Vienna University of Economics and Business Administration
Institute of Finance and Financial Markets
Professor Dr. Otto Loistl
Department of Investment Banking and Capital Markets Communication
Althanstraße 39-45, 1090 Vienna, Austria, Europe

Catallactics: Research Results on Quantitative Modelling of Human Interacting provided by Market Exchanges

Explanatory statement on the planned publication series with the title cited above

Catallactics – the science of human interacting provided by market exchanges

The term "catallactics" has been in common use in economics since the 1920s. At that time, human interacting enabled by exchanges on markets was recognised as driving force for discovering solutions to economic issues and theoretical challenges. Catallactics was, and still is, the science of the capabilities provided by markets, or, more precisely, the effects of human interactions brought forward by markets. Nobel Prizes repeatedly awarded to prominent scholars of this field underline its eminent and lasting importance.

Nobel Prize awards emphasise importance of catallactic research approaches

Particularly, Austrian School economists stretched market processes and their effects as problem-solving mechanism; Schumpeter and von Hayek may be mentioned here as prominent scholars. The latter was awarded the Nobel Prize in 1974. The Nobel Prize awarded to Buchanan for his comprehensive and innovative "development of the contractual and constitutional bases for the theory of economic and political decision-making" [The Royal Swedish Academy of Sciences (2002b)] in 1986 as well as the recent awards to Kahneman and Smith in 2002 and Akerlof, Spence and Stiglitz in 2001 emphasise the importance of the catallactic research paradigm again. After Hayek, however, there was a longer break in awards for research results achieved by this view. For several years accomplishments in explaining economic forces by equilibrium concepts, an abstraction from the concrete activities performed on markets accentuated in catallactics, have been awarded. This abstraction from individual activities was appropriate to structuring the general economic determinants on the macro-level. The principles of human interactions on the micro-level, however, may not be put in place under the equilibrium assumption. The decisive question of the determining forces on the micro-level could not be raised and was not raised. The equilibrium research design's major problem is accentuated by the contradiction in terms that arbitrage opportunities might be discovered and exploited by the application of methods based on the assumption of an arbitrage-free world, i.e. the non-existence of arbitrage opportunities.

Market microstructure goes beyond the paradigm of capital market equilibrium

The necessity to refer to human interaction in order to model the real market performance reliably was however stressed by prominent scholars even during the dominance of the capital market equilibrium paradigm further on:

Kirzner's (1997) synopsis of the Austrian approach to understanding economic processes, for instance, points out the lack of explanatory power of equilibrium models [Cf. Kirzner (1997), p. 61]. Such models explain economic phenomena solely by the conditions of an already-attained equilibrium and/or the non-existence of arbitrage opportunities. Processes from non-equilibrium states to an unique equilibrium state (or several equilibrium states) are not modelled on the level of real human behaviour; they are formal mathematical constructs, e.g. fixed-point systems. A plausible explanation of how equilibrating tendencies might be caused by real human action is not offered [Cf. Kirzner (1997), p. 61]. Tâtonnement processes have already been characterised as swindle by Solow; moreover, he suspects that Walras knew it [Cf. Solow (1956), p. 88]. It is still an open, i.e. not yet investigated, issue whether approaches based on chaos-theoretic concepts are capable of grasping human-controlled interactions.

Establishing "mathematics of human interaction"

Buchanan (2001) consequently pointed out the fundamental necessity of explicitly modelling human interactions in his positive appraisal of von Neumann and Morgenstern's "The Theory of Games and Economic Behaviour". He convincingly shows that even game theory fails to comprehend the advantages of modelling human voluntary exchange as the most fundamental driving economic force [Cf. Buchanan (2001), p. 29]. One may add that in capital market equilibrium theory relying on the "non-existence of arbitrage"-paradigm this basic necessity is realised neither. Buchanan (2001) therefore calls for an explicit consideration of human interaction despite his generally positive appraisal of game theory's achievements. He postulates the displacement of the now-familiar "mathematics of maximization" by an ultimately more useful "mathematics of human interaction" as well as the development of relevant quantitative instruments [Cf. Buchanan (2001), p. 31].

The increasingly accentuated discrepancy between real human decision-making behaviour and today's standard assumptions in economics is comprehensively confirmed by Kahneman and Smith's theoretical and empirical studies [Cf. The Royal Swedish Academy of Sciences (2002a)]. Human beings act in markets; psychology is increasingly becoming an inherent part of economics.

Profoundly expanding our understanding of markets goes hand in hand with deepening our insights into people. The behaviour and information-processing of market participants is rightly the focus of behavioural finance literature [Cf., for instance, Shiller (2000)].

