Trend, randomness, and noise:
exogenous vs. endogenous explanation in complex heterodox analysis (A note on Nicolas Bouleau in *RWER* 60)

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In his paper[2] on the role of stochastics in economics, Nicholas Bouleau argues that the role of randomness has in general been underestimated in economics, that "excessive mathematization"[3] of economic theories creates the illusion that only the models need to be perfected, while there is nothing wrong with the economy. This in turn hides the dangers brought about by neoliberalism in general and recent developments in the financial sector in particular. While we sympathize with the main point Bouleau is making, we disagree with several other important points of his analysis.

Two aspects of the theoretical context of Bouleau's analysis seem particularly important:

First, Bouleau's view on randomness is a phenomenological approach stemming from probability theory in mathematics, not a naturalist view as employed for instance in physics. For physicists, trajectory and probability representations are complementary tools for dynamic description. For example, quantum mechanics formulates its theory in deterministic wave equation, but its wave function has a probabilistic explanation. Problems of classical mechanics do not require this approach. In case of a two-body problem in planet motion, its trajectory is well defined. For a three-body problem, the trajectory may be chaotic with limited predictability. With gases or fluids with large numbers of molecules, as in the case of weather prediction, a nonlinear system of deterministic partial differential equations can be used to describe the system and make sufficiently accurate predictions. The critical issue in physics is its space scale. The central problem in economics, however, is its wide range of time scales. Resource depletion and the debate on the limits of growth mainly address issues of energy, resources and the environment in the time scale of decades or centuries; adding some short-term randomness to the trajectory may not change the long-term dynamics. For the behavior of financial markets environmental changes are an issue of secondary importance. For financial market dynamics the relevant time scale may be hours, minutes, seconds, or shorter.

Second, the question of microfoundations of macrodynamics has been raised, for instance in growth theory, which is closely linked to Bouleau's key issue of the debate on the limits of growth following Meadows et al.'s report to the Club of Rome in 1972. However, the best approaches to realize microfoundations so far have not been simple models relying on simple

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[2] Bouleau, Nicolas. (2012), "Limits to growth and stochastics". *real-world economics review*, **60,** 92-106.
[3] Ibid., p. 94.

stochastic processes (as apparently favored by Bouleau) but population dynamics and the agent-based models of evolutionary economics.[4]

Bouleau suggests that in economic analyses of time series and system dynamics, *randomness* should be the central issue instead of *trend*. However, this is a perspective also assumed by conventional neoclassical approaches to growth and dynamics. In neoclassical models, trend is eliminated by applying different filters and the analysis then is focused on the noise term. Bouleau uses the same starting point as also used in behavioral finance, i.e., noise still is considered *exogenous*, although it may be complex.

We do not contest the observation of Bouleau that randomness easily can make it impossible to yield a stable single *equilibrium* as predicted by neoclassical economics. Our contention rather is that complex deterministic mechanisms do affect randomness, and that *complexity* can be better understood in a framework of *endogenous* noise, particularly in a population dynamics framework. Starting from a heterodox theoretical framework and related modeling and systems analysis, we may obtain better insights into empirical dynamics such as, e.g., into the critical dynamics of the speculation sector ("financial markets").

We also agree with Bouleau that a conception of *uncertainty* different from that given by just *volatility* is required in critical economic analysis of growth and dynamics. However, the main issue is not just a question of how *randomness* affects the *trend*. Going beyond that, we contend that there is no strict separation between trend and uncertainty. We suggest using *endogenous noise* based on a *population process* rather than exogenous noise. Exogenous noise, in the last instance, leads to a representative-agent model as in neoclassical theory. However, in the real world and hence also in realistic models, agents who generate the trend are exactly those who generate the fluctuations, thus randomness and trend are both endogenous.

This all is also not a question of the relative weights of randomness and deterministic functions but rather one of the *length of the time window,* in which we observe the trend-volatility interaction. For example, we may pursue a historical analysis with a trend in a long-run time window or a psychological analysis with randomness in a short-run time window, or analyze the *feedback between trend and noise* in another appropriate and feasible time window. A more general framework would not only consider randomness to be added to the trend but also the trend to be imposed on randomness. The trend is not only masked by volatility; the stochastic patterns may, in fact, not be constant and may change with the trend. This will still be consistent with a proper stochastic process because all exogenous noises are special cases of a population process with endogenous noise. A broader and theoretically more appropriate deterministic analysis in this sense does not mean simplicity, and it is different from, and incompatible with, the core of neoclassical economics. For example, *innovation* is not an exogenous random event that can hide some trend in empirical dynamics of systems, but it endogenously interacts with trends of, say, the exhausting of fossil fuels.

Those different perspectives on noise may determine how to deal with the issues raised in Meadows et al.'s report to the Club of Rome. If we used exogenous noise here, exhausting fossil fuel would have to be considered a shock to the efficient market. Otherwise, in the perspective we indicated above, governments would have to do something to ensure that the

[4] For an overview, see for instance Heinrich, Torsten. (forthcoming 2013), "Technological Change and Network Effects in Growth Regimes: Exploring the Microfoundations of Economic Growth", London: Routledge.

random innovation process can catch up with the fossil fuel exhaustion, as neoliberalism may turn out not to be a reliable and sufficient mechanism to ensure a proper interaction of the exhausting of fossil fuel and innovation. As Bouleau argues "it is impossible to tell from the trajectory what would have happened without that randomness".[5] But endogenous noise is interrelated with a deterministic trend, and it is impossible to tell from randomness what would have happened without that deterministic mechanism.

