BUSINESS CYCLES IN EAST AND SOUTHEAST ASIA

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To My Beloved Father and Mother
and Many Thanks to My Supervisor Alex Mandilaras
The study of an economy's business cycle—defined as a deviation from the long-term output growth rate—is an important task: upward deviations may create inflationary pressures, while downward deviations may be associated with a high unemployment rate. There can be many reasons why an economy may grow at a different rate than the long-term trend. These include government policies, political factors and other internal or external shocks. While it is not possible to eradicate the business cycle—after all a shock is an unexpected development in a relevant variable—the understanding of its statistical properties is helpful in assessing the effects of the various shocks hitting the economy and designing policies to help reduce output variability.

The purpose of this thesis is to model empirically business cycles of selected East and Southeast Asian economies. The region is of particular interest as it consists of both developed economies (e.g. Japan and Singapore) and emerging ones (e.g. South Korea and Thailand). In addition, the so-called Asian tigers experienced a fall from grace during the crisis of 1997-98 but they have recently resumed robust growth rates. Given the prominent role that these economies may play in a world emerging from the severe financial crisis of 2007 the investigation of their business cycles becomes an even more valuable endeavour.
But how can we model the business cycle to answer pertinent questions? A regime-switching methodology is adopted to examine the following issues: first, the degree of persistence of positive and negative growth rate regimes; second, the extent of correlation of the region's economies conditional on the growth regime; third, the informational content of leading indicators; and fourth, the duration dependence of the business cycle. The selected methodology allows the extraction of the relevant information and pervades the conclusions of the thesis.

Following a brief introduction, chapter 2 reviews the modern theory of business cycles, as well as the relevant empirical contributions. The next chapter examines in some depth the economic structure of the sample economies. Understanding the main characteristics of each economy is a prerequisite in appreciating the features of the respective business cycle. Chapter 4 presents the methodology of fixed and time-varying transition probability regime-switching models, which will be used in the subsequent analysis. Chapters 5 and 6 provide the main answers to the research questions outlined above. A summary of the work is offered in the last chapter.
<table>
<thead>
<tr>
<th>Section</th>
<th>Subsections</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1.1</td>
<td>Economic policy</td>
<td>66</td>
</tr>
<tr>
<td>3.1.2</td>
<td>Growth of GDP and its expenditure components</td>
<td>68</td>
</tr>
<tr>
<td>3.1.3</td>
<td>Trading structure and markets</td>
<td>72</td>
</tr>
<tr>
<td>3.2</td>
<td>Hong Kong</td>
<td>72</td>
</tr>
<tr>
<td>3.2.1</td>
<td>Economic policy and structure</td>
<td>72</td>
</tr>
<tr>
<td>3.2.2</td>
<td>Growth of GDP and its expenditure components</td>
<td>74</td>
</tr>
<tr>
<td>3.2.3</td>
<td>Trading structure and markets</td>
<td>78</td>
</tr>
<tr>
<td>3.3</td>
<td>Indonesia</td>
<td>79</td>
</tr>
<tr>
<td>3.3.1</td>
<td>Economic policy and structure</td>
<td>79</td>
</tr>
<tr>
<td>3.3.2</td>
<td>Growth of GDP and its expenditure components</td>
<td>81</td>
</tr>
<tr>
<td>3.3.3</td>
<td>Trading structure and markets</td>
<td>84</td>
</tr>
<tr>
<td>3.4</td>
<td>Japan</td>
<td>86</td>
</tr>
<tr>
<td>3.4.1</td>
<td>Economic policy and structure</td>
<td>86</td>
</tr>
<tr>
<td>3.4.2</td>
<td>Growth of GDP and its expenditure components</td>
<td>89</td>
</tr>
<tr>
<td>3.4.3</td>
<td>Trading structure and markets</td>
<td>94</td>
</tr>
<tr>
<td>3.5</td>
<td>Malaysia</td>
<td>95</td>
</tr>
<tr>
<td>3.5.1</td>
<td>Economic structure</td>
<td>95</td>
</tr>
<tr>
<td>3.5.2</td>
<td>Growth of GDP and its expenditure components</td>
<td>96</td>
</tr>
<tr>
<td>3.5.3</td>
<td>Trading structure and markets</td>
<td>101</td>
</tr>
<tr>
<td>3.6</td>
<td>Philippines</td>
<td>102</td>
</tr>
<tr>
<td>3.6.1</td>
<td>Economic policy and structure</td>
<td>102</td>
</tr>
<tr>
<td>3.6.2</td>
<td>Growth of GDP and its expenditure components</td>
<td>105</td>
</tr>
<tr>
<td>3.6.3</td>
<td>Trading structure and markets</td>
<td>108</td>
</tr>
<tr>
<td>3.7</td>
<td>Singapore</td>
<td>109</td>
</tr>
<tr>
<td>3.7.1</td>
<td>Economic policy</td>
<td>109</td>
</tr>
<tr>
<td>3.7.2</td>
<td>Growth of GDP and its expenditure components</td>
<td>109</td>
</tr>
<tr>
<td>3.7.3</td>
<td>Trading structure and markets</td>
<td>114</td>
</tr>
<tr>
<td>3.8</td>
<td>South Korea</td>
<td>115</td>
</tr>
<tr>
<td>3.8.1</td>
<td>Economic policy and structure</td>
<td>115</td>
</tr>
</tbody>
</table>
### Contents

<table>
<thead>
<tr>
<th>3.8.2</th>
<th>Growth of GDP and its expenditure components</th>
<th>117</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.8.3</td>
<td>Trading structure and markets</td>
<td>123</td>
</tr>
<tr>
<td>3.9</td>
<td>Taiwan</td>
<td>124</td>
</tr>
<tr>
<td>3.9.1</td>
<td>Economic structure</td>
<td>124</td>
</tr>
<tr>
<td>3.9.2</td>
<td>Growth of GDP and its expenditure components</td>
<td>124</td>
</tr>
<tr>
<td>3.9.3</td>
<td>Trading structure and markets</td>
<td>130</td>
</tr>
<tr>
<td>3.10</td>
<td>Thailand</td>
<td>131</td>
</tr>
<tr>
<td>3.10.1</td>
<td>Economic policy and structure</td>
<td>131</td>
</tr>
<tr>
<td>3.10.2</td>
<td>Growth of GDP and its expenditure components</td>
<td>134</td>
</tr>
<tr>
<td>3.10.3</td>
<td>Trading structure and markets</td>
<td>137</td>
</tr>
<tr>
<td>3.11</td>
<td>Regional overview</td>
<td>138</td>
</tr>
<tr>
<td>3.12</td>
<td>Final remarks</td>
<td>154</td>
</tr>
</tbody>
</table>

#### 4 Methodology

<table>
<thead>
<tr>
<th>4.1</th>
<th>Markov-switching models</th>
<th>157</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1.1</td>
<td>The FTP model</td>
<td>157</td>
</tr>
<tr>
<td>4.1.2</td>
<td>The DDMS model</td>
<td>162</td>
</tr>
<tr>
<td>4.1.3</td>
<td>The TVTP model</td>
<td>165</td>
</tr>
<tr>
<td>4.2</td>
<td>The EM algorithm</td>
<td>170</td>
</tr>
<tr>
<td>4.2.1</td>
<td>The FTP model</td>
<td>171</td>
</tr>
<tr>
<td>4.2.2</td>
<td>The TVTP model</td>
<td>179</td>
</tr>
<tr>
<td>4.3</td>
<td>Bayesian inference and Gibbs-sampling</td>
<td>186</td>
</tr>
<tr>
<td>4.3.1</td>
<td>Prior distributions</td>
<td>187</td>
</tr>
<tr>
<td>4.3.2</td>
<td>Conditional distributions and the Gibbs sampling</td>
<td>188</td>
</tr>
<tr>
<td>4.4</td>
<td>The determination of the number of regimes and lags</td>
<td>194</td>
</tr>
<tr>
<td>4.5</td>
<td>Applications of the MS model in the literature</td>
<td>201</td>
</tr>
<tr>
<td>4.5.1</td>
<td>The MS model with time-invariant transition probabilities</td>
<td>201</td>
</tr>
<tr>
<td>4.5.2</td>
<td>The MS model with time-varying transition probabilities</td>
<td>206</td>
</tr>
<tr>
<td>4.6</td>
<td>Concluding remarks</td>
<td>209</td>
</tr>
</tbody>
</table>
## Contents

5 Modelling the Business Cycle with Fixed Transition Probability
   Markov Switching Models 211
   5.1 Empirical study ................................................................. 212
      5.1.1 Data description ....................................................... 213
      5.1.2 Model selection ....................................................... 220
      5.1.3 The MS-AR models for individual countries and districts ... 222
      5.1.4 Common regime shifts in multi-country growth models ... 263
   5.2 Final remarks ................................................................. 287

6 Estimating Business Cycles with Time Varying Markov Switching
   Models 290
   6.1 Introduction ................................................................. 290
   6.2 Data description ........................................................... 291
   6.3 TVTP estimations .......................................................... 299
   6.4 Duration-dependent MSVAR ............................................ 303
   6.5 Final remarks ............................................................... 309

7 Conclusions 310

A Appendix to Chapter 5 316
   A.1 Tables ................................................................. 316

B A Note about Software Used 323

Bibliography 324
List of Figures

1.1 Annual GDP growth rate in 1970-2006 .............................................. 5
1.2 The deviations of real GDP .............................................................. 8
1.3 Cycles in real GDP .............................................................................. 9

2.1 The constraint: partial production function ................................. 18
2.2 Preferences .............................................................................................. 19
2.3 The optimal choice .................................................................................. 20
2.4 The consumption constraint ................................................................. 22
2.5 The consumption preferences ................................................................. 24
2.6 The intertemporal consumption optimum ........................................ 26
2.7 Leisure ...................................................................................................... 27
2.8 Labour supply ........................................................................................... 28
2.9 Labour demand ........................................................................................ 30
2.10 Capital demand ........................................................................................ 31
2.11 The long-run equilibrium ................................................................. 33
2.12 The period of the shock ....................................................................... 34
2.13 The period after the shock ................................................................. 35
2.14 The new long-run equilibrium ................................................................. 36
List of Figures

3.1 China: Annual growth rates of real GDP and GDP expenditure components in 1970-2006 ........................................ 67
3.2 Hong Kong: Annual growth rates of real GDP and GDP expenditure components in 1970-2006 ................................. 75
3.3 Indonesia: Annual growth rates of real GDP and GDP expenditure components in 1970-2006 ........................................ 82
3.4 Japan: Annual growth rates of real GDP and GDP expenditure components in 1970-2006 ........................................ 89
3.5 Malaysia: Annual growth rates of real GDP and GDP expenditure components in 1970-2006 ...................................... 97
3.6 Philippines: Annual growth rates of real GDP and GDP expenditure components in 1970-2006 .................................... 106
3.7 Singapore: Annual growth rates of real GDP and GDP expenditure components in 1970-2006 .................................. 110
3.8 Korea: Annual growth rates of real GDP and GDP expenditure components in 1970-2006 ...................................... 118
3.9 Taiwan: Annual growth rates of real GDP and GDP expenditure components in 1970-2006 ......................................... 125
3.10 Thailand: Annual growth rates of real GDP and GDP expenditure components in 1970-2006 ..................................... 135
3.11 International reserves in 1990-2006 (SDR billions) .................. 152

5.1 The actual quarterly real GDP growth rates ................................. 218
5.2 Hamilton’s MSM(2)-AR(4) model ............................................. 226
5.3 The MS-AR model for the Chinese business cycle ....................... 232
5.4 The MS-AR model for the Hong Kong’s business cycle ................. 234
5.5 The MS-AR model for the Indonesian business cycle .................... 238
5.6 The MS-AR model for the Japanese business cycle ....................... 241
5.7 The MS-AR model for the Korean business cycle ......................... 245
5.8 The MS-AR model for the Malaysian business cycle ..................... 248
5.9 The MS-AR model for the Philippine business cycle .................. 251
5.10 The MS-AR model for the Singapore business cycle .................. 254
5.11 The MS-AR model for the Taiwanese business cycle .................. 258
5.12 The MS-AR model for the Thai business cycle ......................... 261
5.13 The MS-VAR model: Developing economies ............................ 266
5.14 The MS-VAR model: Developed economies ............................. 274
5.15 The MS-VAR model: All Markets ......................................... 283

6.1 The deviations of IP ............................................................... 292
6.2 Cycles in IP ........................................................................... 293
6.3 The actual monthly (quarterly) growth rates ............................... 296
6.4 TVTP probabilities of slow growth ......................................... 302
6.5 Indonesia: DDMSVAR states for recession (top) and expansion (bot-
   tom) .................................................................................. 305
6.6 Japan: DDMSVAR states for recession (top) and expansion (bottom) 306
6.7 Korea: DDMSVAR states for recession (top) and expansion (bottom) 306
6.8 Malaysia: DDMSVAR states for recession (top) and expansion (bottom) 307
6.9 Philippines: DDMSVAR states for recession (top) and expansion
   (bottom) ............................................................................. 307
6.10 Taiwan: DDMSVAR states for recession (top) and expansion (bottom) 308
6.11 Thailand: DDMSVAR states for recession (top) and expansion (bottom) 308
3.1 Average annual growth rates for selected East and Southeast economies 139
3.2 Average trade share from 1990 to 2006 (%) ................................. 141
3.3 Average trade share from 1990 to 2006 (%) ................................. 141
3.4 Average FDI inflows share from 1990 to 2005 (%) ....................... 142
3.5 Average FDI inflows share from 1990 to 2005 (%) ....................... 143
3.6 Average portfolio share in 2001-2006 (%) ................................... 144
3.7 External sector from 1990 to 1998 ............................................. 146
3.8 External sector from 1990 to 1998 (Cont.) ................................. 147
3.9 External sector from 1990 to 1998 (Cont.) ................................. 148
3.10 Social indicators between 1996 and 1998 ............................... 149

