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When Muth's Entrepreneurs Meet Schrödinger's Cat

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Abstract

In his 1961 seminal paper, Muth applied his "rational expectations" hypothesis to a simple model of a competitive market for a homogeneous good produced under random shocks. The hypothesis goes beyond the Marshallian expectational approach to equilibrium in attributing to entrepreneurs the capacity to form theory-based price predictions. We find this capacity already in Cournot (1838), although in a model without explicit fundamental uncertainty. The purpose of this note is to show within the same model that oligopolistic competition adds indeterminacy, hence market uncertainty, to the picture, weakening in some sense the rational expectations hypothesis. Before equilibrium is realised, each entrepreneur stands in a hawkish-dovish superposition, very much as the Schrödinger's cat is in a dead-living superposition.

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1 Introduction

The "rational expectations" hypothesis is, first of all, an ingredient of an equilibrium concept: expectations held about future endogenous variables contribute, through the actions they induce, to the determination of those variables, the value of which should end up as expected for equilibrium to obtain. There is however more in the hypothesis: "expectations, since they are informed predictions of future events, are essentially the same as the predictions of the relevant economic theory" (Muth 1961, p.316). That is what makes Muth call them "rational." That is also what distinguishes "rational expectations" from "perfect foresight," which is simply "an equilibrium concept rather than a condition of individual rationality" (Grossman 1981).

In spite of being the same as the predictions of the relevant theory, rational expectations concern objects that are not immune to their mental representation, so that the theory itself is not complete without the beliefs which rule expectation formation. The future is not just waiting for our observations to come: it is actually the product of the actions we undertake under the guidance of our predictions. Beliefs must consequently be included in the theory and be part of the equilbrium concept. So, the door is open to the existence of "self-fulfilling prophecies" (Azariadis 1981, Azariadis and Guesnerie 1982, Cass and Shell 1983):

> "In a Lucas-type model, any solution may be considered as an (autonomous) *self-fulfilling theory*: if the agents believe in that theory, their behaviour will be such that the theory will be exactly confirmed by the evidence. Our results can thus be interpreted as follows: in the model we analyze, there exists a *continuous infinity of* (autonomous) *self-fulfilling theories*; and in *all* these theories – except the one of Lucas – money is non-'strongly neutral' [...]" (Chiappori and Guesnerie 1990, p.2).

General equilibrium theory as well as macroeconomics, in particular of the New Keynesian brand, have largely made use of this feature of rational expectations and of the equilibrium indeterminacy to which it may contribute.[1] This note is not intended to pursue along those lines. My purpose is to go back to the microeconomic origins of the concept and to examine in

[1] In Arrow-Debreu economies, equilibrium determinacy, or local uniqueness, is a generic property. Many departures from Arrow-Debreu are however conducive to indeterminacy, that is, to the existence of a continuum of equilibria. For a survey on indeterminacy in macroeconomic dynamic general equilibrium models, see Benhabib and Farmer (1999).

a simple model – the one used by Muth (1961) – how indeterminacy steps in as soon as individual actions have a non-negligible impact on the outcome to be predicted.[2] Also, more than the influence of beliefs, or theories, I want to stress the importance of predictions of others' conduct when agents act strategically. Instead of, or in addition to, *fundamental uncertainty*, we have now *market uncertainty* together with a coordination issue:

> "In attempting to optimize her own actions, each agent must attempt to predict the actions of the other agents. A, in forecasting the market strategy of B, must forecast B's forecasts of the forecasts of others including those of A herself. An entrepreneur is uncertain about the moves of his customers and his rivals, and they of his moves. It is not surprising that this process may generate uncertainty in outcomes even in the extreme case in which the fundamentals are non-stochastic. The uncertainty generated by the economy is *market uncertainty*. It is either created by the economy or adopted from outside the economy as a means of coordinating the plans of individual agents. Market uncertainty is not transmitted through the fundamentals. It can be driven by *extrinsic uncertainty*" (Shell 2008).

