# Modelling Trends and Cycles in Economic Time Series

Terence C. Mills
*Professor of Applied Statistics, and Econometrics*
*Department of Economics*
*Loughborough University*

palgrave
macmillan

# Contents

*List of Tables and Figures* ix
*Series Editor's Foreword* xi

**1 Introduction** **1**
**1.1** Historical perspective 1
1.2 Overview of the book 10

**2 'Classical' Techniques of Modelling Trends and Cycles** **13**
2.1 The classical trend-cycle decomposition 13
2.2 Deterministic trend models 14
2.2.1 Linear trends 14
2.2.2 Nonlinear trends 15
2.2.3 Segmented trends and smooth transitions 16
Example 2.1 A linear trend for US output *per capita* 18
Example 2.2 Fitting deterministic trends to UK output 19
Example 2.3 Fitting a smooth transition to US stock prices 22
2.3 Estimating trends using moving averages 23
2.3.1 Simple moving averages 23
2.3.2 Weighted moving averages 24
Example 2.4 Weighted moving average trends for US stock prices 25
2.4 The cyclical component 26
2.4.1 Autoregressive processes for the cyclical component 26
2.4.2 Estimating the cyclical component 30
Example 2.5 The cyclical component of US output *per capita* 30
Example 2.6 The cyclical component of UK output 31
Example 2.7 The cyclical component of US stock prices 32
2.5 Some problems associated with the 'classical' approach 33
Example 2.8 Simulating the Slutsky-Yule effect 34
Further reading and background material 36

**3 Stochastic Trends and Cycles** 39.
3.1 An introduction to stochastic trends 39
3.2 Determining the order of integration of a time series 48
3.3 Some examples of ARIMA modelling 50
Example 3.1 Modelling the dollar/sterling exchange rate 50
Example 3.2 Modelling the *FTA All Share* index 50
Example 3.3 Modelling US output 52
3.4 Trend stationarity versus difference stationarity 54
Example 3.4 Testing TS versus DS processes for UK equities and US output 58
3.5 Unobserved component models and signal extraction 59
3.5.1 Unobserved component models 59
3.5.2 The Beveridge-Nelson decomposition 61
Example 3.5 Decomposing UK equities and US output 64
3.5.3 Signal extraction 66
3.5.4 Basic structural models 67
Example 3.6 Basic structural models for UK equities and US output 70
Further reading and background material 72

**4 Filtering Economic Time Series** 75
4.1 Detrending using linear filters 75
4.1.1 Symmetric linear filters 75
Example 4.1 The simple MA filter 76
4.1.2 Frequency-domain properties of linear filters *77*
Example 4.2 The gain and phase of the simple MA and first differencing filters 81
Example 4.3 Spurious cyclical behaviour 82
4.1.3 Designing a low-pass filter 84
4.1.4 High-pass and band-pass filters 87
Example 4.4 Band-pass business cycle filters 91
4.2 The Hodrick-Prescott filter 92
4.2.1 The Hodrick-Prescott filter in infinite samples 92
4.2.2 The finite sample H-P filter 94
4.2.3 Optimising the smoothing parameter 95
Example 4.5 Band-pass and Hodrick-Prescott cycles for US output 97
Example 4.6 H-P filtering of UK output 97
4.3 Filters and structural models 97

4.3.1 A structural model for the H-P filter 97
4.3.2 The Butterworth filter • 99
Further reading and background material 101

**5 Nonlinear and Nonparametric Trend Modelling** 103
5.1 Regime shift models 103
5.1.1 Markov models 103
Example 5.1 A Markov switching model for US output 107
5.1.2 STAR models 107
Example 5.2 A STAR model for UK output 112
5.2 Nonparametric trends 114
5.2.1 Smoothing estimators 114
5.2.2 Kernel regression 117
5.2.3 Local polynomial regression
Example 5.3 nonparametric trends in US stock prices 117
5.3 Nonlinear stochastic trends 119
Further reading and background material 120

6 **Multivariate Modelling of Trends and Cycles** 123
6.1 Common features in time series 123
6.1.1 Specification and testing for common features 123
6.1.2 Common cycles and codependence 125
Example 6.1 Is there a common cycle in US and Canadian output? 127
6.1.3 Common deterministic trends 127
Example 6.2 Common trends in the Victorian economy 128
6.2 Common trends and cycles in a VAR framework 128
Example 6.3 Common trends and cycles in the UK macroeconomy 134
6.3 Multivariate basic structural models 137
6.3.1 Common trends 137
6.3.2 Common cycles 139
Example 6.4 A multivariate BSM of the UK macroeconomy 139
6.4 Multivariate filtering 142
Example 6.5 Multivariate detrending of UK consumption and output using a common trend restriction 144
Further reading and background material 145

***7*** **Conclusions** **149**

*Computed Examples* 151

*References* 161

*Author Index* **171**

*Subject Index* **173**