5.1 Classical turning points ..................................................... 214
5.2 Classical turning points (Cont.) ............................................. 215
5.3 Descriptive statistics of quarterly real GDP growth rates ............. 219
5.4 Estimation results: The Hamilton model .................................. 223
5.5 Estimation results: The MS-AR models ................................... 229
5.6 Estimation results: The MS-AR models (Cont.) .......................... 230
5.7 Estimation results: Developing economies ............................... 265
<table>
<thead>
<tr>
<th>Table Number</th>
<th>Table Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.8</td>
<td>Estimation results: Developed economies</td>
<td>272</td>
</tr>
<tr>
<td>5.9</td>
<td>Estimation results: Developed economies (Cont.)</td>
<td>273</td>
</tr>
<tr>
<td>5.10</td>
<td>Estimation results: All markets</td>
<td>280</td>
</tr>
<tr>
<td>5.10</td>
<td>Estimation results: All markets</td>
<td>281</td>
</tr>
<tr>
<td>5.10</td>
<td>Estimation results: All markets</td>
<td>282</td>
</tr>
<tr>
<td>6.1</td>
<td>Data description: Industrial Production Index</td>
<td>295</td>
</tr>
<tr>
<td>6.2</td>
<td>Descriptive statistics of monthly (quarterly) IP growth rates</td>
<td>297</td>
</tr>
<tr>
<td>6.3</td>
<td>Data description: The index of composite leading indicators</td>
<td>298</td>
</tr>
<tr>
<td>6.4</td>
<td>Estimation results of the TVTP model</td>
<td>301</td>
</tr>
<tr>
<td>6.5</td>
<td>Estimation results of the DDMS model</td>
<td>304</td>
</tr>
<tr>
<td>A.1</td>
<td>Estimation results: The MS-AR models (Cont.)</td>
<td>317</td>
</tr>
<tr>
<td>A.2</td>
<td>Estimation results: The MS-AR models (Cont.)</td>
<td>318</td>
</tr>
<tr>
<td>A.3</td>
<td>Estimation results: The MS-AR models (Cont.)</td>
<td>319</td>
</tr>
<tr>
<td>A.4</td>
<td>Estimation results: The MS-AR models (Cont.)</td>
<td>320</td>
</tr>
<tr>
<td>A.5</td>
<td>Estimation results: The MS-AR models (Cont.)</td>
<td>321</td>
</tr>
<tr>
<td>A.6</td>
<td>Estimation results: The MS-AR models (Cont.)</td>
<td>322</td>
</tr>
</tbody>
</table>
The study of long-term economic growth and short-term economic fluctuations has a prominent role in the field of economics. The aim is to understand what determines the long-term trend in levels of economic activity (usually approximated by gross domestic product, or GDP), as well as what affects short-run deviations from that trend. The part of economics dealing with the former is broadly known as “growth theory”, whereas the part dealing with the latter is known as “business cycle theory”.

Early discussions on economic growth – and a basic understanding of it – can be traced back to Adam Smith’s “Wealth of Nations” (1776). The interest of studying in business cycles is more active since the 20th century, because of the revelations of a significant degree of consistency in the features of macroeconomic fluctuations across periods of upturns and downturns, which are documented in empirical studies (see, e.g. Mitchell (1927, 1941, 1946, Kuznets 1926, 1946, 1953 and Mills 1936).

This study belongs to the business cycle strand of the literature. Understanding business cycles is not only of academic importance, but a necessary precondition for improving and designing economic policies. In particular, during periods of recession, firms suffer losses or go out of business altogether, unemployment increases,
asset values suffer and households undergo reductions in income – or worse. The economic and social consequences of recessions highlight the significance in understanding business cycles and helping policymakers decide on appropriate policies to control the effects of economic disruptions and even prevent beforehand.

This thesis aims to contribute to this understanding from an empirical viewpoint. I begin with a definition of the business cycle provided by Burns and Mitchell (1946): “Business cycles are a type of fluctuations found in the aggregate economic activity of nations that organise their work mainly in business enterprises: a cycle consists of expansions occurring at about the same time in many economic activities, followed by similarly general recessions, contractions, and revivals which merge into the expansion phase of the next cycle; this sequence of changes is recurrent but not periodic; in duration business cycles vary from more than one year to ten or twelve years; they are not divisible into shorter cycles of similar character with amplitudes approximating their own.”

This description of business cycles has several key points. The first is that expansions and recessions occur from time to time but their frequency and time of occurrence is not known. Related to this is that the business cycle occurs repeatedly in the sequence of expansion, contraction, recession and revival, however, it is not periodic. The second key feature is the separation of business cycles into distinct regimes or states. Finally, the last point in the definition above gives the minimum duration of a full cycle, which is no less than a year. This point suggests implicitly the persistency of business cycles.¹

The measurement of the characteristics of business cycles includes 1) the duration of each regime, 2) the timing of turning points, 3) the degree of persistence, 4) the volatility and 5) the order of the occurrence (leading or lagging variables). Let us start with the duration of the phases. The duration of the expansion phase is from the initial trough to the next date of the peak; the duration of the contraction phase is the opposite journey. In total, the duration of a full cycle is the sum of

¹More recent definitions, for example the U.S.'s National Bureau of Economic Research one, define a recession as two consecutive quarters of real economic activity.
these two regime durations. Next, the turning points are identified as the point in
time of moving from expansion (contraction) to contraction (expansion) when the
business cycle is at its peak (trough). Then, the persistence of business cycles is a
possibility of staying in the same state for another period if the previous periods (at
least one period) are in the state of expansion (or contraction), unless the economy
is hit by new shocks. Moreover, it is natural to use the standard deviation of the
estimated variables to represent the volatility of the business cycle, since it measures
the difference between the actual value of the observed variable and its mean in each
period. Finally, different economic variables do not move simultaneously all the time,
some economic variables may move ahead of attaining their turning points before
others do; these variables are referred to as leading indicators. On the contrary,
those variables that lag behind are known as lagging variables.

So far, I have briefly discussed a definition of the business cycle and its basic fea­
tures. Since this study is an empirical work of identifying business cycles, it requires
an efficient and effective method to capture these characteristics. Hamilton (1989)
establishes a so-called Markov switching (MS) model which produces information
about these features and allows us to carry out hypothesis tests. This particular
model has been further developed by others (for example, Krolzig (1997a) and Fi­
lardo (1994), among others). The MS model applies when a stochastic process is
governed by an unobserved random variable, which switches among different dy­
namic time paths and allows to extract the information about changes in dynamic
behaviour of the data. It considers the parameters of an autoregressive regression
or a vector autoregression as subject to discrete shifts in regimes. By using the MS
model, one can determine the numbers of the states of the economy on the basis of
regime-switching means or intercepts. Using transition probabilities as a byproduct
of the outcome of the MS model, one can identify turning points of business cycles
without any prior information. Allowing for heteroskedasticity reflects business cycle
asymmetries. In the following chapters, the structure of the classic MS model and
its alternatives will be discussed in detail. This model is adopted in the empirical
Next, I discuss why I have selected a group of Asian economies (mainly in East and Southeast Asia) to study the dynamic movements of their macroeconomic fluctuations. Until a few decades ago, most of the economies in the Asian region had paid little attention to their economic development. More recently, however, a rapid growth in economic activity and incomes was registered in a number of economies in the region, and this growth persisted for years. A World Bank publication (1993) refers to this remarkable surge in economic growth as "the economic miracle". This rapid growth continues in the region nowadays even after the economic crisis that hit the region in 1997, especially, those economies who are in East and Southeast Asia.

Figure 1.1 plots the annual growth rates of gross domestic product (GDP) of three areas (East and Southeast Asia, the EU and the US) and the World between 1970 and 2006. It can be seen that the growth rates of East and Southeast Asia are, on average, well above the growth rates of the other two areas and the world most of the time. Moreover, in relation to the growth path, it looks like the EU rates and the US rates are more correlated, whereas the growth pattern of East and Southeast seems to be far less related to the other two economies. The unique and varied patterns of economic development in the region have attracted the interest of more and more researchers and organisations (for instance, Stiglitz and Yusuf (2000), Lincoln (2004), Plummer (2006), Gill and Kharas (2007a, b), and Huang and Magnoli (2008)).

In 2005, the annual GDP growth of the World economy was 3.5%, whereas the economies of East Asia and Pacific grew at 9.1%, excluding high-income economies\(^2\). This strong performance was dominated by China at 10% per annum. In this thesis, I concentrate on 10 representative economies from the region. They are China (mainland) (or simply called China), Hong Kong, Indonesia, Japan, South Korea (or Korea in short), Malaysia, Philippines, Singapore, Taiwan and Thailand.

\(^2\)Data source: World Bank, World Development Indicators, April 2009.
Introduction

Figure 1.1: Annual GDP growth rate in 1970-2006

Notes: Data source: World Bank, World Development Indicators (2009).

Until three decades ago, Japan was the only successful and wealthy economy in Asia. After the Second World War, Japan recovered from severe economic damage and had become one of the most powerful and influential economies in the world by the 1980s. Its huge success in economic development had inspired other economies in the surrounding area. The first group to emerge after Japan is known as the newly industrialising economies (NIESs), which are Hong Kong, South Korea, Singapore and Taiwan. Later, a second group begun to arise: China, Indonesia, Malaysia, Philippines and Thailand. All economies (except Hong Kong, Japan and Singapore) are tracked by the MSCI (Morgan Stanley Capital International) list of emerging market economies in Asia$^3$. All (except Taiwan) are members of the Executive Meeting of the East Asian Pacific Central Banks (EMEAP)$^4$.

Despite sharing some common characteristics, diversifications among those economies are significant. Not only in language, culture, resources and political systems, but also in the size of the respective economies. In the region of East and Southeast

$^3$See http://www.msci.com/products/indices/
$^4$See http://www.emeap.org/
Asia, using the data on GDP at power purchasing parity (PPP)\(^5\) in 2006, China with 6.12 trillion international dollars at current prices, had 42\% of regional GDP. Japan, on the other hand, only had 28\% of regional GDP. Yet the third largest economy in the region, South Korea was just 8\% of the total. The rest of the economies shared totally 20\% of regional GDP. However, the story changes when I use GDP per capita at PPP in 2006. China represents only 2\% of the total while Japan and the four NIEs, each represents over 10\% of regional GDP per capita. Because of these differences, each economy has its own comparative advantages on the basis of factor costs and economic scale. On the other hand, these economies are agglomerated as never before through intraregional trade in goods, money as well as knowledge.

Although there are rapidly growing studies on documenting features of individual and international business cycles on major developed economies using the MS model a limited number of studies\(^6\) have examined the features of business cycles of these Asian economies by applying this particular econometric model. Therefore, the overall objective of my research is to fill this gap by identifying business cycles of the selected economies in the East and Southeast Asian region and to examine their characteristics, both at the individual and at the regional level, in order to better understand the dynamic processes at play. More specifically, this research would like to address the following questions:

1. What are the characteristics of business cycles described in these selected economies?
2. What is the extent of the correlations between countries’ growth rates depend on the actual regime?
3. Is there an informational advantage in using leading indicators in dynamic, regime-switching growth regressions?

\(^6\)For example, Kim (1996), Breunig and Stegman (2003), Watanabe (2003), Chen and Shen (2006a,b), Iiboshi (2007).
4. Is there an informational advantage in using duration dependence in the same context?

Furthermore, in recent years, there is an increasing interest of research on the set up of a regional currency union within the region. Various papers examine the possibility of conducting a monetary union from different aspects. Huang and Guo (2006), Keida (2009) and Nguyen (2010) check the symmetry of shocks. Kim et al. (2003), Sato and Zhang (2006), Shin and Sohn (2006), Rana (2007), Lee and Azali (2010) and Gochoco-Bautisa and Mapa (2010) find evidence of a growing degree of economic integration on business cycles since the 1997 financial crisis, largely by means of trade. These papers suggest that there is a great potential of forming a single currency area in the region, some of them even propose that it could start with a small group of the economies (e.g. the major five members of Association of Southeast Asian Nations (ASEAN)). On the contrary, diversity of production sectors (Hasebe and Shrestha (2006)); a low degree of synchronization based on the optimum currency areas criteria (Mundell (1961, 1997)) (Font-Vilalta and Costa-Font (2006)); variations in the nature of shocks and macroeconomic responses to shocks (Kim (2007), Genberg and Siklos (2010)); the heteroskedasticity in losses and gains associated with inflation (Strobel (2007)); and the constraint on trading a limited set of industrial products (Kumakura (2006)), which imply that the formation of a monetary union is premature. As a byproduct of the empirical analysis relating to the second research question, this topic will be addressed later.