We know since Cournot (1838) that producers' price expectations, conditional on their knowledge of the objective inverse demand and on their conjectures of competitors' decisions, incorporate the impact of their own quantity strategies on the future market price. And we further know since Bertrand (1883) that producers may face, rather than gentle competitors willing to accomodate others' sales targets, fierce undercutting rivals ready to trigger a price war. In other words, in order to form rational expectations of the future market price, entrepreneurs have not only to use the relevant economic theory – the "law of demand" – together with their conjectures of others' quantity strategies. They must also identify each competitor's type, whether a dove or a hawk, with the caveat that this type is not predetermined but revealed only at equilibrium, very much as the cat imagined by Schrödinger (1935) collapses from its dead-alive superposition only after the box has been opened:

> "A cat is penned up in a steel chamber, along with the following device (which must be secured against direct interference

[2]Guesnerie (1992) has revisited much more deeply Muth's model from a game-theoretic viewpoint, but sticking to the assumption of infinitesimal agents.

> by the cat): in a Geiger counter there is a tiny bit of radioactive substance, so small, that perhaps in the course of the hour one of the atoms decays, but also, with equal probability, perhaps none; if it happens, the counter tube discharges and through a relay releases a hammer which shatters a small flask of hydrocyanic acid. If one has left this entire system to itself for an hour, one would say that the cat still lives if meanwhile no atom has decayed. The psi-function of the entire system would express this by having in it the living and dead cat (pardon the expression) mixed or smeared out in equal parts.
>
> It is typical of these cases that an indeterminacy originally restricted to the atomic domain becomes transformed into macroscopic indeterminacy, which can then be resolved by direct observation" (Schrödinger 1935).

In the following, I will recall in section 2 the Marshallian model designed by Muth (1961) and his use of rational expectations to deal with fundamental uncertainty, and I will consider in section 3 how equilibrium indeterminacy generated by strategic interaction creates market uncertainty and concern for coordination, deeply modifying the working of the model. I will briefly conclude in section 4.

2 From Marshall to Muth

2.1 Equilibrium as an expectational concept

Phelps (1987) has emphasized the expectational nature of economic equilibrium, which implies an outcome that conforms to the expectations of the participants in the economy. He refers in particular to Myrdal and Hayek as the pioneers of this view, but Marshall's (short period) equilibrium is already explicitly an expectational concept:

> "In such a market [with much free competition] there is a demand price for each amount of the commodity, that is, a price at which each particular amount of the commodity can find purchasers in a day or week or year. [...L]et us assume that the normal supply price of any amount of that commodity [...] is *the price the expectation of which* will just suffice to maintain the existing aggregate amount of production. [...]When the demand price is equal to the supply price, the amount produced

has no tendency either to be increased or to be diminished; it is in equilibrium" (Marshall 1920, V,III, 4 and 6; my emphasis).

It is easy to design a model of a competitive market for a homogeneous good corresponding to this passage. I will adopt the linear-quadratic specification used by Muth (1961) and make use of the Marshallian concept of *representative firm*.[3] If the representative firm can sell, at market price P, an amount $q = \alpha - \beta P$ (with positive coefficients α and β), we can take as the *demand price*

$$P = (\alpha - q)/\beta. \tag{1}$$

This price, set by professional dealers acting as intermediaries between buyers and sellers (cf. Marshall 1920, V, II, 2), is the price that will actually prevail if an amount q of the commodity is brought to the market. I assume that the cost of producing this amount is $q^2/2\gamma$, so that the corresponding expected profit, given the *expected price* P^e, is given by the difference $P^e q - q^2/2\gamma$. Maximizing it in q leads to the *supply price*

$$P^e = q/\gamma, \tag{2}$$

equal to marginal cost. Using the equilibrium condition (that the price expectation be correct)

$$P^e = P, \tag{3}$$

we obtain the equilibrium values

$$q^* = \alpha\gamma/(\beta + \gamma) \text{ and } P^* = \alpha/(\beta + \gamma). \tag{4}$$

If the equilibrium condition is not satisfied, entrepreneurs' expectations will appear to be wrong, leading the entrepreneurs to engage in a process of error correction, which is out of my concern in this note.

[3] The "representative firm is in a sense an average firm" (Marshall 1920, IV, XIII, 2). Formally, take an industry with a continuum of unit mass of infinitesimal *not necessarily identical* firms, whose actions are thus individually unable to affect the market outcome, a condition for the market to be perfectly competitive. As the continuum of firms has unit mass, its aggregate and average behaviour coincide. This behaviour can be attributed to that of the representative firm, provided it can be rationalised as the behaviour of a virtual firm in a competitive market.

