

## Models as Coordination Devices

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A vital lesson that actor-network theory has taught us is that entities normally classed as “technical” contribute crucially to the construction of “society.” Amongst the many entities that play that role are the mathematical models deployed in financial markets. This brief note explores this – still underappreciated – aspect of the performative (Callon 1998) role of models.

It is very easy to imagine that a model will be adopted and retained if it is empirically accurate (if, in particular, patterns of prices conform at least approximately to its postulates), and discarded if it is found not to be an accurate representation of price patterns or market processes. But a model’s empirical accuracy as a representation (even empirical accuracy generated performatively by the use of the model itself, as in the “Barnesian” performativity of the Black-Scholes option pricing model that is the central hypothesis of MacKenzie 2006) is only one virtue that a model may have, and sometimes not the most important one (Millo and MacKenzie 2009). As two authors from intellectual traditions very different – at least superficially<sup>1</sup> – from that to which Callon has contributed so vitally put it:

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<sup>1</sup> Barnes is of course a founding member of what is sometimes called the “Edinburgh school” in the sociology of knowledge, the approach of which is occasionally counterposed – over-polemically – to that of actor-network theory.

Why models and metaphors are necessary and how they function are vast topics, but suffice it to say here that without the coordination of perception and practice around patterns that already exist in other contexts, systematic research could not go forward. Indeed, this is no more than an instance of the more general point that without the models and metaphors current in our shared everyday culture, social coordination quite generally would not be possible, and social life in the sense that human beings know it could not exist. ... If blinkered vision is sometimes encouraged by shared models and metaphors, it is the price that has to be paid for the coordination they allow (Barnes and Dupré 2008, p. 61).

The process emphasized by Barnes and Dupré, coordination, is a crucial aspect of social order, and thus of society, though mathematical models are not usually thought of as contributors to it. How do models facilitate coordination in financial markets? One important way is that models make it possible to simplify, talk about and orient action towards phenomena that in the absence of the models would remain at best complicated and at worst latent and invisible. The Black-Scholes formula, for example, can be used to simplify options – which are complicated financial instruments<sup>2</sup> – by working backwards from the market price of options to the volatility (the so-called “implied volatility”) of the

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<sup>2</sup> An option conveys a right but not an obligation, for example to buy a set quantity of a given asset at a set price (the exercise price) at (or up to) a given future point in time (the expiry). That’s a simple enough idea, but the complication sets in because multiple options on any given asset will normally be being traded, with different exercise prices, expiries, etc.

underlying asset consistent with those option prices. A host of different instruments are thus reduced to a single underlying metric (sometimes the price of options is quoted not as a dollar amount but as an implied volatility level), and a previous latent and invisible phenomenon (the aggregate of market participants' expectations as to the extent to which prices will remain stable or fluctuate wildly) is rendered visible.

At the heart of the credit crisis is a family of models, the Gaussian copula, which a recent article (Salmon 2009) calls “the formula that killed Wall Street” and describes as “fatally flawed.” What’s striking about the history of this model – which will be addressed in detail in MacKenzie (in preparation) – is that it was *always* “fatally flawed,” in the sense of being empirically inaccurate, and was known to be so from the moment it came into widespread use.<sup>3</sup> The Black-Scholes model enjoyed a phase (ended by the 1987 stockmarket crash) in which it was a reasonable fit to patterns of market prices (MacKenzie and Millo 2003 and MacKenzie 2006 argue that patterns of prices adjusted to fit the model); the Gaussian copula never did. Yet the Black-Scholes model retained a central role after 1987, and the always “flawed” Gaussian copula gained one.

Why? An important part of the answer is that in many contexts the role of a model as a representation is less important than its role as a coordination device. In the cases of both Black-Scholes and the Gaussian copula, a variety of different models have long been available that are (perfectly reasonably) believed by their proponents to be

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better representations than the canonical models. The problem, however, lies precisely in the *variety* of such models. Any two big players such as investment banks will normally each prefer a different model. When it's necessary to coordinate (to talk about options or CDOs – collateralized debt obligations, the instruments that the Gaussian copula models; to reach shared assessments of risk or shared views of implied volatility or its Gaussian-copula analogue, base correlation; and so on), one either has to return to the canonical model or face daunting practical difficulties of communication. Black-Scholes or the Gaussian copula is an Esperanto, and a widely-shared Esperanto is far too valuable a coordination device to be surrendered readily.

Just as it's too easy to think of a model as a representation, it's also too easy to think of it as an abstraction or a purely mental entity. Black-Scholes and the Gaussian copula, however, are *material* devices, and their materiality is external as well as internal to human brains. In this respect, there's a subtle difference between the two models. For important classes of options, the Black-Scholes model has analytical solutions, in other words solutions that can be written down as explicit mathematical expressions. The Gaussian copula has such a solution only in a special case,<sup>4</sup> and in consequence computerized techniques are needed: either “semi-analytical” methods such as fast Fourier transforms and numerical integration or full Monte Carlo simulation. Two market participants who employ the Black-Scholes model with the same agreed

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<sup>4</sup> The special case (Vasicek 1991) is that of a single-period CDO or other pool of debt instruments, which consists of a large number of highly granular assets with identical pairwise asset-value correlations. MacKenzie (in preparation) will discuss the failed attempt by J.P. Morgan to make this special case the market Esperanto.

parameters will thus in practice produce close-to-identical option values or implied volatilities, even if using different material devices to generate the solution: the material implementations of arithmetic are homogeneous enough.<sup>5</sup> In contrast, typical differences in the material implementations of semi-analytic or Monte Carlo techniques mean that two participants using the same version of the Gaussian copula with the same inputs will often generate base correlations or values for a CDO tranche that differ to an extent that, while small, can nevertheless be consequential. This has had the effect that an important form of coordination – the capacity to quote a price for a financial instrument not as a dollar amount but as a level of a more stable and more comprehensible theoretical parameter such as implied volatility or base correlation – has been more limited in the CDO market than in the option market.

Because models such as Black-Scholes and the Gaussian copula have become constitutive of financial markets, their “flaws” are often blamed when crises occur. This response is both right and wrong. It is right in that it highlights the centrality of models to market processes. It is wrong in that it remains trapped in the view of a model as a representation and thus misses what Callon has taught us. The “flaws” in the Gaussian copula (in the sense of its deficiencies as a representation) were not what killed Wall Street; rather, what happened was that the entire, huge, highly-ordered pattern of coordinated sociotechnical behaviour that the Gaussian copula helped foster turned disastrously self-undermining.

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<sup>5</sup> They are not, in fact, entirely homogeneous: see MacKenzie (1993).

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