Before I proceed any further, it may be worthwhile to preview the cyclical fluctuations of the selected economies. The quarterly GDP is used (except for Singapore, for which the quarterly industrial production (IP) index is used instead) and is transformed by taking the change of the logarithm of the series. The method that is employed in here is known as Hodrick-Prescott (HP) filter (1997). In Figure

\[ HP = \sum_{t=1}^{T} (y_t - g_t)^2 + \lambda \sum_{t=2}^{T-1} [(g_{t+1} - g_t) - (g_t - g_{t-1})]^2 \]
Figure 1.2: The deviations of real GDP
Figure 1.3: Cycles in real GDP
1.2, the graphs illustrate the deviations of real GDP from its trend for the group of the selected economies. It tells the same story in Figure 1.3 where the cyclical components are explicitly plotted. The graphs further confirm that business cycles are the alternations of upturns and downturns, and they appear to be irregular and be far from periodic.

For the purpose of clarity, the structure of the thesis is organised as follows. Chapter 2 outlines the theoretical background and reviews a range of empirical studies on business cycles. The purpose is to facilitate a better understanding of the subject and to highlight what has been done in comprehending business cycles. The theory of real business cycle (RBC) is explained in detail. The reason of choosing the RBC theory is because it deals with the sources of causing business cycles which are paid a little attention in traditional theory. It emphasises that business cycles are a phenomenon of supply-side effects. The process of how supply shocks affecting the decisions of economic agents result in business cycles is explained. Moreover, the further development of empirical studies based on the classic RBC model are reviewed. A caveat is needed here: the theory is presented for completeness but plays no active role in selecting the empirical methodology. No claim is made that MS models constitute the 'correct' way of bringing RBC theory to the data. The rest of the chapter reviews a number of empirical studies on several major issues in the business cycle literature: the international business cycle and economic indicators in predicting turning points.

Chapter 3 provides a macroeconomic overview of the 10 selected economies. The overview of each economy encompasses its economic structure, important economic policies and economic performance which is reviewed from an overall GDP growth perspective to a breakdown of GDP expenditure components. These economies are in different stages of economic development, and as a result, the speed of economic growth and the maturity of economic sectors vary quite dramatically. However, through the links of trade and investment flows, there is a tendency for 'convergence'.

The trend component $g_t$ is obtained by minimising $HP$ with respect to all of $g_t, t = 1, \ldots, T$. The cyclical component $c_t$ is subsequently calculated as $c_t = y_t - g_t$. 

\textit{Introduction} 10
Introduction

among these economies. Basically, the idea of this chapter is to give an insight to the macroeconomic background of each economy and offer a platform for comprehending issues related to their path of economic development.

Chapter 4 discusses the chosen econometric model, that is, the Markov switching (MS) model, which is used in this thesis to provide answers to the questions posed earlier in this chapter. Three different MS models will be considered, the MS model with time-invariant transition probabilities (FTP), the MS model with duration dependent (DDMS) and the MS model with time-varying transition probabilities (TVTP). The basic framework of these econometric models is sketched, along with the available estimation mechanisms – the expectation-maximisation algorithm and Bayesian analysis and the Gibbs-sampling approach. Having presented the frameworks of the three different types of the MS models, the rest of the chapter is dedicated to a review of empirical works on modelling business cycles through the use of this class of models.

Chapter 5 presents the empirical results of business cycles of the 10 economies by using the MS model with fixed transition probabilities (FTP). In the first part, each economy is estimated individually using both the standard Hamilton model and the extended FTP models. There is evidence that the latter models work better, as asymmetries of the business cycle are found in the empirical estimations. Furthermore, according to the outcome of the dating exercise within the chosen models there is some evidence of synchronic movements of business cycles across the economies. This finding encourages the use of a vector structure of the FTP model. The results are supportive of a regional business cycle as there are four downturns detected between 1995 and 2006 across the selected economies. On the downside, the empirical output also suggests that in some cases, the FTP models are not the best choice for modelling business cycles and other appropriate alternative options are encouraged. This issue is tackled in the following chapter.

Chapter 6 relaxes the assumption of fixed transition probabilities and allows exogenous variables to affect the transition probability, i.e. the probability of switching
across regimes is now informed by additional variables. The choice of a composite leading indicator (CLI) as the exogenous variable enables me to assess its performance. In addition, the focus turns on the duration dependence in the context of this dynamic setting and the question of whether the transition probabilities depend on how long regimes persist is addressed.

Chapter 7 summarises the findings, discusses the caveats and discusses future research.
The Theory and Evidence on Business Cycles

Business cycles have been widely documented over two-hundred years; however, efforts to develop a formal theory of the business cycle are more recent. In the early 1980s, there was a significant development in business cycle theory, which was pioneered by Kydland and Prescott (1982) and Long and Plosser (1983). It became known as the real business cycle (RBC) theory. The importance of the RBC approach in the literature is impossible to understate. There are three major reasons why the RBC theory is chosen in this study. First, the RBC theory challenges the traditional thoughts about what causes business cycle fluctuations. It argues that business cycles are caused by supply-side shocks rather than demand-side shocks to the economy. Second, it has altered the rules of carrying out quantitative research in macroeconomics. The RBC theory set up a range of instruments within the context of a competitive equilibrium approach to calculate the equilibria of business cycle models and to examine their behaviour empirically. Lastly, at least in academic journals, it has become a dominant approach to business cycles.

Although monetarism (Friedman 1968, Laidler 1976) and new classical economics (Lucas 1972, 1973) and Barro and Gordon 1983) stress the importance of
The Theory and Evidence on Business Cycles

The supply side in determining aggregate output and question the effectiveness of active demand policies pursued by the government, the RBC theory goes further in several aspects. The standard RBC theory proposes that fluctuations in output resulting from exogenous deviations in productivity are purely determined by the supply side of the economy under the absence of market imperfections. Generally, the standard RBC model includes firms and households. Building on microeconomic foundations, it assumes that firms maximise profits and households maximise utility. All firms are assumed to be similar, thus, the behaviour of a single firm represents the behaviour of all other firms. Likewise, this scenario also applies to households. Business cycles are then explained as the consequences of the optimal response of rational economic agents to the fluctuations in relative prices by means of adjusting their supply of labour and consumption. Moreover, the standard RBC theory also assumes that monetary and fiscal policies are neutral. It argues that these policies only result in variations in nominal variables (i.e., the price level) but do not affect real variables, such as aggregate output and employment. However, this point of view can be altered as the assumption is relaxed. In alternative RBC models, changes in fiscal and monetary policies do have influence on the economy. Further discussion on this follows in section 2.1.8.

In this chapter I present the basic concepts of RBC theory (Section 2.1) and further studies based on the fundamental framework of the RBC theory. Then I proceed to review the empirical literature on business cycles (Section 2.2), mainly on two topics: international business cycles and economic indicators in predicting turning points. However, I omit the empirical work that has been carried out using the Markov switching models. Contributions based on these models are surveyed following a detailed discussion of the workings of regime switching specifications in Chapter 4. Finally, Section 2.3 sums up the main findings.
2.1 The real business cycle theory

The purpose of this section is to demonstrate the main features of the RBC model in a simple environment. In this manifestation, the goal is to outline an intuitive understanding of the model, rather than to build up mathematical proofs of the relevant propositions. I also discuss extensions to and limitations of the model.

2.1.1 The standard model

Consider a closed economy with elimination of government. There are a large number of alike, infinite-lived and price-taking households. All of them are rational and forward-looking, and their intertemporal utility from time \( t \) on is given by the discounted sum of current utilities

\[
U_t = \sum_{\tau=t}^{\infty} \beta^{\tau-t} u(C_{\tau}, 1 - L_{\tau})
\]  

(2.1)

where \( C_t \) and \( L_t \) denote the household's consumption and the time spent working during period \( t \). Since the representative household’s time endowment is standardised to unity, therefore, \( 1 - L_t \) denotes leisure time at time \( t \). Moreover, \( \beta(0 < \beta < 1) \) is a discount factor that reveals time preference between current and future consumption-leisure bundles. The utility function \( u \) relates positively to consumption and leisure, what is more, it is convex and continuously differentiable with positive but diminishing marginal utilities, i.e. \( \frac{\partial u}{\partial x} > 0 > \frac{\partial^2 u}{\partial x^2} \), for \( x = C_t, 1 - L_t \).

Firms behave similarly and produce a single homogeneous good \( Y \) by adopting capital \( K \) and labour \( L \), using current technology \( A \). The production function is characterised as the neoclassic form

\[
Y_s = Y_t = A_t F(K_t, L_t)
\]  

(2.2)

where \( F \) is concave and continuously differentiable with positive but decreasing
marginal products, i.e. $\frac{\partial F}{\partial x} > 0 > \frac{\partial^2 F}{\partial x^2}$, for $x = K_t, L_t$. In addition, the production function is assumed to be constant returns to scale, that is, $A_t F(bK_t, bL_t) = bA_t F(K_t, L_t)$. Note that the technology shock $A_t$ is random and exogenous, but is realised before making any decision in period $t$. Furthermore, this shock is assumed to follow a stationary first-order Markov process that the distribution of $A_t$ depends on $A_{t-1}$ if the shock occurs, otherwise, it is constant over time.

According to the assumption of perfect competition, marginal products are paid to equal the real wage $w_t$ and the real interest rate $r_t$ in period $t$, respectively

$$w_t = A_t \frac{\partial F}{\partial L_t}$$  \hspace{1cm} (2.3)  \\
r_t = A_t \frac{\partial F}{\partial K_t}$$ \hspace{1cm} (2.4)

Output in each period is either consumed or saved, where saved output is added to the capital stock in the next period. In each period, there is a fraction $\delta$ of capital worn out through depreciation. Hence, the capital stock at time $t+1$ is

$$K_{t+1} = Y_t - C_t + (1 - \delta)K_t$$ \hspace{1cm} (2.5)

In this closed economy with the absence of government, aggregate demand of the economy only involves consumption $C$ and investment $I$

$$Y_d = C + I$$ \hspace{1cm} (2.6)

Thus, under the condition of market clearing, it holds that aggregate demand equals aggregate supply

$$Y_d = Y_s$$

So far, we have demonstrated the main building blocks of the model. In the complete RBC model, households' horizon is infinite, but in order to sketch how output and the major macroeconomic variables respond to shocks, I will first start with describing the behaviour of households and firms by limiting the time horizon
to two periods. Then I will analyse the general properties of the full-scale model.

2.1.2 The behaviour of households

According to the utility function (2.1), households need to decide how much to work (and leisure) and consume (and save) today and in the future, so as to maximise utility. It should be clear that households’ decisions on how much time to devote to work affect supply of the economy and are coincident with decisions on a lifetime pattern of income. At the same time, the choice of lifetime consumption pattern determines total expenditure of the economy but does not have to be equivalent with the lifetime income pattern as long as it is funded by it. These two decisions are interconnected, namely, when one of rational choices is made it is highly unlikely that the other is not being noticed. Therefore, I discuss choices made in the current period and intertemporal choices separately.

Moreover, the analysis of household behaviour implies the classification of the available choices that households can attain, and the optimal choice among them all. In short, it is necessary to identify the constraint and the preference.

Current-period choices

The constraint. The choices that households face are determined by the production function. Since the amount of capital stock and the technology state are known at the beginning of the current period, the only factor affecting output (or income) is labour supply. Consequently, the potential household constraint is a partial production function which measures the amount of output that can be produced with a certain level of labour input, given both a fixed level of capital and technology. The partial production function reveals the tradeoff between income and leisure time (which equals 1 minus work time) as shown in Figure 2.1. However, the variables that we are interested in are combinations of consumption and leisure time. Thus, the partial production function can be used as the household constraint only if consumption equals net income (which is gross income minus capital depreciation).
This condition is satisfied only in a steady state (or a long-run equilibrium). In the steady state, changes in capital stock (i.e., net investment, which is gross investment less depreciation) is zero due to the fact that total investment is used to replace capital that exhausts, net income equals consumption, according to (2.6).

An individual household observes the constraint differently than from the whole economy viewpoint. The individual household's constraint is a linear line that is tangent the partial production function with a slope equal to the real wage rate. Nonetheless, the individual household's decisions of time spent working cannot affect the real wage rate in the aggregate level. Hence, the linear constraint cannot be the feasible constraint of the entire economy. Alternatively, the partial production function plays as a partial constraint. Thus, changes in the real wage always alter the slope along the partial production function, that is, the marginal product of labour.

The preference. The preferences of households are represented by the indifference
Figure 2.2: Preferences
Figure 2.3: The optimal choice

curve which shows the tradeoff between consumption and leisure. In Figure 2.2, indifference curves are convex to the point where both consumption and leisure time are zero, i.e. households work entirely during the whole time and consume nothing at all. Moving along the indifference curve, the further to the right or the left, greater compensation is required for the loss in either consumption or leisure. Moreover, a rise in either consumption or leisure increases household utility. The higher the indifference curve, the greater the utility level.

The optimal choice. The optimal choice of consumption and leisure of the household is obtained by combining the constraint and the preference together, as shown Figure 2.3. The maximum utility is attained where the indifference curve is tangent to the constraint, for example, the optimal point A. Points above the optimal are desirable but unaffordable, whereas points below reduce utility.

Shifts in the optimal choice. Changes in either the indifference curve or the constraint or both will alter the location of the optimal choice. In the RBC theory, the research concentrates on shifts in the constraint.
Under the framework of the model, there are two factors that affect the constraint: technology and capital stock. The improvement of technology and an increase in the capital stock shift the constraint upwards to a higher level. As a result, at the new optimal point, the household’s income also rises. However, the effect on labour supply is less straightforward. It may rise or fall, depending on the function forms of production and utility. In reality, in the long-run, the empirical evidence suggests that employment is relatively stable over time, regardless of changes in technology and capital. So, in Figure 2.3, the optimal point A moves vertically to the new optimal point B.

