. The direct link is that writing is equivalent to a difference because if it were not remarkable to remark, then there would be no writing. It is remarkable to say that something is going to pay a 100 above a certain strike and zero below it. It's only because it is remarkable that we mark it on a piece of paper and we write it, for writing is definitely linked to contingency. Writing was invented in the history of humanity because of the exchange, because you basically write something in order to guarantee that whatever you are giving away to your counterparty, you will get something in exchange. The other face of writing is also the exchange; it is writing that allows me to get this shortcut between contingency and price. When I establish that the marketplace is the place where contingent claims receive prices, it's later that I remark that because it is contingent it is "nobody's place in particular," it is there that a lot of people have to meet and exchange the stuff.

As soon as you have written that the only thing that remains is to see

what difference it makes to someone else and see what he's prepared to pay for it, so this is how price is invented. A future contingency translates into a present price. That's a direct derivation.

That's not to say that there is a future contingency, so there are therefore states of the world and we can assign probabilities to them and I have to compute a present value as the expectation of the payoff. That's the received view of probability. My shortcut is that as soon as there is a contingent outcome in the future, the only thing that it can have today is a price, via the market, because the market is the medium for translating contingencies into prices.

DT: So, all those counterparties on the market are inserting themselves into the markets, utilizing the traditional view of probability, in order to evaluate whether they accept what is here on this present contingent claim?

EA: If you want to push my thought to the limit, it is that the market gives price to the contingent claim, anyway – independently of whether we invented probability or possibility or tools or whatever. Actually, that corresponds to everyone's intuition, for a contingent claim. No matter how complex, put it out into the market and the market will find a price. The reason why we have the methodologies is merely to compute a delta and insert the trader into the market. In practice, this is what happens. Traders don't use Black–Scholes to price the options because the market prices the option. They only use Black–Scholes to find implied volatility and to compute the delta.

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