2.2 Rational expectations

Muth (1961) introduces stochastic "variations in yields due to weather" represented by a random variable u such that the decision to produce a quantity q translates in fact into an output $q+u$. Notice that the shocks on production are supposed to be perfectly correlated across firms. I assume the random variable u to be normally distributed, with zero mean and variance small enough to make negligible the probability of obtaining negative values for $q+u$. Taking again the production cost to be $q^2/2\gamma$, the expected profit from deciding to produce the amount q is

$$\mathbb{E}\left(P\left(q+u\right)-q^2/2\gamma\right)=\mathbb{E}\left(P\right)q+\mathbb{E}\left(Pu\right)-q^2/2\gamma. \tag{5}$$

The second term on the right-hand side cannot be taken as nil, since P is affected by the shocks on aggregate production, but it does not depend upon the decision variable q because the firm is infinitesimal. We thus obtain a problem of maximization of $\mathbb{E}\left(P\right)q-q^2/2\gamma$, identical to the corresponding problem in Marshall and having a certainty equivalent solution $q=\gamma\mathbb{E}\left(P\right)$.

That P is here taken as independent from q, a consequence of firms being negligible with respect to market size, is a feature common to Marshall and Muth. The difference is that Muth's price expectation is not, as in Marshall's case, some *a priori* arbitrary expected price P^e, of course required to be equal to the demand price P at equilibrium. It is the mathematical expectation $\mathbb{E}\left(P\right)$ assumed to be predicted by the entrepreneurs in accordance with the theory. Here, the theory is just the condition of equality of demand $\alpha-\beta P$ and supply $\gamma\mathbb{E}\left(P\right)+u$, together with the knowledge of the distribution of u (with $\mathbb{E}\left(u\right)=0$), so that $\mathbb{E}\left(P\right)=\alpha/\left(\beta+\gamma\right)$. By construction, entrepreneurs are assumed to expect, not an arbitrary price P^e, but the specific price $\alpha/\left(\beta+\gamma\right)$. The difference between the two authors' analyses is however, at this stage, essentially a difference of interpretation: "the problem we have been discussing so far is of little empirical interest, because the shocks were assumed to be completely unpredictable." (Muth 1961, p.318). Muth considers then the case of serially correlated disturbances, a case where the theory is more informative, allowing to improve expectation formation by the entrepreneurs. This extension is, again, out of my concern in this note.

3 Back to Cournot and Bertrand

3.1 Equilibrium in the context of strategic interaction

Marshall's and Muth's entrepreneurs act in competitive markets, form expectations about market prices which they cannot influence and face uncertainty concerning the sole fundamentals. Cournot's producers act in oligopolistic markets, make theory-based price predictions, taking into account the influence of their own strategies together with the conjectured strategies of their competitors.

I shall use the same model to present Cournot competition (1838, ch.VII), with inverse demand $P = (\alpha - Q/n)/\beta$, where the output q of the representative firm is replaced by the average output $Q/n \equiv \sum_j q_j/n$ supplied by n firms, each firm i producing an amount q_i at cost $q_i^2/2\gamma$. Entrepreneur i conjectures and takes as given the sales targets of his competitors, so that his price prediction, for a sales target q_i, is $P = \left(\alpha - \left(\sum_{j \neq i} q_j + q_i\right)/n\right)/\beta$. His expected profit is given by the difference $Pq_i - q_i^2/2\gamma$, the maximization of which implies the first order condition $q_i = (\alpha - Q/n)/(1/n + \beta/\gamma)$, the same for any firm, leading to the symmetric equilibrium: $q^* = \alpha\gamma/(\beta + \gamma + \gamma/n)$. The equilibrium price is accordingly $P^* = \alpha/(\beta + \gamma/(1 + \gamma/\beta n))$. If the number of firms increases indefinitely, market power eventually vanishes, competition becoming *indefinite* (Cournot's term for the later "perfect"), and the equilibrium values q^* and P^* tend to their Marshallian values.[4]

At this point, what must be emphasized is that we are not just requiring that the price expectations of Cournot's entrepreneurs be consistent at equilibrium with the predictions of the theory. We are assuming that the entrepreneurs use the theory to form expectations about the impact of their own decisions on the future market price. There is however a hole in Cournot's construction. Although he writes that the choice of the sales target q_i is effected "by properly modifying the price," the way this modification comes about is left implicit, except that we are told that "the price is necessarily the same" for each entrepreneur, so that there is no place for a vector of prices $(p_1, ..., p_n)$. Bertrand (1883) ignores this condition and