So far, the demonstration of the optimal point is a long-run equilibrium. When the time horizon of the model is extended to multiple periods, shocks to the economy can drive economic growth away from its long-run growth path. The characteristics of fluctuations and the adjustment path to the original or the new steady steady state are determined by intertemporal optimisation. This denotes that the household’s choices must satisfy the optimal condition every period. Household utility which includes intertemporal variables is affected by the household current and future decisions. Next, we will discuss how the household chooses consumption and leisure in two periods.

**Intertemporal choices**

In a two-period model, households need to decide the allocation between time of work and leisure, as well as income between consumption and saving today and tomorrow. Decisions that are made today affect the welfare tomorrow. To show how those choices are made, we will pretend that each decision is made independently, taking the others as given.

*The consumption constraint.* As usual, household consumption is limited by the household’s income. Whereas households have to decide how much to consume across different time periods, they face an intertemporal budget constraint (BC) which indicates total incomes that are available for consumption in the current and
future periods. A point that measures the amount of income that is earned today and tomorrow and is consumed immediately in the period which it hoards, is called the endowment point and lies on the 45-degree line, such as point A in Figure 2.4a. The household’s intertemporal budget constraint passes through this point.

Under the existence of credit markets, households can either save or borrow at the real interest rate $r$, so households can consume either more or less than their incomes in a single period.

Formally, the intertemporal budget constraint can be expressed as

$$C_1 + \frac{C_2}{1 + r} = Y_1 + \frac{Y_2}{1 + r}$$

(2.7)

The economic interpretation of (2.7) is that if the real interest rate is zero,
consumption equals income in each period. If, on the other hand, the real interest rate is greater than zero, both consumption and income in the future are discounted by the factor $1 + r$ which comes from interest payments on saved income.

The intertemporal budget constraint rotates around the endowment point A if there is a change in the real interest rate. A higher real interest rate discourages the incentive of consuming and increases saving in current period, as a result, consumption is higher in the future. Moreover, the intertemporal budget constraint shifts outward when total income increases, such as from point A to point C in Figure 2.4b.

The consumption preferences. Household consumption preferences involve also intertemporal decisions and are still represented by the indifference curve. The shape of the indifference curve is convex to the origin, the further the indifference curve is away from the origin, the higher utility it represents, as indicated in Figure 2.5. The indifference curve shows the combination of current and future consumption that gives the household the same satisfaction. The slope of the indifference curve at any point is measured by the marginal rate of substitution (MRS). It is negative and reveals the additional amount of current consumption is required to compensate for every unit of decreasing in future consumption.

Alone the indifference curve ($\mathcal{I}_C$), the MRS is low such as at point C where current consumption is relatively higher than future consumption, an additional unit increase in current consumption only needs to sacrifice a relative small amount of future consumption. Whereas the MRS is high at point D where current consumption is low, an additional unit of it requires to give up a relative large amount of future consumption. Additionally, when indifference curves interact the 45-degree line at points like A and B, the marginal utilities of current and future consumption are equal. If there is no a discount factor $\beta$, then the MRS is -1. However, according to the utility function (2.1), the MRS is equal to $-1/\beta$ which says that one unit of future consumption is only worth $\beta$ units of current consumption.

The intertemporal consumption optimum. Household intertemporal optimal con-
Figure 2.5: The consumption preferences

![Diagram showing consumption preferences](image-url)
sumption choice is determined by the indifference curves and the budget constraint. The household always attains the higher indifference curve, but it is constrained by total income that is available to the household. The best choice is the indifference curve that is tangent to the budget constraint, like point A in Figure 2.6a. At the optimal point, the slope of the budget equals the slope of the indifference curve, namely, the MRS

\[ MRS = -(1 + r) \]  

(2.8)

There is one particular point where the optimal point lies on the 45-degree line, i.e. point A. At this point, since the MRS of the indifference curve \(-1/\beta\), so according to (2.8)

\[ \beta = \frac{1}{1 + r} \]

Suppose there is a shock which results in increasing the real interest rate. The rise in the real interest rate rotates the intertemporal budget constraint around point A to the new constraint \( BC_2 \) where the slope is steeper. Accordingly, the optimal choice moves from A to B which lies on a higher indifference curve. This is because a higher real interest rate encourages households to save more today than the initial level under the original interest rate. As a result, households consume less today and more in the future. In summary, the higher the real interest rate in current period, the more households save and the less they consume today. The relationship between the real interest rate and current consumption is negative, as illustrated in Figure 2.6b which is measured by the consumption demand line (CD).

*The intertemporal labour supply.* The supply of labour is driven by the mechanism of the intertemporal substitution of labour supply. This refers to similar goods or services at different times are exchangeable. In the discussion of households’ decision about the allocation of consumption spending over two periods, we showed that consumption is being delayed when the real interest rate increases in one period in order to enjoy a higher level of consumption in the other period, or consumption outweighs the amount of income to be earned in the very same period when the
Figure 2.6: The intertemporal consumption optimum
The Theory and Evidence on Business Cycles

(a) Utility of leisure

(real interest rate is low. In the case of labour supply, it is less clear-cut. Assume households have determined the allocation of consumption spending over time, they need to decide how many hours they work can finance their consumption bundles.

As before, the optimal labour supply is determined by the constraint and indifference curves. The only difference in the diagram of indifference curves is that both axes represent leisure instead of consumption (Figure 2.7a). The constraint of labour supply passes through a point which represents households’ choice of consumption over periods, that is so-called the consumption plan. At this point, households require incomes to support their consumption in the same period in the context of the absence of credit markets, this converts to the amount of time spend working. This particular point A lies exactly on the 45-degree line as shown in Figure 2.7b. In order to achieve this consumption plan, households work $L_{A,1}$ in current period and $L_{A,2}$ in future period. The inclusion of credit markets offers households more choices. Households can enjoy more leisure today in exchange for work more tomorrow via borrowing, or the other way around via saving. There are infinite choices, and all the choices line up to a straight line which the slope reveals the real interest rate and possibly the wage rate. While the real interest rate is high, household spend more

Figure 2.7: Leisure

(a) Utility of leisure

(b) The intertemporal constraint

real interest rate is low. In the case of labour supply, it is less clear-cut. Assume households have determined the allocation of consumption spending over time, they need to decide how many hours they work can finance their consumption bundles.

As before, the optimal labour supply is determined by the constraint and indifference curves. The only difference in the diagram of indifference curves is that both axes represent leisure instead of consumption (Figure 2.7a). The constraint of labour supply passes through a point which represents households’ choice of consumption over periods, that is so-called the consumption plan. At this point, households require incomes to support their consumption in the same period in the context of the absence of credit markets, this converts to the amount of time spend working. This particular point A lies exactly on the 45-degree line as shown in Figure 2.7b. In order to achieve this consumption plan, households work $L_{A,1}$ in current period and $L_{A,2}$ in future period. The inclusion of credit markets offers households more choices. Households can enjoy more leisure today in exchange for work more tomorrow via borrowing, or the other way around via saving. There are infinite choices, and all the choices line up to a straight line which the slope reveals the real interest rate and possibly the wage rate. While the real interest rate is high, household spend more
time on working and save a fraction of added incomes, so as to enjoy more leisure time in period when the real interest rate is low. In the other situation where a rise in the wage rate, the opportunity cost of leisure is more expensive than otherwise. The rational choice would be work more today and enjoy leisure tomorrow. In both cases, the constraint pivots around the consumption plan.

By combining the constraint and indifference curves, we are able to determine labour supply. Utility is maximised at which the constraint is tangent to the indifference curve. At the optimal point A, there is no change in either income or the wage rate, the slope is \(-(1 + r)\) and the MRS is \(-1/\beta\), so \(\beta = \frac{1}{1+r}\). If the real interest rate rises to \(r_B\), the optimal point moves to point B where households increase work time thereby output increases as well. This analysis reveals an important relationship, that is, labour supply is positively related to the real interest rate,
The Theory and Evidence on Business Cycles

as graphed in Figure 2.8b. This is known as intertemporal substitution in labour supply.

Up to now, we have discussed household behaviour under different time horizons. Next, we need to identify the behaviour of the firm on the demand of inputs to complete the overall picture.

2.1.3 The behaviour of the firm

In the perfect competition market, the representative firm maximises profits by employing capital and labour until marginal products equal marginal costs.

Let us start with the demand for labour. Firms hire an additional unit of labour whenever the marginal revenue that generates by another unit of labour is above the marginal cost of it. Therefore, the labour demand curve can be derived from the partial production function.

In Figure 2.9, the first graph sketches the partial production function, that is, holding technology and capital constant, output increases as the input of labour increases. However, the slope of the partial production function (in other words, the MPL) becomes flatter as labour input increases. If we separate the MPL in an independent graph, measuring the quantity of labour on the horizontal axis and the MPL (or the real wage rate) on the vertical axis, we obtain a downward-sloping MPL curve. This curve is also the labour demand curve.

Given the real wage rate $w_1$, when employment is less than $L_1$, the MPL surpasses $w_1$ and profits rise by increasing labour input. In the contrary, when employment is above $L_1$, the MPL is below $w_1$ and profits rise by decreasing labour input, holding other things being equal. Therefore, the representative firm attains the maximum profit by adopting $L_1$ units of labour given $w_1$. This is shown in the second and third panels of Figure 2.9. At different real wage rates, it generates different profit maximising employment. Since the MPL reveals profit maximising employment, it also represents the labour demand curve. This together with the labour supply curve determine the equilibrium real wage rate.
Figure 2.9: Labour demand
The derivation of demand for capital is similar process, except the axes measure capital and the real interest rate, as indicated in Figure 2.10a. At a specific real interest rate like \( r_1 \), firms hire \( K_1 \) units of capital where the marginal product of capital (MPK) is equal to the real interest rate, in order to maximise profits.

There are two major differences between the demand of labour and that of capital. The first difference is that firms have to invest to change capital stocks. Firms increase capital stocks when the real interest rate is below the marginal product of capital (MPK), so net investment is positive. In contrast, firms reduce capital stocks if the real interest rate is above the MPK, thus net investment is negative. Moreover, net investment is exactly zero when the MPK equals the real interest rate (Figure 2.10b). Second, input of labour can be used straightway whereas there is a time lag on input of capital. Consequently, firms are forward-looking in relation to investment decisions. So the position of net investment demand is determined by the expectation of the MPK for the next period.
2.1.4 The long-run equilibrium

Until now, we have illustrated the demand- and supply-side choices of the economic agents, the next step is putting all these fundamental elements together to define the long-run equilibrium of the RBC model.

First, the long-run equilibrium track positions on a horizontal line (LRE) which is labelled at the interest rate $r$ is equal to the reciprocal of the discount factor $\beta$ minus 1. This has already been demonstrated in the early, in the long-run equilibrium, all variables lie on the 45-degree line after the effects of shocks disappear in the intertemporal decision diagrams. The economy deviates from this long-run equilibrium path after hitting by shocks. Next, adding the aggregate supply curve (AS) with a positive slope. At the point where AS is across LRE, there is no intertemporal substitution. Above the equilibrium, the real interest rate is greater than the time discount factor which means the cost of continuing leisure and consumption are more expensive now, so rational households increase their supply of labour today in exchange for working less tomorrow. Below the equilibrium, the result is converse. Then, inserting the aggregate demand curve (AD) into the diagram. AD is simply the horizontal sum of demand for consumption (CD) and that for investment (NID). The slope of AD is negative. In the long-run equilibrium, the intersection point of AD and AS sits accurately on the LRE (Figure 2.11).

2.1.5 The response to shocks

In this part, we are going to show how this basic RBC model reacts to a one-time shock. Assume there is an unanticipated positive technology shock that raises production permanently.

The period of the shock. In Figure 2.12, this positive technology shock increases output so aggregate supply ($AS_1$) shifts horizontally to the right to $AS_2$. Given the same level of the real interest rate, capital and labour are more productive than before. The new long-run equilibrium of AS still lies on the LRE line at point B with an increased output level from $Y_1$ to $Y_2$. For consumption, it always equals
income in the long-run equilibrium, since income has increased and if this point is the long-run equilibrium, then the CD line shifts the same distance as AS to the right and is parallel to the original CD curve (i.e. from $CD_1$ to $CD_2$). $CD_2$ and $AS_2$ cross at point B on the LRE line. For investment, we are looking at the NID line which reveals the expectation of MPK in the next period. While firms observe that the shock has permanent effects on output, they predict that marginal productivity will be higher in the future. Therefore, the MPK shifts outward, in turn, this results a rise in desire for capital. Subsequently, to increase capital stocks, firms need to invest first, so the NID line moves from $NID_1$ to $NID_2$. Now summing the CD and NID lines levelly to get the AD curve. It can be seen from the diagram that the new AD curve intersects the $AS_2$ curve at point C which is way above the long-run equilibrium. At the long-run equilibrium, the supply of output fails to meet the demand of output. Firms plan to produce output at $Y_2$ but demand for labour and investment requires output at $Y_3$. In order to reduce the gap between the short
supply and the excess demand, a rise in the real interest rate solves the problem by means of the intertemporal substitution mechanism. An increase in the interest rate results in the expansion of work time, this further gives rise to a rise in labour supply and output. Meanwhile, this rising interest rate reduces the incentive of consumption today by saving more so as to enjoy more consumption tomorrow. Thus, moving along the $CD_2$ line up from point B. Moreover, firms’ demand for investment also falls since the higher interest rate makes investment more expensive. Hence, the combination effects of intertemporal substitution of labour and consumption drive down aggregate demand along the AD curve to point C where AD equals AS at the interest rate $r_2$, and this produces output $Y_4$.