Implementation in the model of capital market synergetics

By applying McFadden's discrete choice models [Cf. The Royal Swedish Academy of Sciences (2000)] we developed in formal terms the explicit human behaviour in markets by capital market synergetics [Loistl/Landes (eds.) (1989); Landes/Loistl (1992); Vogt (1993); Füser (1994); Haffner (1995); Schneider (1998); Casey (2000); Loistl/Vetter (2000)]. The realistic formal modelling of human decision-making explicitly takes into account the interactions enabled by exchanges on markets and thereby grants these forces the central role they ever played in reality also in economic models. The focus of our research program on human interaction will be adequately emphasised by the term "catallactics". Current research further specifies the basic model's appropriateness to modelling real market situations with interacting participants [Cf. Loistl et al. (2001, 2002); Pax (2002); Schossmann (2002); Veverka (2002); Wolfger (2002); Zwick (2002)]. An analogy of the formal methods applied by us to nuclear physics explicates the philosophy of our approach:

We apply stochastic differential equations introduced by the pioneers of nuclear physics like Fokker and Planck, developing the famous Fokker-Planck equation, a stochastic differential equation modelling both time and state space continuously [Cf. Risken (1984)].

For modelling stock market performance on the micro-level, however, we think a stochastic process with continuous time and discrete state space might be appropriate. This form of stochastic differential equation is commonly termed master equation [Cf. Haken (1983), p. 88ff.]. The discrete state space is appropriate as security price changes occur in discrete increments, even if the minimum increments become smaller [Cf. Loistl et al. (2003)]. And also the continuous time assumption is appropriate: it provides the possibility that events might happen at any point in time, determined by the endogenous forces prevailing at the market by the preferences of the market participants. Security trades happen at asynchronous time points that could not be predetermined in advance. Real times series of price quotations are certainly not equidistant [Cf. Campbell et al. (1997), p. 84ff., and the literature cited therein].

The evolution of the market state z is then represented by the time evolution of the probability function of z, $P_t(z)$, obeying the so-called *master equation*, a linear differential equation determining the transition rates for the transition $z \to z'$, i.e. the transition from state z to state z' [Landes/Loistl (1992), p. 215]:

$$\frac{\mathrm{d}}{\mathrm{d}t} P_t(z) = \sum_{z' \neq z} l(z, z') P_t(z') - \sum_{z' \neq z} l(z', z) P_t(z)$$

We can handle the challenge of realising both the requirements of applying a memoryless Markov process on the one hand and that acting people keep in mind the history of events on the other by a specific condition originating the catallactic/KapSyn system of master equations:

The transition rate $l(z',z)$ of the transition $z \to z'$ called forth by the activity A of agent i in state z is determined by the relation [Landes/Loistl (1992), p. 214]

$$l(z',z) = We^{\Phi(A,z)} .$$

Transition rates are determined by (an exponential function whose exponent is) the utility generated by the activity A causing the transition $z \to z'$. The term $\Phi(A,z)$ corresponds to the utility of the activity A chosen in the market state z. [Details are given in Landes/Loistl (1992), p. 220ff.]

But we do not intend to simplify this system of stochastic differential equations to attain an analytically tractable system that is however only a certainly insufficient proxy of the real world. Our purpose is to model a system that is a realistic isomorphic model of the true performance at the market's microstructure.

We rely on numerical solutions. Our first goal is therefore not to deriving analytical solutions at the expense of the isomorphic structure. With appropriate computer power available, a numerical solution is possible. By the way, nobody would seriously restrict the modelling of space science to differential equations that can be solved analytically. The same is true for modelling the pricing of exotic options. Its numerical solution is now an issue where much research effort is devoted to. [Cf. Wilmott (1998), p. 613ff., and Schäfer (1998)].

We are convinced that the term “catallactics” describes our research program adequately and characterises the research results’ publication series appropriately. The term is still well known by people engaged in dynamic economic modelling. It will be used again by mainstream economic thinking like in the 1920/30s after realising and overcoming the shortcomings of equilibrium approaches, becoming aware of the importance of realistic market performance even in theoretical modelling. We believe there is no need to introduce a new term as an appropriate one already exists but was wrongly forgotten in the times of equilibrium euphoria. Recent Nobel Prize awards also show that the research momentum is with catallactics again and not with capital market equilibrium.

Vienna, 9 January 2003

Otto Loistl and Markus Rudolf

PS: We do not propose the originally applied term “KapSyn” (following synergetics) as title for our planned publication series even if our research concept bears this name. In our opinion, synergetics fails to embrace the central role interacting individuals play in economics. Our model’s decisive achievement is the interactive flexible implementation of transition rates controlled by human actions’ attractiveness. Transition probabilities are held constant in physics, even in the physics of synergetics. Arthur (1988) of the Santa Fe Institute also mentions the master equation well known as introduced to physics already a long time ago [Cf. Arthur (1988), p. 23ff.]. However, we believe that a catallactic modelling of human behaviour deserves the interactive determination of transition rates by actions’ attractiveness. The specific form of the master equation used in our model fulfils this property. The basic ideas of our model are provided by Landes/Loistl (1992). Even if this paper might be difficult to get from the original source, it is now available from our Institute’s homepage under <http://ifm.wu-wien.ac.at/Forschung/KapSynDLDefault.html>.

Cited Literature

Arthur, W.B. (1988): Self-Reinforcing Mechanisms in Economics, in: Anderson, P.W./Arrow, K.J./Pines, D. (eds.): The Economy as an Evolving Complex System, Santa Fe Institute Studies in the Sciences of Complexity, New York u.a., pp. 9-31.