[4] In a market with a continuum $[0, 1]$ of infinitesimal firms, the output of the representative firm is by definition equal to average (as well as total) output. With large firms, a convenient way to consider the convergence of Cournot to competitive equilibrium as the market becomes indefinitely large is to introduce market replication, on both sides. On the demand side, by taking demand $D(P, n) = n(\alpha - \beta P)$, inverse demand is $P = (\alpha - Q/n)/\beta$ as I have assumed (see Frayssé 1986, III.5). On the supply side, we would in general have to multiply by n the proportion of firms of each type, but I have directly assumed a single type, to simplify the exposition.

objects to Cournot that entrepreneurs would undercut each other in order to increase their market shares (actually, in order to take over the whole market), thus engaging in a price war that would have no limit.

3.2 Market uncertainty

Let us now suppose that entrepreneurs are Cournotian, in the sense that they accept to accomodate their competitors' sales targets and in the sense that they know that the law of one price applies. As a consequence, they form the market price expectation: $P(Q) = (\alpha - Q/n)/\beta$, where $Q = \sum_j q_j$ is the sum of all entrepreneurs' sales targets. However, entrepreneurs are also supposed non-Cournotian, in the sense that they cannot fully manipulate alone the market price. Each entrepreneur i can only announce his own price p_i, under two constraints:

$$p_i \leq \min(\mathbf{p}_{-i}) \equiv \min(p_1, ..., p_{i-1}, p_{i+1}, ..., p_n) \text{ and } p_i \leq P(Q), \tag{6}$$

ensuring *price competitiveness* and *sales target feasibility*, respectively. We can accordingly design what may be called a *Cournot-Bertrand oligopoly game*: entrepreneur i's strategy is now a price-quantity pair (p_i, q_i) chosen to maximize the expected profit $p_i q_i - q_i^2/2\gamma$ under the two preceding constraints (for a more precise characterization, see d'Aspremont and Dos Santos Ferreira 2009). A profile $(\mathbf{p}^*, \mathbf{q}^*)$ of admissible strategies maximizing each entrepreneur i's profit and such that demand is served ($\min(\mathbf{p}^*) = P(Q^*)$) is a *Cournot-Bertrand equilibrium.*

The price competitiveness constraint introduces equilibrium symmetry in prices and equilibrium indeterminacy, the equilibrium price p^* taking a priori any value between the Cournot and Bertrand prices (see d'Aspremont *et al.* 1991). Let $\mathcal{L}_i$ be the Lagrangian corresponding to entrepreneur i's program, with

$$\mathcal{L}_i = p_i q_i - \frac{q_i^2}{2\gamma} - \lambda_i (p_i - \min(\mathbf{p}_{-i})) - \nu_i \left(p_i - \frac{\alpha - \left(q_i + \sum_{j \neq i} q_j\right)/n}{\beta} \right). \tag{7}$$

By taking $\partial\mathcal{L}_i/\partial p_i = \partial\mathcal{L}_i/\partial q_i = \partial\mathcal{L}_i/\partial\lambda_i = \partial\mathcal{L}_i/\partial\nu_i = 0$ as the first order necessary condition for maximizing the expected profit, we obtain indeed at equilibrium the following formula for the Lerner index (the excess of price over marginal cost relative to price):

$$\frac{P^* - q_i^*/\gamma}{P^*} = \theta_i \frac{q_i^*}{Q^*} \frac{Q^*/n}{\beta P^*}. \tag{8}$$

The right-hand side of this equation is the product of three terms: the parameter $\theta_i \equiv \nu_i / (\lambda_i + \nu_i) \in [0, 1]$, the market share q_i^* / Q^* and the absolute value of the inverse demand elasticity $(Q^*/n) / \beta p^*$. The product of the two last terms is the well-known expression for the Lerner index at Cournot equilibrium. Here, this expression is multiplied by the parameter θ_i – the relative weight put on the sales target feasibility constraint at a specific equilibrium – which may be interpreted as the *competitive softness* or accomodativeness of rivals' targets. At its maximum value ($\theta_i = 1$) we obtain the Cournot expression. At its minimum value ($\theta_i = 0$) we obtain Bertrand, or rather the Marshallian perfectly competitive behaviour, with the resulting equality of price and marginal cost. Notice further that at two equilibria with the same price P^* (and hence the same aggregate quantity Q^*) but differing by the values of the θ_i's, a lower θ_i (a higher competitive toughness) is necessarily associated with a higher q_i^* (hence, a higher market share q_i^* / Q^*): hawks have larger territories than doves.