The period after the shock. Although, the shock has only one-period effect and there are no new shocks in the next period, the point C is not the long-run equilibrium, the movements of all these variables are still in progress. The driving force behind this is the assumption of ‘time-to-build’, which is introduced by Kydland and Prescott (1982). Due to lags in the investment progress, those goods that are invested in last period become effective capital, therefore, capital stocks raise with a time lag. This in turn raises production regardless technology shocks, and aggregate
supply moves further to the right ($AS_3$). Consumption demand also shifts to position $CD_3$ where it is across $AS_3$ at point D. This is due to same reason discussed above. The continuing increasing capital accompanied with decreasing in the MPK. The $NID_2$ line shifts backward slightly to $NID_3$. Adding consumption and net investment together, the AD curve shifts to $AD_3$ and also produces a new equilibrium at point E. At this point, income still increases ($Y_5 > Y_4$) but the interest rate falls to $r_3$. Furthermore, since this point is still not the long-run equilibrium, the intertemporal substitution mechanism still works to reduce the amplitude of the deviation slowly. The above progress is demonstrated in Figure 2.13.

The progress carries on further ahead as capital stocks continue to increase. It follows that income still raises and the interest rate still falls, at a reduced amount, until all the deviant effects disappear and the economy finally arrives at a new long-run equilibrium at point F (Figure 2.14). At this point, the discount factor equals the reciprocal of the time discount factor $\beta$ minus one once again; the net investment demand line shifts back to the original place ($NID_1$) where net investment is zero; consumption is equal to income ($CD_4$); and AD and AS intersect at point F which gives income $Y_6(> Y_1)$. 

Figure 2.13: The period after the shock
Figure 2.14: The new long-run equilibrium
2.1.6 General solution of the basic RBC model

Up to this point I have confined myself to discussing the intuition of the RBC theory using graphs. I now turn to a mathematical treatment in order to derive general solutions of the basic RBC model.

*Efficiency.* To start with, I will derive the efficiency conditions for the maximisation problem. In each period $t$, the economic state is expressed by the technology $A_t$ and capital $K_t$, and households make decisions on consumption $C_t$ and leisure time $(1 - L_t)$ (or labour supply $L_t$), once decisions of those variables are made the paths of other variables are determined. Thus, we need to find the optimal paths for $\{C_t\}_{t=1}^{\infty}$ and $\{L_t\}_{t=1}^{\infty}$ that maximise utility. Additionally, the capital stock in period $t + 1$ is determined jointly by $C_t$ and $L_t$, as stated in equations (2.2) and (2.5). So the household's maximisation problem is

$$\max_{\{C_t, L_t\}_{t=1}^{\infty}} : E_t\left[\sum_{t'=t}^{\infty} \beta^{t'-t} u(C_{t'}, 1 - L_{t'})\right]$$

s.t. $K_{t+1} = (1 - \delta)K_t + A_t F(K_t, L_t) - C_t$ \hspace{1cm} (2.9)

where the operator $E(\cdot)$ indicates the rational expectation of the argument conditioned upon information up to time $t$.

Nonetheless, the productivity shock $A_t$ is random and unpredictable, the household's optimisation problem faces uncertainty. Fortunately, this problem can be solved by using dynamic programming techniques\(^1\). This technique leads to the framework of the principle of optimality\(^2\) which declares that the choice of $\{C_t, L_t\}_{t=1}^{\infty}$ are optimal only if the remaining choices of $\{C_t, L_t\}_{t=t'}^{\infty}$ (primes denotes next period values, i.e. $t' > t$) also maximise expected utility over the remaining time horizon $(t', t' + 1, \ldots)$. Otherwise, it will be benefit to switch to other optimal paths for

\(^1\) Dynamic programming decomposes the optimisation problem which includes $n$ variables into $n$ stages where each stage comprises a subproblem with a single variable, in order to derive the optimal solution.

\(^2\) The principle of optimality states that future decisions for the remaining stages will constitute an optimal policy regardless of the policy adopted in previous stages.
\{C_t, L_t\}_{t=1}^{\infty}$ which maximise utility over $(t', t' + 1, \cdots)$. In short, the optimal paths have to be efficient.

To solve the problem, it calls for the Bellman equation which restates the above maximisation problem as the following equation:

$$V(K_t, A_t) \equiv \max_{\{C_t, L_t\}} \{u(C_t, 1 - L_t) + \beta E_t[V(K_{t+1}, A_{t+1})]\}$$ (2.10)

subject to the same constraint as (2.9). Here, the function $V$ denotes the value function and represents the utility level. The level of intertemporal utility that can attain over the remaining period relies on the availability of capital stocks and the state of technology. Equation (2.10) describes that the optimal choice of $(C_t, L_t)$ today maximises the sum of current utility $u(C_t, 1 - L_t)$ and the discounted expectation of all future utilities $\beta E_t[V(K_{t+1}, A_{t+1})]$, where the latter is itself maximised.

Taking the first order condition (FOC) of the Bellman equation with respect to consumption $C_t$ and leisure $1 - L_t$, and setting equal to zero, this yields the necessary optimality conditions

$$\frac{\partial V(K_t, A_t)}{\partial C_t} = \frac{\partial u}{\partial C_t} + \beta E_t\left[\frac{\partial V(K_{t+1}, A_{t+1})}{\partial K_{t+1}} \cdot \frac{\partial K_{t+1}}{\partial C_t}\right]$$

$$= \frac{\partial u}{\partial C_t} - \beta E_t[V'(K_{t+1}, A_{t+1})] = 0$$

i.e.

$$\frac{\partial u}{\partial C_t} = \beta E_t[V'(K_{t+1}, A_{t+1})]$$ (2.11)

And

$$\frac{\partial V(K_t, A_t)}{\partial (1 - L_t)} = \frac{\partial u}{\partial (1 - L_t)} + \beta E_t\left[\frac{\partial V(K_{t+1}, A_{t+1})}{\partial K_{t+1}} \cdot \frac{\partial K_{t+1}}{\partial (1 - L_t)}\right]$$

$$= \frac{\partial u}{\partial (1 - L_t)} - \beta A_t \frac{\partial F}{\partial L_t} E_t[V'(K_{t+1}, A_{t+1})] = 0$$

i.e.

$$\frac{\partial u}{\partial (1 - L_t)} = \beta A_t \frac{\partial F}{\partial L_t} E_t[V'(K_{t+1}, A_{t+1})]$$ (2.12)
Moreover, differentiating (2.10) with respect to \( K_t \), we obtain
\[
V'(K_t, A_t) = \frac{\partial V(K_t, A_t)}{\partial K_t} = \beta E_t \left[ \frac{\partial V(K_{t+1}, A_{t+1})}{\partial K_{t+1}} \cdot \frac{\partial K_{t+1}}{\partial K_t} \right] 
= \beta (1 - \delta + A_t \frac{\partial F}{\partial K_t}) E_t[V'(K_{t+1}, A_{t+1})] 
\tag{2.13}
\]

This equation tells that the change in intertemporal utility \( V(K_t, A_t) \) results from one unit change in the capital stock \( K_t \) is the discounted product of, first, the change in the amount of the total commodity stocks in the next period if the additional capital is saved (or consumed), \((1 - \delta + A_t \frac{\partial F}{\partial K_t})\), in the previous period, and second, the change in the expected value of intertemporal utility caused by the additional change in capital, \( E_t[V'(K_{t+1}, A_{t+1})] \).

However, the value function \( V(K_t, A_t) \) does not have prior knowledge of its explicit functional form, moreover, solutions of consumption, labour supply and capital to the maximisation problem are required to satisfy (2.9)-(2.13), concurrently, this makes solving the problem more difficult in general. The existence of a closed form solution to this problem is applicable only under specified restrictions on \( u, F \) and \( \delta \). We will explain this later. Before that, it is essential to show that the market equilibrium satisfies the efficiency conditions, despite of the functional forms.

**Market equilibrium.** According to the perfect competitive assumption, goods, labour and capital are traded in a perfect market. Capital stocks \( K_t \) are owned by households who can sell or rent capital services to firms period-by-period to earn interest payment \( r_t \). Furthermore, households spend \( L_t \) amount of time on working out of the total time endowment per period and are paid at the real wage rate \( w_t \). While, the production function displays constant returns to scale which means each firm operates on a indefinite scale, hence, the supply-side of the economy will behave identically even if there are many firms. Therefore, the production sector as a whole can be viewed as appropriate amount of capital \( K_t \) and labour \( L_t \) up to the level where marginal product equals marginal cost respectively as shown by (2.3) and (2.4). In the meantime, at this equilibrium level of inputs, firms make zero-profit,
The Theory and Evidence on Business Cycles

Households have two income sources, one is the payment on devoting time on working, the other is earned from interest payment by renting capital services. Thus, the household’s budget constraint can be indicated as

\[ K_{t+1} = (1 - \delta)K_t + w_tL_t + r_tK_t - C_t \quad (2.14) \]

As a result, the household solves the following maximisation problem

\[
\max : E_t[\sum_{\tau=t}^{\infty} \beta^{\tau-t}u(C_t, 1 - L_t)] \\
\text{s.t. } K_{t+1} = (1 - \delta)K_t + w_tL_t + r_tK_t - C_t 
\]

Again, applying the dynamic programming technique and using the Bellman equation which is subject to (2.14), the first order condition with respect to \( C_t \) and \( (1 - L_t) \) are given as

\[
\frac{\partial u}{\partial C_t} = \beta E_t[V'(K_{t+1}, A_{t+1})] 
\]

And

\[
\frac{\partial V(K_t, A_t)}{\partial (1 - L_t)} = \frac{\partial u}{\partial (1 - L_t)} + \beta E_t[\frac{\partial V(K_{t+1}, A_{t+1})}{\partial K_{t+1}}] \cdot \frac{\partial K_{t+1}}{\partial (1 - L_t)} \\
= \frac{\partial u}{\partial (1 - L_t)} - \beta w_tE_t[V'(K_{t+1}, A_{t+1})] = 0
\]

i.e.

\[
\frac{\partial u}{\partial (1 - L_t)} = \beta w_tE_t[V'(K_{t+1}, A_{t+1})] 
\]

Then, differentiating the Bellman equation with respect to \( K_t \)

\[
V'(K_t, A_t) = \beta (1 - \delta + r_t)E_t[V'(K_{t+1}, A_{t+1})] 
\]

Substituting (2.3) and (2.4) into (2.16)-(2.18) and rewriting the budget constraint (2.14) by using the fact that \( Y_t = w_tL_t + r_tK_t \), we get exactly identical expressions.
as (2.12)-(2.13) and (2.9), which represent the optimal path. Because the optimal path and the equilibrium path are the same, it shows that the market equilibrium is efficient.

2.1.7 Closed form solutions

There are only few functional forms for the utility and the production functions that will ensure the existence of closed form solutions for $C_t$ and $L_t$. One of these special cases that has been used commonly involves a Cobb-Douglas production function and a log-linear utility function as follows:

$$Y_t = A_t L_t^a K_t^{1-a} \quad (0 < a < 1) \quad (2.19)$$

$$u(C_t, 1 - L_t) = \log C_t + b \log(1 - L_t) \quad (b < 0) \quad (2.20)$$

Besides, the capital depreciation is assumed to be equal to one (i.e. $\delta = 1$, capital is fully used up each period). So the constraint (2.5) is simplified as

$$K_{t+1} = Y_t - C_t \quad (2.21)$$

Now, according to (2.11)-(2.13), they give

$$\frac{1}{C_t} = \beta E_t[V'(K_{t+1}, A_{t+1})] \quad (2.22)$$

$$\frac{b}{1 - L_t} = \beta a Y_t E_t[V'(K_{t+1}, A_{t+1})] \quad (2.23)$$

$$V'(K_t, A_t) = \beta \frac{(1 - \alpha) Y_t}{K_t} E_t[V'(K_{t+1}, A_{t+1})] \quad (2.24)$$

Substituting (2.22) into (2.24), it enables to eliminate $E_t[V'(K_{t+1}, A_{t+1})]$.

$$V'(K_t, A_t) = \frac{1}{C_t} \frac{(1 - \alpha) Y_{t+1}}{K_t}$$

$\textit{The righthand side of (2.23) is originally written as } \beta \alpha (A_t K_t^{1-a} L_t^{a-1}) E_t[V'(K_{t+1}, A_{t+1})], \textit{ rearranging it so that we have (2.23). Similarly, the original outcome of (2.24) is } \beta (1 - \alpha) (A_t K_t^{1-a} L_t^{a} E_t[V'(K_{t+1}, A_{t+1})].$
Therefore,

\[ E_t[V'(K_{t+1}, A_{t+1})] = E_t\left[\frac{1}{C_{t+1}} (1 - \alpha)Y_{t+1}\right] \]

Then, placing this in (2.22), we obtain

\[ \frac{1}{C_t} = \beta E_t\left[\frac{1}{C_{t+1}} (1 - \alpha)Y_{t+1}\right] \]

(2.25)

A fraction of output which is sold to household is saved. The relationship between consumption and the saved output proportion is given as \( C_t = (1 - s_t)Y_t \), and it satisfies the optimal condition for consumption. Given this relationship, (2.21) is simplified as \( K_{t+1} = s_tY_t \).

