Financial Physics

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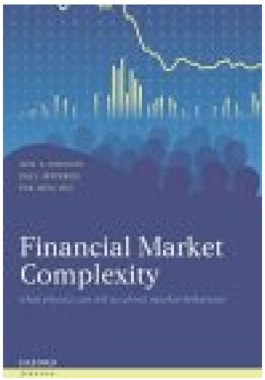

The course has ***7 handouts*** *which are Chapters from the textbook shown above:*
Financial Market Complexity: What Physics can tell us about market behaviour
Oxford University Press, 2003 ISBN: 0198526652
by Neil F. Johnson, P. Jefferies and Pak Ming Hui

This is a course about financial markets … for physicists. It is not surprising to find courses on quantitative finance run by economists, mathematicians, and even computer scientists – but physicists? There is a simple reason, or rather a simple 'complex' reason. Financial markets are complicated, dynamical systems which are continually generating high-frequency data-series. This data records the aggregate action of the market's many participants, each of who is trying to win in this vast global 'game'. In fact it can be argued that financial markets provide the most well-documented, and longest running, record of a large-scale 'complex system'. In short, financial markets constitute a real-world complex system which is continually evolving, which has significant practical importance, and which produces an enormous amount of data – and that's the appeal.

It has been said that being a successful investor is like being a successful burglar. Most burglars know how to get into a building, and what to take - but only the successful ones know how, and most importantly *when*, to get out. 'Time' is therefore crucial in financial markets. Since our goal is to understand *real-world* markets as opposed to idealized ones, time also takes centre-stage in this book. Time relates to dynamics, and it is this evolving complex-system dynamics which underpins our scientific interest in financial markets.

Most, if not all, standard finance courses make some kind of apparently innocuous assumptions about market dynamics. For example they assume that the markets are in some kind of steady state or represent a stationary process, and that there are no implicit temporal correlations - or at best, that these correlations are of a specific type. As we show in the present course, these assumptions can give misleading answers to practical problems such as minimizing financial risk, coping with extreme events such as crashes or drawdowns, and pricing derivatives in non-ideal markets. Having said this, standard finance theory usually works. But it is the 'usually' that we are interested in – or rather the 'unusually'. We focus on how and why real financial markets deviate from the standard finance theory paradigm of random-walk behaviour, and the consequences of such deviation. In particular, we will be interested in the tails of the distribution of price returns, and in the dynamics induced by crowd-like behaviour in markets. The consequences for managing risk will also feature quite prominently. In short, the following questions provide the focus of this course: *How* do financial markets behave? *Why* do financial markets behave in the way that they do? *What* can we do to minimize risk, given this behaviour?

The relationship between science, and in particular physics, and finance is still in the courtship phase – hence the (not so) occasional squabbles. Despite the immaturity of this so-called Econophysics field, there are many people interested in knowing more about it, including practitioners and students. A common request is 'where can we learn about these Econophysics ideas, and how to implement them?' The latter part of this request, concerning implementation, motivated us to give this course. In particular, we felt that there was a need to produce a course which takes a relatively small number of topics – the essential ones in our opinion - and treats them as thoroughly as possible.

The course has **7 handouts** which are Chapters from the following textbook:

Financial Market Complexity: What Physics can tell us about market behaviour

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Not all the Chapters in the book will be covered in this course since this would create an overload of material. Instead, the course material consists of, and is restricted to, the following:

In addition to **Handout 1** (which is the one you are reading now), there is **Handout 2** (referred to as 'Chapter 1'), **Handout 3** (referred to as 'Chapter 2'), **Handout 4** (referred to as 'Chapter 3'), **Handout 5** (referred to as 'Chapter 4'), **Handout 6** (referred to as 'Chapter 6'), and **Handout 7** (referred to as 'Chapter 7'). I hope this isn't too confusing – I believe that changing things around would have introduced too many typos.

After discussing the background to the concept of complexity and the structure of financial markets in **Handout 2** (labelled as 'Chapter 1'), **Handout 3** (labelled as 'Chapter 2') examines the assumptions upon which standard finance theory is built. Reality sets in with **Handout 4** (labelled as 'Chapter 3'), where we analyze data from two seemingly different markets and uncover certain universal features which cannot be explained within standard finance theory. **Handout 5** (labelled as 'Chapter 4') marks a significant departure from the philosophy of standard finance theory, being concerned with exploring microscopic models of markets which are faithful to real market microstructure yet which also reproduce the real-world statistical features discussed in Handout 4. **Handout 6** (labelled as 'Chapter 6') moves to the practical problem of how to quantify and hedge risk in real-world markets. **Handout 7** (labelled as 'Chapter 7') discusses deterministic descriptions of market dynamics, incorporating the topics of chaos and the all-important phenomena of market crashes.

The course was given for the first time in 2002, hence there are several past Finals papers available for viewing.

The course material in these Handouts is self-contained.
Not all the material in these Handouts is required knowledge for the course – I will indicate in lectures what is required, and what constitutes additional reading which you may find interesting but which will not be examined.

Also see the website of the new interdisciplinary finance research center involving Physics-Maths-Computing, the Oxford Centre for Computational Finance **www.occf.ox.ac.uk**

CONTENT OF COURSE/BOOK

SOME ADDITIONAL TEXTS REFERRED TO IN THE HANDOUTS
(These are not required texts; just listed for interest)

[WDH] *The mathematics of financial derivatives*, P. Wilmott, J. Dewynne and S. Howison (Cambridge University Press, 1996).
[BP] *Theory of financial risks*, J.P. Bouchaud and M. Potters (Cambridge University Press, 2000).
[MS] *An introduction to Econophysics*, R.N. Mantegna and H.E. Stanley (Cambridge University Press, 2000).
[W] *Derivatives*, P. Wilmott (Wiley, 1998).
[G] *The nature of mathematical modelling*, N. Gershenfeld (Cambridge University Press, 1999).
[F] *An introduction to probability theory and its applications*, W. Feller (Wiley, 1968).
[V] *The statistical mechanics of financial markets*, J. Voit (Springer, 2001).
[S] *Non-linear dynamics and chaos*, S. Strogatz (Perseus, 2001).
[So] *Critical phenomena in natural sciences: chaos, fractals, self-organization and disorder*, D. Sornette (Springer, 2000).
[CLM] *The econometrics of financial markets*, J.Y. Campbell, A.W. Lo and A.C. MacKinlay (Princeton University Press, 1997).
[P] *Finance & financial markets*, K. Pilbeam (Macmillan business, 1998).