On the Financial Crisis 2008 from a Physicist’s Viewpoint:
A Spin-Glass Interpretation

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Dec. 17, 2008; updated version as of Jan. 14, 2009

Abstract
In an informal way, a number of thoughts on the financial crisis 2008 are presented from
a physicist’s viewpoint, considering the problem as a nonergodicity transition of a spin-
glass-like system. Some suggestions concerning the way out of the crisis are also discussed,
concerning Keynesian deficit spending methods, tax reductions, and finally the method
ruin and recreate, which is known from optimization theory. The de Almeida-Thouless
instability line of spin glass theory is also given a financial interpretation.

1 Introduction
This is an informal communication, not intended for publication. The topic, the financial
crisis 2008 and its probable expansion into a serious economic crisis, is closely connected to
spin-glass physics, (not only) to the opinion of the author. This is more or less common
wisdom of the econophysics community ([1]). (If you want to comment on some issue, please
send mail).

Furthermore, the degrees of freedom of the system, which may be represented by a two-
dimensional graph, are, in a strong simplification, replaced by binary (i.e., ‘Ising’) degrees
of freedom, \( s_i \), where the signs, \( \pm 1 \), may correspond to gains and losses, respectively, of the
individual companies competing for profit, which are represented by the vertices \( i \) of the graph
and interact with each other in a global market.

These interactions are frustrated - a notion known from spin-glass theory, e.g. around a
closed loop with an odd number of edges, taking the products (‘Wilson loop products’) of
an odd number of the Ising variables, the interactions - whatever they may be - will lead to
a positive outcome at the end, if the loop product is taken in one direction, and a negative
outcome, if it is in the opposite direction. (The frustration or complexity of the system will
become important below.)

This possibility of inherent ’frustration’ in the loop of simultaneous cooperation and com-
petition, [2], (a certain quenched correlation of the system, leading to essentially unavoidable
and equally probable gains and losses, where the probability of a loss in a ”betting situation”
seems to have sometimes been forgotten by the global ”players”, or shifted to future genera-
tions), is fixed by the interactions on the graph, which is typical for a spin-glass system,

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assuming that the graph itself is disordered, with fixed random positions and interactions ("quenching").

Here is the place, where the interest rate, \( r \), of the central bank of the involved currency, comes into play. Since very low values of \( r \) enhance the tendency of the investment banks to invent new "structured financial products", whatsoever, an enhancement(!) of the interest rate should also be considered as a means to reduce the complexity of the financial market, not only as a means to reduce the danger of inflation. Of course, the primary effect of a change of \( r \) is in conflict with this consideration: primarily, at low values of \( r \) everyone gets loans (e.g., for houses), which then become too expensive, if \( r \) is increasing again.

One should also consider that one is not dealing with a closed system, but rather a system with two ”sinks”, the Iraque, and Afghanistan.

"Whatever the interactions may be": this is a crucial text item. Typically, since there are many "groups" (\( N \gg 1 \)), the interactions of the system may roughly correspond to a seemingly rather special spherical spin glass, a "p-spin-glass", i.e. with \( p \) interacting spins, where \( p \gg 1 \) (many companies, \( p \), form an interacting group) and where the spherical condition \( \sum_{i=1}^{N} s_i^2 = N \) is natural.

2 More analogies

The following remarks are obvious:

The interaction is described by a global optimization function, corresponding physically to the Hamiltonian of the system, and is not essential, in contrast to the degrees of freedom of the system and some relevant macroscopic variables, e.g. the specific volume or specific size \( v \) of a company or group of cooperating companies. In an ideal situation (remember the ideal gas) one thinks 'The larger the better', because of the synergies, but the reality may be different: recently one has apparently come to the opposite conclusion that 'As small as possible' is more beautiful, because in this way the costs seem to be reduced more effectively (unfortunately, to say it mildly, in both cases the unemployment is enhanced.) This change of paradigm - the analogon is a change of slope of the saturation pressure \( p(v) \) - may be considered as a warning signal for criticality.

Another essential physical parameter, the temperature, seems to correspond to the economic activity: enhancing (or reducing) the temperature, respectively, is perhaps analogous to turning up (or slowing down) the economic activity (the analogy is more visible in the German language: "Temperatur" versus "Konjunktur"). Finally, the physical variable \( p \) (pressure) may be translated economically into a "reciprocal specific wealth" or "individual economic pressure", an intensive quantity, in contrast to the size parameter \( V \), which is extensive. (\( v = \frac{V}{N} \) is the specific company size, or specific group size, where \( N \) is the number of companies or groups of cooperating companies).

Furthermore, physically there are two "fluid" phases of a system, a vapor phase, which is a wealthy phase in our economical interpretation, and a liquid (or poor) phase, respectively.