Buchanan, J.M. (2001): Game theory, mathematics, and economics, Journal of Economic Methodology 8, pp. 27-32. German translation provided by Hartmut Kliemt: Buchanan, J.M. (2001): Spieltheorie, Mathematik und Wirtschaftswissenschaft, in: Grüske, K.-D. (Hrsg.): Vademecum zu dem Klassiker der Spieltheorie, Düsseldorf, pp. 103-110.

Campbell, J.Y./Lo, A.W./MacKinlay, A.C. (1997): The Econometrics of Financial Markets, Princeton (NJ).

Casey, C. (2000): Corporate Valuation and Market Price Determination. The Microstructure of Capital Markets, Wiesbaden. [in German]

Füser, K. (1994): Forecasting Capabilities of Capital Market Synergetics. Neural Networks for Preference Pattern Recognition and Parallel Computing using Transputers to Enhance Performance, Ludwigsburg u.a. [in German]

Haffner, C. (1995): Modelling Real Stock Market Events by Capital Market Synergetics, Frankfurt am Main u.a. [in German]

Haken, H. (1983): Synergetics. An Introduction. Nonequilibrium Phase Transitions and Self-Organization in Physics, Chemistry, and Biology, 3rd revised and enlarged edition, Springer Series in Synergetics, Berlin u.a.

Kirzner, I.M. (1997): Entrepreneurial Discovery and the Competitive Market Process: An Austrian Approach, Journal of Economic Literature 35, pp. 60-85.

Landes, T./Loistl, O. (1992): Complexity Models in Financial Markets, Applied Stochastic Models and Data Analysis 8, pp. 209-228.

Loistl, O./Landes, T. (eds.) (1989): The Dynamic Pricing of Financial Assets, Hamburg.

Loistl, O./Schossmann, B./Vetter, O. (2001): XETRA Efficiency Evaluation and NASDAQ Modelling by KapSyn, European Journal of Operational Research 135, pp. 270-295.

Loistl, O./Schossmann, B./Vetter, O./Veverka, A. (2002): A Comparison of Transaction Costs on Xetra and on Nasdaq, Quantitative Finance 2, pp. 199-216.

Loistl, O./Schossmann, B./Veverka, A. (2003): Tick Size and Spreads: The Case of Nasdaq's Decimalization, European Journal of Operational Research, forthcoming.

Loistl, O./Vetter, O. (2000): KapSyn. Computer-Modelled Stock Exchanges, User Handbook, Version 3.01, 130 pages (downloadable from website http://ifm.wu-wien.ac.at/Forschung/KapSynDLDefault.html).

Pax, N. (2002): Quantitative Determination of Market Impact and Market Liquidity, work in progress. [in German]

Risken, H. (1984): The Fokker-Planck Equation. Methods of Solution and Applications, Springer Series in Synergetics, Berlin u.a.

Schäfer, M. (1998): Application and Valuation of Exotic Options, Wiesbaden [in German]

Schneider, C. (1998): System Analysis with Kohonen Cards. A Capital Market Model, Frankfurt am Main u.a. [in German]

Schossmann, B. (2002): The Implementation of Nasdaq at KapSyn, work in progress.

Shiller, R.J. (2000): Irrational Exuberance, Princeton (NJ).

Solow, R. (1956): Review of Léon Walras' Elements of Pure Economics, translated by William Jaffé, Econometrica 24, pp. 87-89.

The Royal Swedish Academy of Sciences (2000): Advanced Information on the Bank of Sweden Prize in Economic Sciences in Memory of Alfred Nobel. The Scientific Contributions of James Heckman and Daniel McFadden, Stockholm.

The Royal Swedish Academy of Sciences (2002a): Advanced Information on the Prize in Economic Sciences 2002. Foundations of Behavioral and Experimental Economics: Daniel Kahneman and Vernon Smith, Stockholm.

The Royal Swedish Academy of Sciences (2002b): Homepage of The Royal Swedish Academy of Sciences, Motivation for the Prize in Economics 1986 to James M. Buchanan, Jr., http://www.kva.se/KVA_Root/eng/awards/nobel/economy/index.asp.

Veverka, A. (2002): Operating Efficiency of Trading Platforms. Optimal Design of Xetra and Nasdaq, work in progress. [in German]

Vogt, C. (1993): Analysing the Microstructure of Real Capital Markets: Equilibrium Theory versus Non-equilibrium Reality, Dissertation, Universität – Gesamthochschule Paderborn, Paderborn. [in German]

Wilmott, P. (1998): Derivatives. The Theory and Practice of Financial Engineering, New York u.a.

Wolfger, B. (2002): Computer-Modelling of Real Stock Exchange Events: The Market Microstructure of Tradepoint Stock Exchange by means of KapSyn Microstructure Modelling, to appear in "Series on Catallactics: Research Results on Quantitative Modelling of Human Interacting provided by Market Exchanges", Volume 2.

Zwick, H. (2002): Agent-based Modelling of Exchange Rate Determination. The Microstructure of Foreign Exchange Markets, to appear in "Series on Catallactics: Research Results on Quantitative Modelling of Human Interacting provided by Market Exchanges", Volume 1. [in German]