Substituting \( C_{t+1} = (1 - s_{t+1})Y_{t+1} \) and \( K_{t+1} = s_tY_t \) into (2.25) gives

\[ \frac{1}{C_t} = \beta E_t\left[\frac{1}{(1 - s_{t+1})Y_{t+1}} \frac{1}{s_tY_t} (1 - \alpha)Y_{t+1}\right] \]

\[ = \beta(1 - \alpha) E_t\left[\frac{1}{(1 - s_{t+1})s_tY_t} \right] \]

Given the combination of log-linear utility, Cobb-Douglas production and 100% depreciation, income and substitution effects on saving which result from either technology and capital moving opposite and offsetting each other. Hence, it follows that \( s \) is constant over time at some value. Moreover, this constant saving rate implies that \( E_t\left[\frac{1}{(1 - s_{t+1})s_tY_t} \right] \) is just \( \frac{1}{2C_t} \) while \( C_t = (1 - s)Y_t \). Inserting this into the above equation obtains

\[ s = \beta(1 - \alpha) \]

Then substituting this into \( C_t = (1 - s)Y_t \), we get the optimal solution for consumption

\[ C_t = [1 - \beta(1 - \alpha)]Y_t \]

(2.26)

Moreover, we are deriving the optimal choice for labour supply by the substitu-
tion of (2.22) into (2.23) so as to remove the term $E_t[V'(K_{t+1}, A_{t+1})]$, 

$$\frac{1/(1-L_t)}{1/C_t} = \frac{\alpha Y_t}{L_t}$$

This equation shows that the marginal rate of substitution between leisure and consumption $\frac{\partial u}{\partial u/\partial C_t}$ is equal to the real wage, $w_t = \frac{\alpha Y_t}{L_t}$, times a fraction.

Substitution of (2.26) into the above equation

$$L_t = \frac{\alpha}{\alpha + \beta[1 - \beta(1 - \alpha)]}$$

which suggests that labour supply is constant over time. The reason is that changes in either capital or technology or both cause the responses of labour supply to the relative wage and the interest rate balance each other, regardless households' willingness to substitute their labour supply inter-temporally.

As shown earlier, the market equilibrium of the model is also an efficient solution to the maximisation problem of expected utility of households. The optimal solutions of this special case have unique outcomes, so the market equilibrium solutions must also be unique. The solution of the capital stock in the next period is determined by $C_t$ and $L_t$ jointly according to Equation (2.21).

Until now, the model has shown an example of how real shocks induce fluctuations in aggregate output of an economy. In this particular RBC model, movements in aggregate output embody the time-varying Pareto optimum. However, this special case does not fit the major attributes of business cycles very well, namely the constant saving rate and inelastic labour supply. The former implies that the volatilities of consumption and investment are equivalent. This is not the case in empirical evidence. In practice, investment is more volatile than consumption. Likewise, employment and working hours exhibit strongly pro-cyclical since it moves in the same direction as aggregate output. Furthermore, the real wage in this special model is given as $\frac{\alpha Y_t}{L_t}$, while $L_t$ is constant, this implies the real wage moves strongly with output. In fact, this relationship between the real wage and output is a bit ambiguous.
Accordingly, the model needs to be amended in order to improve its explanation power of capturing business cycle features.

2.1.8 Extensions to the standard RBC model

In this part, I discuss extensions to the standard RBC model, as well as the criticisms directed at the basic model.

Christiano and Eichenbaum (1992) claim that the most significant inadequacy of existing RBC models is the relationship between hours worked and productivity. According to the standard RBC model, the correlation between the two variables is estimated more than 0.9 which is overestimated compared to the actual correlation. Meanwhile, as mentioned above, existing RBC models predict that labour supply is insensitive to output fluctuations which is in contrast to the actual outcome. As a result, it would be attractive to add some variations in hours worked and employment to improve the fitness of the model. One of studies in this field is conducted by Hansen (1985) who introduces the concept of ‘indivisible labour’.

Existing RBC models have been criticised for relying heavily on households’ willingness to substitute labour for leisure (that is, changes in hours worked) along the intensive margin\(^4\). The effect of this substitution is not so significant (Ashenfelter 1984 and Rouwenhorst 1991) to explain fluctuations in employment. So Hansen considers an extreme case where households face only two possibilities, 0 (which is not working at all) and \(L_0\) (which is working full-time). This assumption implies the variation of employment by entering and exiting the labour market which is along the extensive margin, and is based on the presence of certain amount of fixed costs of working. Households have identical ex ante conditions, but they are drawn randomly from employment and unemployment once the total number of employment is determined. Thus this can be represented as a probability value, \(\alpha_t\), of workers being employed. Average hours worked in period \(t\) is \(L_t = \alpha_t L_0\). Accordingly,

\(^4\)An extensive margin refers to the amount of usable inputs that are employed. An intensive margin refers to the amount of utilization exploited within a given extensive margin.
inserting this into expected utility of the representative household yields

\[ Eu(C_t, 1 - L_t) = \alpha_t[\log C_t + b \log(1 - L_0)] + (1 - \alpha_t)(\log C_t + b \log 1) \]

\[ = \log C_t + b\alpha_t \log(1 - L_0) \]

\[ = \log C_t + b \frac{L_t \log(1 - L_0)}{L_0} \]

This equation shows that \( L_t \) is linear in the utility function, so leisure time in different periods is perfectly substitutive and the elasticity of leisure in different periods and that of labour supply are infinite for the aggregate economy. The equilibrium solutions of the RBC model with indivisible labour show employment fluctuations in response to aggregate shocks.

Kydland and Prescott (1982) modify the standard model by introducing the assumption of multiple-period construction. They suppose that the completion of new investment projects require several periods of time. Besides, only finished capital goods are part of capital stocks. Moreover, a single period and resource are demanded for each stage of production. The results reveals significant improvement to persistence of output movement, however, the model is not sensitive to parameter selection.

Long and Plosser (1983) establish a multi-sector model to capture the common characteristics of business cycles, and to explore the spread out effects of shocks across sectors of the economy. The assumption that any produced commodity can be used as a production input of other commodities enables the transmission channel of shocks among sectors. The behaviour of the optimal paths of those interested variables reveals that if the quantity of commodity \( i \) increases unanticipatedly at time \( t \), then the output of commodities that employ commodity \( i \) as an input will also unanticipatedly higher at time \( t \). In addition, if the commodity has been used alternatively in production of at least several commodities, this not only will transmit the effects of shocks across sectors, but also will spread the effects forward in the future. This discloses persistence and comovement of business cycles. The model infers that equilibrium employment correlates positively to output at time \( t \), due
to the difference between the producers' willingness of substitution in inputs and the consumers' willingness of substitution of commodities and/or between current and future consumption and leisure. Furthermore, the model also reveals that fluctuations in consumption goods (transportation and trade sector) is much smaller than those which are normally used as produced inputs (agriculture, mining and manufacturing sector).

King and Plosser (1984) investigate the correlation between money and real economic activity under the framework of real business cycle models. In this type of real business cycle model, monetary services is viewed as an intermediate good which is the output produced by the financial-banking industry, and is used by firms to produce final goods and by households to buy final goods. When there is an unanticipated increase in wealth which results in a higher level of net investment, and a rise in hours worked in order that real output increases. Such an expansion leads to a higher credit volume since firms require more funds to finance the increased demand for output. The empirical analysis of the model finds that there is a significant positive contemporaneous correlation between real monetary variables and aggregate output, but the causality is that movements in the latter give rise to the former.

Benhabib et al. (1991) include home production into the the standard RBC model by supposing that households choose between home production and market production which both use time and capital to produce goods. In respect to this, activities can be more volatile in the market due to the difference in relative productivity of two sectors, since households can choose between market and home production. Moreover, the extent of the fluctuations caused by technology shocks relies on the willingness of households to substitute between home and market goods at a certain period as well as on the willingness to substitute between these goods at different periods. In this model, it argues that if the effect of technology shocks to market production is relatively higher, labour will switch from home production to market production, in turn, this causes a positive correlation between hours of
work in the market sector and productivity. On the other hand, if the effect of the shocks to home production is relatively higher, labour will flow into the home so that there is a negative relationship between market hours and productivity. When the shocks hit the two sectors in line with the presence of these two shocks, the net effect reduces the tightness between employment and wages or productivity and output. In addition, the model is able to explain fluctuations in macroeconomic variables at some extent, given rational estimates of technology shocks. Furthermore, the model also predicts that the volatility of consumption is moderately smaller than that of output, and investment is more fluctuated than output.

Christiano and Eichenbaum (1992) argue that there are a variety of important shocks which generate the business cycle, other than technology shocks. They focus on the important role of shocks to government consumption. They use two different data sets, household and establishment data, to estimate the divisible-labour and the indivisible-labour models. They find that the divisible-labour model is rejected by both data sets, in spite of the inclusion of government. Additionally, the incorporation of government into the indivisible-labour model improves the empirical performance significantly. An increase in government consumption extracts resources from the private sector which acts like a reduction in agent's wealth. Thus, agents experience a decrease in utility and benefit from less leisure, while leisure is assumed to be a normal good. So households increase working hours and shift the labour supply curve in response to government consumption shocks, and this reduces the strong positive correlation between working hours and productivity.

Buckus et al. (1993) extends the closed form RBC model to an international background, with the purpose of comparing the characteristics of international business cycles and emphasising two inconsistencies between the theory and the data in international macroeconomics. The model substitutes two countries as economic agents who produce a single good and trade it since the outputs of this single good are imperfect substitutes. In the theoretical model, it is found that the correlation of fluctuations of output across countries is lower than the correlations of fluctuations
of consumption and productivity. It is the contrary case in the data. Moreover, although the theoretical model is able to replicate the property of persistence of relative price fluctuations (which concerns the terms of trade) as characterised in the data, it fails to explain the high volatility of fluctuations in relative prices.

Merz (1995) incorporates trade frictions in the labour market into the standard neoclassical growth model (i.e., standard RBC models), therefore producing new analytical framework that combining the stochastic neoclassic growth model and the transaction cost approach to unemployment. The transactions cost approach involves two-sided research, one is search externalities and the other relates to wage determination. The former stems from the job match between the number of workers searching for jobs and the number of jobs that are provided by firms. This is the main propagation mechanism of technology shocks. The latter describes when there is a newly formed job match, wage determination is required. By introducing trade frictions to RBC models, labour supply is more volatile than in the standard RBC model. A positive technology shock increases labour productivity, the number of job vacancies and the intensity of aggregate search. This further converts to a fall in unemployment. The opposite holds true for a negative technology shock. The results also suggest that real wage is less volatile over the business cycle. This is because when firms and workers bargain wages, they consider not only the marginal product of labour, but also include costs of job search and predetermined utility. Thereby, workers are implicitly insured against underlying income risks.

The above papers are only the tip of the iceberg among a large number of extensions to the standard RBC model. Efforts to improve the RBC model to match actual business cycles by incorporating other factors are still ongoing.

In the next section, I will turn to discussing the limitations of RBC models.
Limitations

There are several objections arising from the theoretical framework of RBC theory. Some of the more important and common ones are discussed in this section\(^5\).

The first of these objections concerns the technology shocks which are viewed as the primary source of cyclical fluctuations. However, there is no hard evidence that proves that the economy is driven by large and unexpected changes in technological levels. Prescott (1986) measures the technological change (based on Solow, 1956) by Solow residual, which is defined as the difference between the percentage changes in output and the percentage changes in the sum of the inputs (labour and capital), where each input is weighted by its factor share.

His method measures the Solow residual by applying a constant factor share estimate in each period, which is unlikely to fit the observations well and is likely to produce an overestimated variance of the pace of technological progress since there is more variation to be taken into the account of residual. Mankiw (1989) argues that the cyclical behaviour of productivity may arise from labour hoarding and behaviour in other sides other than the production side. He shows that this cyclical productivity behaviour in other periods of the economic boom is alike to the World War II boom which is mainly driven by the demand side. Consequently, the Solow residual is not a good measurement of changes in technology.

On the other hand, there are numbers of causes that can explain an increase in output, for example, increasing returns, increases in capital intensity and labour utilisation, and input redistribution towards more productive firms\(^6\). Thus, if technology shocks are in fact smaller than the Solow residual measures, then the ability of the standard RBC model to explain business cycles is questionable.

The second objection of the model is related to its propagation mechanism, the intertemporal substitution of labour. According to this mechanism, households are

\(^5\)These objections are mainly posed by Summers (1986) and Mankiw (1989).

willing to allocate work hours over time, thereby inducing variations in employment in the model. A small fall in the real wage or in the interest rate results in a considerable fall in labour supply. However, such a response is unlikely to happen in practice. Empirical studies find that the likelihood of individuals changing labour supply through the intertemporal substitution channel in response to changes in the real wage or in the real interest rate is quite small or even rejected by the data (for instance, MaCurdy (1981), Altonji (1986), and Ham and Reilly (2002)).

