

# Chapter 75

## Improving Long-Term Financial Risk Forecasts using High-Frequency Data and Scaling Laws

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### ABSTRACT

*This chapter uses the abundance of high frequency data to estimate scaling law models and then apply appropriately scaled measures to provide long-term market risk forecasts. The objective is to analyse extreme price movements from tick-by-tick real-time data to trace the footprints of traders that eventually form the overall movement of market prices (price coastline) and potential bubbles. The framework is applied to empirical limit order book data from the London Stock Exchange. The sample period ranges from June 2007 to June 2008 and covers the start of the subprime crisis that later escalated into the economic crisis. After extracting the scaling exponent and checking its robustness with bootstrap simulations, the authors investigate longer term price movements in more detail, making use of the scale invariance property of the scaling law. In particular, they provide financial risk forecasts for a testing period and compare these with the popular Value-at-Risk and expected tail loss measures, showing the outperformance of the scaling law approach. Finally, a set of simulations are run to explore which scaling exponent is more likely to trigger market turbulence.*

### INTRODUCTION

The current economic downturn has made clear how little we actually know about the weakness and vulnerability of our financial system. Heavily hit by the financial tsunami that was triggered by

the credit crunch, which started in the summer of 2007, many people questioned why no one foresaw the timing, gravity, and aftermath of the crisis. However, this bubble was not the only one that has burst in the last 100 years, nor was it the biggest. Interestingly, “mini-bubbles,” i.e. stock market crashes on a much smaller scale, are actually observed almost every day.

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Until the turn of the millennium, the analysis of daily financial market data was considered the highest meaningful sampling frequency for economic and financial time series, although early studies using intraday data did exist. However, due to the computerisation of financial markets, stock exchanges nowadays use high-speed databases that record every single market event. More comprehensive data sets of financial markets are now available, containing abundant information. This data is sampled in real-time and therefore termed “high-frequency data” (Dacorogna, et al., 2001). The richness of this data, in both quantity and quality, allows examination of each single transaction and market movement, something that was not possible with conventional time series data and methods.

The research in high-frequency finance has shed some light on trading behaviour and intraday patterns in recent years. However, it is still in its infancy as most models in this area still fail to exploit the whole potential of the data. This study applies scaling law based concepts to measure stock price movements in a multiple time frame setting, making optimal use of the high-frequency transaction data.

The major advantage of applying scaling laws is their universality and scale invariance providing both flexibility and consistency in modeling (e.g., Gabaix, 2009; Lux, 2006). Applying fractal theory and scaling laws, which explain how phenomena are the same at different scales (self-similarity), one can search for explanations of the “long-term” big crisis (years) by shifting to another time scale,

e.g. short-term intraday periods (minutes). The remarkable feature of this concept is that the results and their implications apply to both short-term and longer-term price movements. For example, Glattfelder et al. (2011) and Bisig et al. (2009) (among others) have successfully applied this framework to high-frequency foreign exchange data. Their research indicates that one can use the abundance of intra-day data to develop robust models and then use appropriately scaled models to explain long-term market behaviour, using the scale invariance property of the scaling law. Given the current economic crisis, a deeper understanding of fundamental mechanics and behaviour of financial markets is clearly required. The objective is to analyse market events on a tick-by-tick real-time basis to trace back the footprints of traders that eventually form the overall movement of market prices and potential bubbles.

In this study, the proposed scaling law methodology will be applied on empirical limit order book data extracted from the SETS (Stock Exchange Trading System) that is operated by the London Stock Exchange. In particular, we focus on high-frequency transaction data of five selected stocks (from different sectors) listed in the FTSE 100 stock index (see Table 1). The sample period ranges from 1 June 2007 to 30 June 2008, covering a 13-month period. The first seven months from 01 June 2007 to 30 December 2007 are declared as the in-sample period. The remaining six months from 02 January 2008 to 20 June 2008 form the out-of-sample period used for testing purposes, where we provide financial risk forecasts derived

*Table 1. List of selected stocks listed in the FTSE 100 index*

Company	ISIN	Mnemonic	Trades
RIO TINTO	GB0007188757	<b>RIO</b>	3004567
ROYAL BANK OF SCOTLAND	GB0007547838	<b>RBS</b>	3573172
BRITISH PETROLEUM	GB0007980591	<b>BP.</b>	2183779
GLAXOSMITHKLINE	GB0009252882	<b>GSK</b>	1915837
LONMIN	GB0031192486	<b>LMI</b>	1179223

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