Here the well-known Van der Waals theory (see e.g. [3]) of the vapor \( \leftrightarrow \) liquid transition is set into an economical analogy between economic phases with two different degrees of wealth. Physically one has a stable and a metastable vapor phase and two corresponding liquid phases, which are separated from the vapor by the famous Maxwell line, which is reached at a value \( v_{\text{Maxwell}} \), separating also the ranges of stability and metastability. Furthermore, if one starts in the "wealthy" phase and reduces \( v \) gradually below \( v_{\text{Maxwell}} \), there is a critical size
Maxwell, where with gradually decreasing \( v \) the metatatable system becomes unstable and jumps to the "poor" phase.

3 Non-ergodicity

In the p-spin-glass analogy (see e.g. [4]) the instability is a dynamic freezing phenomenon, which may correspond to G"otze's well-known mode-coupling theory, [5], which describes a kind of transition to immobility in the context of amorphization of liquid metals. Economically, the nonergodicity means, for example, that the financial institutions do no longer cooperate with each other, nor with their clients. To get out of the crisis, there are more-or-less obvious prescriptions: the most direct way is to follow the well-known Keynesian measures of enhancing the "Konjunktur" by deficit spending of the state. Physically this corresponds to an enhancement of the temperature, i.e. a vertical perturbation in the usual axes. In contrast, a tax reduction, which is also under discussion, would correspond to a more horizontal perturbation, which seems less effective (of course, computer simulations on this issue might be useful). One may also try to reduce the "frustration" possibility (or complexity) of the system, by forbidding extremely risky financial products, e.g., the possibility of short selling leased assets.

4 Replica-symmetry breaking

The signature of spin-glass behaviour, and specifically of the related non-ergodicity transition, is 'replica-symmetry breaking', which is a complicated issue, which we don't treat - in an elementary way, one might say that there are unsurmountable barriers between the ergodic components. Details can again be found in [4]. Especially, it should be noted that spherical p-spin-glasses, which are here under consideration, have only 1-step replica symmetry breaking, i.e., there are only two hierarchies, may be the "normal" financial products, and the "structured financial derivatives" (in any case, the two fluid states of the Van-der-Waals theory should be related). Actually, although there the risk is broadened both in space and also in time, by some kind of "interassuring", the promises concerned are higher gains, which also means higher losses in case of a failure since the probability distributions involved are usually symmetric and have "fat tails" both on the gain and on the loss sides.

The essential point is the danger that the system has become eventually so complex that the companies "assuring the risk" belong to different, noncooperating 'valleys' of the spin-glass system, after non-ergodicity has appeared.

5 Ways out of the crisis

A combination of the above-mentioned methods may be useful, since the optimal perturbation is perhaps essentially vertical, but not exactly. Numerical simulations on this issue would be helpful. In an extreme case one might also consider brute-force methods, as the method ruin and recreate, which is known from optimization theory, and is actually not so brute-force as it sounds, but rather smooth. [6].

According to a hint of T. Preis, it may be essential to take into account that financial processes are nonstationary. But even then the spherical condition, \( \sum_{i=1}^{N} s_i^2 = N \), might
remain valid, as well as the interpretation of the crisis as a freezing into a nonergodic state of a p-state-spin-glass model as described by [4].

6 Countermeasures of the state and the de Almeida-Thouless line

The capital flow from the state as a countermeasure against the crisis could be analogous to the external field $h$ of the spin-glass theory. As a consequence, the famous de Almeida-Thouless instability line, [7], to surmount the crisis, should follow the law $h^{2/3} \propto T_f$, where $T_f$ is the freezing temperature (“Konjunktur”) of the system.

Acknowledgement

The author thanks T. Preis for useful remarks.

References

[1] See e.g. De Olivera, S.M., Stauffer, D., Evolution, money, war, and computers, Stuttgart, Teubner 1999.

[2] Here we remind to a proverb in the Lower German language: Wat dem eenen siin Uhl is dem annern siin Nachtigall (What is an owl for someone is a nightingale for an other person).

[3] Krey, U., Owen, A., Basic Theoretical Physics - A Concise Overview, Berlin Heidelberg New York, Springer 2007.

[4] Castellani, T., Cavagna, A., Spin-Glass Theory for Pedestrians, eprint cond-mat/0505032 (2005), and references therein.

[5] Götze, W., Sjøgren, L., Rep. Progr. Phys. 55, 241 (1992)

[6] Schneider, J.: PhD-thesis of the physics faculty of the university of Regensburg, May 1999.

[7] J.L.R. de Almeida, D.J. Thouless: J. Phys. A11, 983 (1978)