Another criticism pertains to money and prices. Theories before RBC theory had paid attention to the important role of monetary policy in affecting the stabilisation of the economy. In contrast, the RBC model claims that the influences of monetary shocks on real variables are the reactions to the true disturbances - technology shocks (King and Plosser (1984)). However, there are both strong historical analysis (Friedman and Schwartz (1963a), and C.Romer and D.Romer (1989)) and statistical evidence (Sims (1992), Christiano et al. (1996), and Bernanke and Mihov (1998)) that movements in money have real effects on output movements. Meanwhile, the standard RBC model also ignores the cyclical behaviour of prices. In the standard RBC literature, the papers (Kydland and Prescott (1982), and Long and Plosser (1983))) do not provide any actual or model-estimated results regard to price effects.

The most popular justification of real effects of monetary shocks is nominal rigidities. This explanation departs from the perfect competitive assumptions of the standard RBC model and offers an alternative channel to prove that money and prices matter and raises the possibility of the existence of considerable problems in the fundamental features of the standard RBC model.

In conclusion, the RBC theory has been extremely influential in understanding business cycles. This does not mean, however that it is immune to criticism. In fact, there have been several extensions, reviewed in the previous section, in an effort to address the limitations of the model.

Having examined this important theoretical strand of the literature, I now turn to the more applied literature on business cycles. Particular attention is paid to
international business cycles and the significance of leading and lagging indicators.

2.2 Topics in the business cycle literature

In this section I review contributions that are more applied in nature and relate to two significant issues in the business cycle literature: the comovement of national cycles and the role of economic indicators in predicting turning points. As mentioned earlier, this survey excludes contributions that have employed the Markov switching approach. An extensive discussion of the MS approach is reserved for the next chapter, after I have had the opportunity to go through the workings of this methodology in detail.

International business cycles

Understanding the co-movements of business cycles is important for building up business cycle theory and implementing policy. Suppose most of fluctuations in economic activities are captured by a common shift in business cycles, this would provide support to the predicted results of theoretical models to emphasise common structures of the markets across countries and regions. If fluctuations of domestic business cycles are due to worldwide fluctuations, stabilisation policies may be inefficient.

Several recent studies have concentrated on capturing a common or global component in economic fluctuations. Gregory et al. (1997) use a Kalman filtering technique and dynamic factor analysis in a study of the G7 countries. They decompose the dynamics of a series of macroeconomic fluctuations into a world common factor, a country-specific common factor, and a factor specific to each individual aggregate variable. They report that those countries’ business cycles not only appear to be co-moving, but also some common features of output fluctuations may be due to the influence of a world cycle.

Frankel and Rose (1998) discover that countries in a currency union, which results
in greater integration of goods and services markets through trade links, tend to have more correlated business cycles, since a higher level of trade allows shocks to spread more easily across national borders. They point out particularly that the continuation of European trade liberalisation is expected to result in more firmly correlated European business cycles.

An alternative view about the international business cycle is discussed by Kalemili-Ozcanet al. (2001). They suggest that economic integration, particularly, the integration of capital market, will lead to higher specialisation in production, in turn, it will be less symmetry of output fluctuations across countries. This is a counter-effect to the effect of lower trade barriers which gives rise to the symmetry of fluctuations proposed by Frankel and Rose (1998). They conduct an empirical study on OECD countries and the US. They find that the effects of output shocks on the aggregate outputs of the OECD and the US are less correlated in the light of high industrial specialisation.

Heathcote and Perri (2002) observe that there is a fall in the correlation of shocks between US and the rest of the world in recent years. They argue that this fall increases the degree of diversification of international asset trade accompanied with the increased integration in financial markets, hence it is likely to lead to a reduction of international correlations of macroeconomic fluctuations. Of course, the recent financial crisis of 2007 has shown that shocks emanating from the US have great capacity in destabilising other economies.

Mansour (2003) uses 113 countries' output data to identify sources of common movements and to estimate the global business cycle. He employs a dynamic factor analysis to investigate the existence of the international business cycle. In his findings, he uncovers that there is an international business cycle which is generated by world shocks. Europe and the region around South Africa appear to be highly sensitive to the world shocks, whereas North America, South-East Asia and Oceania are less affected by the world shocks. However, he finds that the relationship between the characteristics of national business cycles (in terms of intensity, sensitivity and
persistence) and the world shocks is unclear. In addition, he finds that the EU and Oceania are the most integrated groups. Mansour also finds evidence of the existence of a European business cycle, but the influence of shocks differs remarkably across the EU countries.

Bordo and Helbling (2003) study international synchronisation of business cycles across 16 countries from 1880 to 2001. They use different methodologies and find that there is a long-term trend of increasing synchronisation over 120 years and across different international monetary regimes. They find that global shocks are the leading factors of explaining increased synchronisation. They suggest that the increasing importance of common shocks is the reflection of growing globalisation, in particular, through international trade and the integration of financial markets. On the other hand, they find little evidence to support the role of the policy in stimulating synchronisation.

Imbs (2004) investigates the relations between trade, finance, specialisation and business cycle synchronisation. The paper finds that the overall effect of trade on business cycle co-movements is strong, largely through intra-industry trade. Furthermore, specialisation has a considerable effect on the correlation of business cycles, which the economies have similar economic structures tend to be more symmetric. Besides, the economies with strong financial linkage are more synchronised.

Bergman (2008) uses a combination of a bandpass filter and the GARCH model to examine business cycles of Finland and Sweden in relation to the EU and the non-EU business cycle. The empirical evidence shows that the Finnish business cycle is more synchronised with the non-EU business cycle before joining the EMU in 1999, whereas it is the opposite case in the Swedish business cycle during the same period. However, the situation has changed significantly since 1999. The influence of the EU business cycle is more powerful than that of the non-EU business cycle, in contrast to the strong correlation between the Swedish business cycle and the non-EU business cycle. Moreover, both Swedish and Finnish business cycles are largely affected by international business cycles. Additionally, the investigation of
comovement of business cycles between Finland and Sweden, suggests that their business cycles were highly correlated during the 1990s but not so much during other periods.

Having reviewed large evidence of common movements of business cycles, a question arises: *In what ways does the synchronisation of business cycles happen across open economies?* Several papers outline mechanisms that help explaining the synchronisation of business cycles.

Boileau (1996) introduces a two-country model that includes externality and non-market or household production to explain output correlations across countries. The model assumes the spillover of knowledge and the substitution between market and non-market production. The paper argues that a positive shock in the market sector in one country results in reallocations of resources, labour and capital from household production to market production. These reallocations upgrade knowledge, further, since knowledge is international flowed via externality, it acts as a positive shock to the other country. At the same time, the higher demand for market goods in country 1 causes an increase in the relative price of market goods in country 2, consequently, higher exports of market goods result similar reallocations from household to market sector. Hence the cross-country correlation of output is highly correlated. Canova and Ubide (1998) also argue that household production is an important mechanism that accounts for international business cycles.

Boileau (2002) also suggests that the transmission of output fluctuations is through the trade in capital goods (such as machinery and equipment). The standard theory of international real business cycle (IRBC) assumes that output fluctuations are caused by exogenous shocks that are correlated across countries so that this results in the synchronisation of output fluctuations. In Boileau's paper, it is argued that co-movements of output fluctuations result from the transmission of an investment-specific technical change which is embodied in capital goods via trade in capital goods. The paper concludes that a model with trade in capital goods and the investment-specific technical change produce a highly cross-country correlation
of output.

Cook (2002) examines sequential market entry under the imperfect competition environment as a propagation mechanism of international business cycles. He finds that a positive domestic expansion in one country increases the levels of output, employment and investment. This increases the level of global output. Because of sequential entry, additional entrants reduces only the markups but the output level of marginal entrants is unaffected, thus, with greater level of global output, this leads additional firms to entry the market as long as these entrants earn sufficient profits to cover fixed costs. Due to increasing competition, the relative prices of resources increase in the other country, hence it results in an expansion in output in that country as well. Therefore, this generates strong business cycle correlation between countries.

Head (2002) proposes that co-movements of cross-country's business cycles are due to increasing returns to scale to intermediate goods. In the paper, it argues that technology shocks induce contemporaneous correlations of productivity in two countries via the mechanism of increasing returns to scale, even these technology shocks are purely country-specific, which in turn cause international co-movements of output. In other words, increasing returns to scale work as common or highly correlated shocks across countries.

Finally, it is common belief that countries trade more tend to have more synchronisation. Kose and Yi (2006) use a three-country model with transportation costs to model the relationship between trade and correlated business cycles. They find that the model can explain stronger correlations of business cycles for country-pairs that trade more, but the outcomes of the model still fail to explain the magnitude of the empirical findings. Additionally, they introduce an increased correlation of total factor productivity (TFP) into the model, and they find that this certainly improves the results of the model.

The above discussion highlights the importance of business cycle synchronisation in a ‘globalised’ economy. The empirical work in Chapter 5 addresses this issue with
Economic indicators and business cycles

Next, I am going to provide a brief background discussion on potential leading indicators that may contain useful information for the identification and the forecast of business cycles. A leading indicator is used in the dynamic model explored in Chapter 6.

Friedman and Schwartz (1963b) provide statistical evidence to show that the money stock and its changes influence the movements of business cycles. They point out that the cyclical movement in the money stock would result in a sizeable change in output movements in the short-term period by the changes in money income or price. Sims (1972) tests the causality between money and income and finds evidence to support the hypothesis that fluctuations of money could help the prediction of income fluctuations.

Kanoh and Saito (1994) attempt to develop an index that captures the states of business cycles, from the businessmen's point of view on current and future economic conditions regarding to their own business conditions. Using the industrial data and linear time series models, the empirical results find that such an index performs quite well in dating business cycle turning points. In addition, businessmen's judgement about the state of the future economy is more important than that of current economy. Moreover, it also suggests that the businessmen's judgement of the economic state in the manufacturing sector is more likely to be affected by actual economic conditions than in the non-manufacturing sector.

Similarly, Taylor and McNabb (2007) investigate the role of consumer and business confidence indicators in predicting business cycles for 4 European economies. First of all, they use cross-correlations obtained from VAR forecast errors at different horizons to examine the relationship between confidence indicators and business cycles. The outcome suggests that confidence indicators are pro-cyclical leading indicators and are statistically significantly in relation to output. Then they use a
forecast probit model to check the ability of the confidence indicators in predicting economic downturns. It is found that both confidence indicators have greater predictive power in explaining the UK business cycle than in other three countries (apart from the impact of consumer confidence in the Netherlands). However, there is no strong conclusion as to which the confidence indicator is the best. Finally, they apply VAR analysis to consider the forecast ability of economic activity as a whole. The results show that the confidence indicators have increased predictive power only in the case of the UK and the Netherlands.

It is natural to consider that financial ‘quantity’ variables, such as aggregate money supply, are not the only source of embodying information about output movements. It is reasonable to include financial ‘price’ variables, such as interest rates. Moolman (2003) examines a variety of leading indicators by using the probit model. The paper finds that the models with interest rates perform outstandingly in predicting turning points of South African business cycles over the course of the sample period. Mylonidis (2003) also investigate the abilities of different leading indicators in forecasting the phases of business cycles in Greece. The results suggest that real short-run interest rates play an important role in forecasting future output, in particular, volatilities of real short-term interest rates include useful leading information for the volatility of industrial production.

The use of a composite index of leading indicators (CLI) is also very popular in measuring and predicting economic conditions. The CLI has been used for a long time in forecasting the US business cycle. In recent years, governments of many countries have increasingly used the CLI to try and predict future economic movements. Even the media have published their own cyclical indicators.

Recall that under the definition in Chapter 1 business cycles are recurrent and alternating periods of upward and downward movements that extend unequally to the numerous economic processes and agents. These are adequately moved simultaneously to register as fluctuations in the aggregate level of output, real income, employment and trade. The historical evidence shows well recognised and important
consistency of the common movements together with distinctive attributes of the individual processes and cycles. Since there is no a single theory that can successfully explain all the characteristics of the business cycle, the identification and the prediction of business cycles cannot be solely summarised by any single sequence of cause and effect.

In order to maximise the ability of capturing true signals, the CLI covers a great range of economic processes from data that have been historically examined helpfulness. General speaking, series that correspond to commitment (e.g. orders and contracts) in the early stages of production and to investments which lead to final output and employment; series that represent the relation of prices and costs, the diffusion of marginal costs and profits, and economic expectations, in which all of these are less constraint and are altered first; and series that reveal important links between stocks and flows of engaging demand and supply of goods and services which are affected by adjustments in fixed capital and inventories, money and credit flows. As a result, a summary index embodying the whole group of these relationships should have a better predictive power over time than any individual indicator series.

Therefore, the construction of the CLI should serve to extract the maximum amount of information about future economic movements in output from a number of indicator series spanning a range of economic processes. Hymans (1973) outlines five points that CLI construction should comply with. First, in general, a widespread group of series that represent different economic processes should be considered, as predictive indicators should reach a turning point contemporaneously before a turning point in aggregate economic activity becomes realised. Second, these leading series should be able to signal any forthcoming fundamental change in aggregate activity. Third, the earliest and strongest leading series rely on the real factors that result in the impending turn and on the precise course of evoking the turn. Fourth, in order to minimise the effects of false signals (i.e. wrongly signalling an impending turn), it is essential to develop a mechanism that collects signals about the same forthcoming change which is given by the potential indicator series in terms of both
quantitative and qualitative aspects. Finally, the component series of the CLI are assigned to equal and positive weights to prevent the more volatile series from taking over the total index.