Thus, a Cournot-Bertrand game is in some sense, for each entrepreneur, a superposition of hawk and dove very much as the superposition of living and dead cat in quantum theory. The superposition collapses with the observation, once a specific equilibrium is identified, although that observation will indicate not that some entrepreneur i is eventually either a dove or a hawk, but rather that he is θ_i% dove and $(1 - \theta_i)$% hawk. Notice that we may also refer to real world observations, not simply as a moment of a thought experiment. In the *New Empirical Industrial Organization* (*NEIO*) literature, we find precisely the above formula for the Lerner index, only with a uniform *conduct parameter* θ as a market statistic, rather than with a diversified θ_i characterizing each entrepreneur i's conduct.[5]

Qualifying the competitive softness as a parameter might suggest exogeneity of the variable θ_i.[6] As an index defined on the basis of Lagrange multipliers, θ_i is of course an endogenous variable. However, in an alternative approach, we may take θ_i as a pre-determined competitive conduct, removing equilibrium indeterminacy. Telling that firms are assumed to play either Cournot or Bertrand is indeed not different from choosing *a priori* either $\theta_i = 1$ or $\theta_i = 0$ for any i, respectively. More generally, take the ob-

[5]See Bresnahan (1989) for a survey of the *NEIO* literature and Corts (1999) for a warning concerning the possible mismeasurement of market power by the conduct parameter method, as we change the modelling of firm conduct.

[6]This qualification conforms with the established econometric terminology ("conduct parameter") as well as with the established topological terminology: the set E of equilibria $(p^*, q_1^*, ..., q_n^*)$ such that both constraints are binding for all the firms is a n-dimensional manifold in $\mathbb{R}^{n+1}$ which can be parametrized by the map $(0, 1)^n \to E$.

servationally equivalent formulation of the Cournot-Bertrand game in which the payoff of each entrepreneur i is a convex combination of Cournot's payoff with weight θ_i and of a competitive payoff with weight $1 - \theta_i$:

$$\theta_i \left[q_i P \left(q_i +_{j \equiv i} q_j \right) - \frac{q_i^2}{2\gamma} \right] + (1 - \theta_i) \left[q_i \min (\mathbf{p}) - \frac{q_i^2}{2\gamma} \right]. \tag{9}$$

With demand served at equilibrium ($\min(\mathbf{p}^*) = P(Q^*)$), it is easy to check that the first order condition for maximization in q_i of this payoff leads precisely to the above formula of the Lerner index. The competitive softness θ_i is then not anymore a parameter value indexing a specific equilibrium in a continuum of potential equilibrium states but the exogenously given type, more or less hawkish or more or less dovish, of a specific entrepreneur. In the Schrödinger's cat version of the Cournot-Bertrand game, by contrast, each entrepreneur's type is revealed only at equilibrium, once the box is opened, which is more in line with the original formulation of the game.

4 Concluding remarks

Indeterminacy has too often been viewed as a symptom of bad modelling or at least as the source of *bad cases* in which no "unique outcome [of agents' mental activities] will emerge, and the Muthian case for the rational-expectations hypothesis will have to be reformulated in [...] much weaker terms" (Guesnerie 1992, p.1255). Yet, indeterminacy is at the very core of oligopolistic competition, as acknowledged by Edgeworth (1881) or Stackelberg (1934), a fact that is somewhat hidden by the ubiquitous prior choice by the modeller of one particular regime, whatever it may be. The purpose of this note was just to illustrate, by referring to the very simple model at the basis of Muth's seminal paper, how indeterminacy easily steps in, adding market uncertainty to fundamental uncertainty, when entrepreneurs are but a few.

An important issue linked to market uncertainty has been left aside, namely coordination. How do entrepreneurs coordinate on the market price? The answers to this question are of two main types. One is institutional, concerning "facilitating practices" (Salop 1986), like the *best price guarantee*, which ensures that the lowest list price will automatically be matched by all firms having listed higher prices. The other is informational, making price setting depend upon some public signal. This signal may be extrinsic – a "sunspot" – since reducing market uncertainty may prevail over reducing fundamental uncertainty, as in Keynes's "beauty contest" where agents' concern for coordination dominates their interest for fundamentals.[7]

References

[1] d'Aspremont, C. and Dos Santos Ferreira, R. (2009). Price-quantity competition with varying toughness. *Games and Economic Behavior* 65, 62–82.

