

# Contents

<b>Preface</b>	<b>xi</b>
<b>1 Introduction</b>	<b>1</b>
<b>I Static Models</b>	<b>5</b>
<b>2 Unobserved Heterogeneity</b>	<b>7</b>
2.1 Overview	7
2.2 Fixed Effects Models	11
2.2.1 Assumptions	11
2.2.2 Within-Group Estimation	14
2.3 Heteroskedasticity and Serial Correlation	18
2.3.1 Robust Standard Errors for Within-Group Estimators	18
2.3.2 Optimal GLS with Heteroskedasticity and Autocorrelation of Unknown Form	20
2.3.3 Improved GMM and Minimum Distance Estimation under Heteroskedasticity and Autocorrelation of Unknown Form	20
2.4 Likelihood Approaches	23
2.4.1 Joint Likelihood	24
2.4.2 Conditional Likelihood	24
2.4.3 Marginal (or Integrated) Likelihood	25
2.5 Nonlinear Models with Additive Effects	27
2.5.1 Nonlinear Regression	27
2.5.2 Linear Structural Equation	28
2.5.3 Nonlinear Simultaneous Equations	29
<b>3 Error Components</b>	<b>31</b>
3.1 A Variance Decomposition	31
3.2 Error-Components Regression	34
3.2.1 The Model	34

3.2.2	GLS and ML Estimation	35
3.2.3	GLS, Within-Groups, and Between-Groups	36
3.3	Testing for Correlated Unobserved Heterogeneity	37
3.3.1	Specification Tests	38
3.3.2	Robust Alternatives	41
3.4	Models with Information in Levels	42
3.5	Estimating the Error Component Distributions	44
<b>4</b>	<b>Error in Variables</b>	<b>47</b>
4.1	An Introduction to the Standard Regression Model with Errors in Variables	47
4.2	Measurement Error Bias and Unobserved Heterogeneity Bias	49
4.3	Instrumental Variable Estimation with Panel Data	51
4.4	Illustration: Measuring Economies of Scale in Firm Money Demand	53
<b>II</b>	<b>Time Series Models with Error Components</b>	<b>55</b>
<b>5</b>	<b>Covariance Structures for Dynamic Error Components</b>	<b>57</b>
5.1	Introduction	57
5.2	Time Effects	60
5.3	Moving Average Autocovariances	64
5.4	Estimating Covariance Structures	67
5.4.1	GMM/MD Estimation	68
5.4.2	Using Transformations of the Original Moments	70
5.4.3	Relationship between GMM and Pseudo ML	71
5.4.4	Testing Covariance Restrictions	73
5.5	Illustration: Testing the Permanent Income Hypothesis	75
<b>6</b>	<b>Autoregressive Models with Individual Effects</b>	<b>81</b>
6.1	Assumptions	82
6.2	The Within-Group Estimator	84
6.3	Instrumental Variable Estimation	88
6.4	Initial Conditions and Heteroskedasticity	91
6.4.1	Estimation under Stationarity	91
6.4.2	Unrestricted Initial Conditions	96
6.4.3	Time Series Heteroskedasticity	107
6.4.4	Time Effects in Autoregressive Models	108
6.5	Mean Stationarity	110
6.6	Unit Roots	113
6.7	Estimating and Testing VARs for Firm Employment and Wages	116

<b>III</b>	<b>Dynamics and Predeterminedness</b>	<b>127</b>
<b>7</b>	<b>Models with both Strictly Exogenous and Lagged Dependent Variables</b>	<b>129</b>
7.1	The Nature of the Model	129
7.2	An Example: Cigarette Addiction	130
7.3	GMM Estimation	133
7.3.1	2SLS Estimation from a Large $T$ Perspective	133
7.3.2	Optimal IV Estimation in a Small $T$ , Large $N$ Context	134
7.3.3	GMM with the Number of Moments Increasing with $T$	135
7.3.4	Explanatory Variables Uncorrelated with the Effects	137
7.3.5	Enforcing Restrictions in the Covariance Matrix	137
7.4	Maximum Likelihood	138
7.4.1	Estimation with Unrestricted Covariance Matrix	138
7.4.2	MLE with Covariance Restrictions	140
7.4.3	MLE with Correlated $xs$	141
<b>8</b>	<b>Predetermined Variables</b>	<b>143</b>
8.1	Introduction and Examples	144
8.1.1	Partial Adjustment with Feedback	145
8.1.2	Euler Equation for Household Consumption	145
8.1.3	Cross-Country Growth and Convergence	148
8.2	Large $T$ Within-Group Estimation	149
8.3	Small $T$ GMM Estimation	151
8.3.1	Moments and Weight Matrices	151
8.3.2	The Irrelevance of Filtering	152
8.4	Optimal Instruments	155
8.5	Instruments Uncorrelated with the Effects	159
8.5.1	System Estimators	159
8.5.2	Stationarity Restrictions	161
8.5.3	Illustration: A Dynamic Evaluation of Job Training	162
8.5.4	Time-Invariant Explanatory Variables	164
8.5.5	Levels Moments Implied by Lack of Serial Correlation	164
8.6	Estimating the Effect of Fertility on Female Labour Participation	165
8.7	Other Estimation Methods	169
<b>IV</b>	<b>Appendices</b>	<b>175</b>
<b>A</b>	<b>Generalized Method of Moments Estimation</b>	<b>177</b>
A.1	Method of Moment Estimation Problems	177
A.2	General Formulation	180
A.3	Examples: 2SLS and 3SLS	181
A.4	Consistency of GMM Estimators	184

A.5	Asymptotic Normality	185
A.6	Estimating the Asymptotic Variance	188
A.7	Optimal Weight Matrix	190
A.8	Testing the Overidentifying Restrictions	192
<b>B</b>	<b>Optimal Instruments in Conditional Models</b>	<b>199</b>
B.1	Introduction	199
B.2	Linear Regression	200
B.3	Nonlinear Regression	203
B.4	Nonlinear Structural Equation	204
B.5	Multivariate Nonlinear Regression	206
B.6	Nonlinear Simultaneous Equation System	208
	<b>References</b>	<b>215</b>
	<b>Index</b>	<b>227</b>