For example, financial market behavior typically shows turbulences, which are rooted in social interactions among agents. If agents make decisions independently (i.e. with weak interactions), the aggregate series would look like a short-term correlated time series without trend. If, however, decision-making is not independent (i.e. with strong interactions), the aggregate series is highly correlated with changing trends. The neoclassical perspective in finance simply ignores social correlations and thus changing trends. Behavioral economists realize the existence of social interaction, but do generally not attempt to create modified financial models to include population behavior and changing trends.

In empirical observations and analyses by Tang and Chen,[6] for instance, the particular conditions of the *financial crisis* could be calculated (before the crisis) and observed from both deterministic and random mechanics perspectives. The background and mechanisms basically were the same but the positive feedbacks in the process of blowing up the bubble eventually ended and the trend changed its direction. It was found that then, suddenly, the speculation sector panicked. This was a combined effect of endogenous deterministic and 'random' mechanisms. In the *long-term* financial-market dynamics, deterministic transition probabilities as those rooted in complexity theory were observed by averaging daily price ups and downs in a long-term time window. However, the *short-term* possibility of a financial crisis could be observed and analyzed using stochastic methods, particularly by monitoring the *higher moments* of the data distribution, ranging from 3rd to 5th order, i.e. *randomness by moments higher than the variance*.

Our answer to Bouleau's question "whether price formation in markets is truly stochastic in nature or whether it is governed by some complex, chaotic mechanism"[7], therefore, is: It depends on the *time horizon* of the analysis, as stochastic and chaotic mechanisms are critically depending on the time window in which we observe human behavior.

In the case of the financial sector we contend, that it was the *phase of de-regulation during the Reagan administration* that caused the instability of this sector and eventually the current financial crisis and bubble implosion (so far moderated by sinking current and future taxpayers' money). The sector may be described as consisting of *two different regimes of sector dynamics*. One is a "*calm regime"*, where *randomness is restricted by the trend*. The other one is a "*turbulent regime"* with a high crisis probability, where *randomness interacts with the trend* through particular feedback mechanisms. In the period 1950-1980, the financial sector largely was in the "calm regime"; since 1981, however, it has become ever more turbulent and fragile. In sum, in our understanding and approach of *endogenous noise*,

[5] Bouleau, Nicolas. (2012), "Limits to growth and stochastics". *real-world economics review*, **60,** 92-106, p. 97.
[6] Tang, Yinan and Chen, Ping. (2012), "Time Varying Moments, Dynamic Instability, and Crisis Warning", working paper. Tang, Yinan and Chen, Ping. (2012), "Transition Probability, Dynamic Regimes, and Diagnosis of Financial Crisis", working paper.
[7] Bouleau, Nicolas. (2012), "Limits to growth and stochastics". *real-world economics review*, **60,** 92-106, p. 99.

deterministic analysis will yield the opposite conclusion of neoclassical economics, models and measurement.

Put more philosophical, *exogenous noise* has a fundamental problem that mirrors the inertial reference of Newtonian mechanics in physics: Whenever it is attempted to describe the motion of an inertial reference in Newtonian mechanics, a new inertial reference must be introduced. And whenever one tries to endogenously explain something in the exogenous noise approach, one must introduce another exogenous noise. This will trigger an infinite recourse until, figuratively speaking, we find the "God" who produces the initial noise and the absolute inertial reference. For example, if we take *innovation* as an exogenous shock for stock prices, there must be some other exogenous shock to analyze, say, R&D expenses, when trying to explain innovation. In this recourse, we will find the new introduced noises becoming simpler and simpler. Hence exogenous-noise models can hardly challenge neoclassical theory; this would come down to the mere assumption that "God" is inefficient.

The epistemological status of an endogenous-noise approach, in contrast, appears similar to the relativity theory of Einstein with weakened assumptions: Relativity theory does not need an inertial reference, and our approach does not need an exogenous noise source.

Finally, when we try to deal with the microfoundations of the complex dynamics of human society, we will not be hampered by deterministic mechanisms, but would be hampered by exogenous noise. Trend and randomness in endogenous-noise approaches show that human behavior has a particular time structure. This is related to the idea of *evolutionary modeling*. For example, in an *evolutionary model* of structural emergence, agents may make decisions in a deterministic initial institutional setting, and the randomness of agents' decisions usually will change the initial institutional setting through institutional emergence and change[8]. This implies a feedback mechanism between endogenous 'trend' and 'noise' in a population model, where the main randomness of agents' decisions is not from reacting to exogenous shocks but from uncertainty, individual search behavior, and particular agency capabilities.

Bouleau tried to use the extended implication of randomness to question the validity of the IPCC (Intergovernmental Panel on Climate Change) positions. This implies that uncertainty in the financial sector would impose analytical difficulties in modeling macrodynamics. We doubt this reasoning. Historically, climate change is the driving force for biological evolution. In human society, technological change has a tremendous impact on climate and ecological change, which in turn has a fundamental impact on social and economic behavior. The financial sector may have a short-term impact on social behavior, but little influence on long-term technological trends.

However, we do appreciate Bouleau's insight that interest groups may have a different framework when addressing social issues. That is why European countries do have a strong support for a zero-growth paradigm, while developing countries do not and while U.S. governments have strong ties with the financial sector. We all know the simple truth that says: "Traders like volatility."

[8] See, e.g., Elsner, Wolfram and Heinrich, Torsten. (2011) "Coordination on 'Meso'-Levels: On the Co-evolution of Institutions, Networks and Platform Size", in: S. Mann (Ed.), *Sectors Matter! Exploring Mesoeconomics*, Berlin, Heidelberg: Springer, 115-63.

Bouleau offers an important critique of the way models are constructed in economics, to the degree to which this may mask crucial factors instead of highlighting them. We do, however, believe that the problem does not lie with randomness in general, but rather with the bewildering lack of proper microfoundations on the one hand and the failure to devise models able to consider complex feedback mechanisms, systems with different regimes, and other common traits of complex systems.

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