[2] d'Aspremont, C., Dos Santos Ferreira, R. and Gérard-Varet, L.-A. (1991). Pricing schemes and Cournotian equilibria. *American Economic Review* 81, 666–673.

[3] Azariadis, C. (1981). Self-fulfilling prophecies. *Journal of Economic Theory* 25, 380–396.

[4] Azariadis, C. and Guesnerie, R. (1982). Prophéties créatrices et persistence des theories. *Revue Economique* 33, 787–806.

[5] Benhabib, J. and Farmer, R.E.A. (1999). Indeterminacy and sunspots in macroeconomics. In: Taylor, J.B. and Woodford, M. (Eds.), *Handbook of Macroeconomics*, 1 A, ch.6, 387-448, Elsevier.

[6] Bertrand, J. (1883). Review of Walras' *Théorie mathématique de la richesse sociale* and Cournot's *Recherches sur les principes mathématiques de la théorie des richesses. Journal des Savants*, 499–508.

[7] Bresnahan, T. (1989). Empirical studies of industries with market power. In: Schmalensee, R. and Willig, R.D. (Eds.), *Handbook of Industrial Organization*, vol. II. Elsevier Science Publishers B.V., 1011–1057.

[8] Cass, D. and Shell K. (1983). Do sunspots matter? *Journal of Political Economy* 91, 193–227.

[9] Chiappori, P.-A. and Guesnerie, R. (1990). Anticipations, indétermination et non-neutralité de la monnaie. *Annales d'économie et de statistique* 19, 1–25.

[10] Cornand, C. and Dos Santos Ferreira, R. (2020). Cooperation in a differentiated duopoly when information is dispersed: A beauty contest game with endogenous concern for coordination. *Mathematical Social Sciences,* https://doi.org/10.1016/j.mathsocsci.2020.02.003.

[7] On this point, see Cornand and Dos Santos Ferreira (2020).

[11] Corts, K.S. (1999). Conduct parameters and the measurement of market power. *Journal of Econometrics* 88, 227–250.

[12] Cournot, A. (1838). *Recherches sur les principes mathématiques de la théorie des richesses*. Hachette, Paris.

[13] Edgeworth, F.Y. (1881). *Mathematical Psychics*. London, Kegan Paul.

[14] Frayssé, J. (1986). *Equilibres de Cournot dans les grands marchés*. Monographies de l'Econométrie. Paris, Editions du CNRS.

[15] Grossman, S.J. (1981). An introduction to the theory of rational expectations under asymetric information. *Review of Economic Studies* 48, 541–559.

[16] Guesnerie, R. (1992). An Exploration of the Eductive Justifications of the Rational-Expectations Hypothesis. *American Economic Review* 82, 1254–1278.

[17] Marshall, A. (1920). *Principles of Economics* (Revised ed.). London, Macmillan.

[18] Muth, J. (1961). Rational Expectations and the Theory of Price Movements. *Econometrica* 29, 315–35.

[19] Phelps, E.S. (1987). Equilibrium: An expectational concept. In: Eatwell, J., Milgate, M. and Newman, P. (Eds.), *The New Palgrave: A Dictionary of Economics*. London, Macmillan.

[20] Salop, S.C. (1986). Practices that (credibly) facilitate oligopoly coordination. In: Stiglitz, J.E. and Mathewson, G.F. (Eds.), *New Developments in the Analysis of Market Structure*. London, Macmillan, 265–290.

[21] Schrödinger, E. (1935). Die gegenwärtige Situation in der Quantenmechanik. *Naturwissenschaften* 23, 807–812. English translation by Trimmer J.D. (1980). The Present Situation in Quantum Mechanics: A Translation of Schrödinger's "Cat Paradox" Paper. *Proceedings of the American Philosophical Society* 124, 323–338.

[22] Shell, K. (2008). Sunspot equilibrium. In: Blume, L.E. and Durlauf, S.N. (Eds.), *The New Palgrave Dictionary of Economics* (2nd ed.). New York, Palgrave Macmillan.

[23] Stackelberg, H.v. (1934). *Marktform und Gleichgewicht*. English translation by Bazin, D., Urch, L., Hill, R. (2011). *Market Structure and Equilibrium*. Berlin, Springer.

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