There are numerous studies investigate the use of the CLI. Hymans (1973) evaluates the structure and forecasting content of the CLI. The author finds that the estimated results show no differences (using either the historically revised CLI or the preliminary CLI). However, when the CLI is used to predict turning points, predictions of using the ex ante CLI actually outperform that of using the ex post CLI. He also finds similar results with earlier studies on the issue of the frequent occurrence of false signals. In addition, he constructs an alternative leading indicator index by employing cross-spectral techniques and shows that the latter is substantially better when it comes to the subject of false signals (but this is at the expense of poorer performance of lead periods of turning points).

Auerbach (1982) performs a similar test on the significance of leading indicator variables for the prediction of business cycles and the adequacy of the index construction by applying a linear regression. The main results suggest that the composite index is helpful in forecasting business cycles but only half of the component series are significant. The magnitudes of the weights imposed on the individual series turn out to be irrelevant to the prediction. Moreover, simple elimination of insignificant individual series in prediction from the index deteriorates the index's performance in out-of-sample forecasts. The overall results of conventional leading index which acts as a predictor are reasonably good.

Similarly, Diebold and Rudebusch (1989) apply the nonregression approach to evaluate the ability of leading indicators in economic prediction with a focus on the forecast of turning points. They suggest that the CLI would be more helpful if it is constructed to be specific to different economic phases given that the economy behaves differently during expansions and recessions.

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7This is different from Hymans (1973) who examines the relationship between the index and turning points; here the author examines all points of business cycles instead.
Other empirical studies on business cycles

Potter (1995) adopts a nonlinear model, namely self-extracting threshold autoregressions (SETAR) to uncover the asymmetric feature of business cycles of the post 1945 US economy. The adopted model has two main features. First, the model defines nonlinearity by using the observed historical time series straightaway. Second, the switching probabilities of different regimes are variant over time. The empirical estimation finds distinctive changes in the intercept term and the second autoregressive coefficient between two regimes. The application of nonlinear impulse response functions (NLIRFs) further reveals asymmetries in that if the economy is attacked by large negative shocks, output will go back to its long-run trend quicker compared to its response to the same magnitude of positive shocks. Moreover, the SETAR model is found more favourable than the linear models according to statistical tests in the paper and its forecasting accuracy.

Narayan (2004) employs panel Lagrange multiplier unit root tests to examine the existence of a unit root in real output of 24 Chinese provinces. The main feature of this test is the allowance of a structural break when performing a unit root test. When the series of real GDP and real GDP per capita are tested by allowing one structural break, more cases are found to reject the null hypothesis (i.e. that the series has a unit root) in comparison with the test without the structural break. This implies that real GDP and real GDP per capita are stationary processes.

Lehr and Wang (2000) apply a structural VAR approach to study the short-run dynamic effects of financial intermediation over business cycles. The empirical study adopts the time series of three economies with fully-developed financial sectors but with distinctive institutional and regulatory settings, namely, the US, the UK and Germany. They find that the financial intermediation shocks can cause fluctuations in output. Although the dynamic response of output to the financial intermediation disturbance is very similar across the countries, country-specific factors do influence the size of output’s response and the shocks. Moreover, different financial intermediation measurements affect the magnitudes of the contribution of financial
intermediation in explaining output fluctuations.

Roos and Russell (2000) use the error correction model by including foreign economic activity and real cash rate, in addition to foreign and domestic real share price to investigate the influence of the US stock market on the Australian business cycle. Several important findings are pointed out. First, the inclusion of the Australian real share price suggests it has a remarkably positive effect on Australian fluctuations. Second, the Australian share market not only contains information which is relevant to the impact of the US market, but also includes unique information about domestic output fluctuations. Third, the impact of the US share market on Australian business cycles is empirically evident, but it is less influential than that of real cash rate or foreign economic activity. Finally, the insertion of the share market variables cannot fully explain why US economic activity has the large and instant impact on Australian business cycles.

Hercowitz and Strawczynski (2004) employ panel data regressions to study the impact of business cycles on the asymmetry of government spending. The empirical study of the OECD countries finds that government spending is likely to increase in recessions, hence it can be viewed as countercyclical policy. However, in expansions, government expenditure is still above average. This may be explained by tax revenues abound – high tax revenues during expansions make it hard to convince governments to cut spending correspondingly. In the end, it results in upward cyclical ratcheting in government spending. This phenomenon is particularly strong in transfers and subsidies. Lastly, they test the relationship of cyclical ratcheting with the strength of governments and changes in fiscal regimes. The results show no evidence of supporting a relationship.

Motivated by questioning the validity of constant transition probabilities of the Hamilton's MS model, Diebold and Rudebusch (1990) employ nonparametric tests to analyse the nature of duration dependence in the US business cycle. They find that there is weak evidence for duration dependence in both expansions and contractions in the full sample period, even though prewar expansions reveal strong
duration dependence, and postwar contractions show relatively significant duration dependence than prewar contractions. This provides a support for the assumption of constant transition probabilities in the Hamilton model (1989). However, it is also found that a whole cycle exhibits considerable duration dependence in different sample periods. This is something I explore in Chapter 6.

Sichel (1991) assesses business cycle duration dependence in US using a parametric hazard model – a continuous-time Weibull duration model. Several results and implications are suggested in the empirical study. First, expansions show considerable positive duration dependence in prewar data but not in postwar data, while contractions show positive duration dependence after the war but not before the war. This implies a switch in the duration dependence pattern between the periods of the war before and after. This may suggest an alteration in the economic cyclical behaviour over time. Second, the length of the expansionary duration extends and that of the recessionary duration shortens after the war. This means that some changes in the characteristics of business cycles. Third, the variation of the duration dependence between expansions and contractions indicates an asymmetry of business cycles. Lastly, neither the duration of an expansion nor that of a contraction relies on the duration of the previous opposite phase.

Diebold et al. (1993) use an exponential-quadratic hazard model to further investigate the existence of duration dependence in business cycles. They find the similar empirical results for the US prewar and postwar business cycles as the early studies. Moreover, they enlarge prewar data by including three additional countries: Germany, France and the UK. They uncover that all these countries show strong positive duration dependence in expansions but not in contractions which coincides with the findings in the US. Moreover, there is also significant evidence of duration dependence in prewar whole cycles in the data of all three additional countries.

More recently, Castro (2008) adopts a discrete-time duration model to show that business cycle duration dependence can also be affected by other economic factors, apart from the length of a phase has lasted. His study has several contributions to
the analysis of business cycle duration in the postwar period. Firstly, expansions and recessions are found to be positive duration dependence, additionally, a positive effect of the OECD composite leading indicator can extend the duration of expansions, especially, two of its components – interest rate spreads and stock prices. On the other hand, the duration of recessions is negatively related to the duration of the preceding expansion. Secondly, an increase in private investment also lengthens the duration of expansions. Thirdly, a rise in the oil price or the attainment of a peak in the US economy accelerates the ending of an expansion in the other industrial economies. Nonetheless, the exit of a contraction in the US economy does not appear to have a similar effect. Finally, neither political conditionings nor fiscal rules have any impact on the duration of business cycle states.

2.3 Concluding remarks

This chapter provides a theoretical and empirical overview of business cycles. It starts the discussion by outlining the basic building blocks of the RBC model; then it considers the behaviour of two agents (households and firms) that act separately; finally, by combining these elements it explains how an aggregate technology shock affects output through inputs of capital and labour and results in fluctuations in consumption and investment. The model is presented formally and it is shown that only specified functional forms for preferences and production yield explicit closed-form solutions for the variables of interest.

Undoubtedly, there are several ways in which the predictions of the model do not match the facts. For instance, the model predicts that hours worked is highly related with productivity which is not necessarily the case in reality. These inconsistencies may be because of the simplicity of the model. Consequently, more sophisticated and more robust versions of the RBC models are considered. Extended models try to identify the possible sources of fluctuations under the same fundamental framework. Moreover, I have discussed the limitations of the RBC approach, such as omitting money and prices from the model. An encompassing approach delivers different
conclusions than the simple model where technology shocks are the only source of fluctuations.

Although the interpretation of the RBC theory in explaining the mechanisms generating the business cycle is not unchallenging, it is undeniable that the RBC approach has offered significant methodological developments and offers a well-founded structure in which to study business cycles. The message though would not make happy reading to policymakers as it is predicted that a substantial fraction of fluctuations in output and employment is an inevitable consequence of a variety of unpredictable shocks.

This chapter also discusses empirical studies on modelling business cycles, e.g. examining the issue of comovement among national business cycles. A full review of the empirical literature would have been beyond the scope of this work and, hence, a more focused approach has been adopted. Lessons from this review chapter inform the research presented later, especially in relation to business cycle synchronisation (see Chapter 5) and the use of leading indicators in the context of a time-varying (dynamic) framework (see Chapter 6).
Over the last century, Asia has experienced huge transformations and transitions both politically and economically. Within the region, the countries differ significantly in terms of their culture, demography, politics and the economy, but, equally, they share certain attributes and are subject to an increasing pattern of economic interdependence. Since the 1970s, the region, and especially those countries in East and Southeast Asia, have exhibited impressive annual growth rates of gross domestic product (GDP).

The purpose of this chapter is to provide a macroeconomic overview of selected countries and districts in East and Southeast Asia, including China, Hong Kong, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Taiwan and Thailand. It reviews their economic structure, performance and economic relationships. It is imperative to have a good understanding of the sample economies before proceeding to the analysis of their business cycles and checking for common components.

Specifically, the statistics presented in this chapter focus on GDP (and its components), foreign trade and investment flows in detail. Data on real GDP growth
are from the World Bank (WB).\(^1\) Real growth rates of private consumption, investment (gross fixed capital formation), government spending and exports and imports are estimated on the basis of constant local currency prices for most of countries and districts, except Singapore where it is estimated at current prices\(^2\). Moreover, foreign direct investment (FDI) growth rates are calculated at current prices. Furthermore, some figures and the sources of country-specific information are gathered from *Country Report* and *Country Profile* of the Economist Intelligence Unit (EIU).

The structure of this chapter is, first, I review each country individually and then I provide an analysis from the regional viewpoint. At last, it is the conclusion.

### 3.1 China

#### 3.1.1 Economic policy

In December 1978, the Chinese Party leadership made a decision of shifting its economic policy from the centralised planning economic system to the 'socialist modernisation', in order to make the economy more efficient and provide the necessary economic conditions for high and rapid economic growth. The result of this reform is made China to become the second largest economy in the world today.

The reform of the industry structure was carried out from two aspects. The 'vertical aspect' was maintaining the control of the major industries while deregulating the minor industries. The percentage share of state-owned and state-holding enterprises in gross industrial output value dropped from 89.4% in 1980 to 69.95% in 1989, whereas that of collective (township and village), individual and foreign investors either in wholly or in jointly owned enterprises increased dramatically from 10.5% in 1980 to 30.1% in 1989. The 'horizontal aspect' of the industrial reform was the industrial output share of light and heavy industry. In 1980, light industry

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\(^1\) The exception is Taiwan for which the data source is Taiwan's Directorate General of Budget, Accounting and Statistics (DGBAS)

\(^2\) GDP's components of Singapore are only available in the unit of current national currency at the International Financial Statistics (IFS) of the International Monetary Fund (IMF).
Figure 3.1: China: Annual growth rates of real GDP and GDP expenditure components in 1970-2006

Notes: Data source: WB, World Development Indicators (2009)
produced 47% of total industrial output, and heavy industry produced 53% of that. By 1986, the industrial output share of two industries almost equalised (49.7% for light industry and 50.3% for heavy industry).

Since the economic restructuring started in late-1978, the economic decision power was gradually decentralised from the central government to local authorities and producers. This decentralisation allowed local authorities and producers to make their own economic decisions with regard to their economic conditions, thereby putting in place expansion incentives and eventually resulting in high growth of fixed-capital investment. By 1989, fixed-capital investment had increased more than threefold compared to 1980. Consequently, rapid growth of fixed capital investment was one of determinants which caused growth in the Chinese economy in the 1980s.

The other important determinant of China's economic growth in the 1980s was China's foreign trade. Before the decentralisation of the trade system, foreign trade was highly controlled by the central government. In 1984, the policy for foreign trade was exports promotions. Provinces were given more powers to administrate exports targets (in value terms) under the guidance plan. In 1988, a contract system between the Ministry of Foreign Economic Relations and Trade (MOFERT) and provincial administrations and Foreign Trade Corporations (FTCs) decreased the share of planned exports further. Between 1984 and 1989, the dollar value of exports rose from $20.2bn to $57.2bn. On the other side, planning was important for imports because of protection of domestic industry and foreign exchange reserves, but the share of planned imports had also decreased. Although exports expanded in the mid-1980s, the consumption of consumer goods boosted imports remarkably and led to trade deficits.

### 3.1.2 Growth of GDP and its expenditure components

Its nominal GDP at current prices increased from $189.4bn in 1980 to $344bn in 1989 and the average annual real GDP growth rate was 9.8% per year. However, the year-to-year growth rate was unstable. The real growth rate decreased from
7.8% in 1980 to 5.2% in 1981, then soared to 15.2% in 1984 due to a huge increase in investment and government consumption; after that it dropped to 8.8% in 1986 and finally fell to 4.1% in 1989. The reason behind such rapid growth was that the economic reforms that had been rolled out were effective in boosting economic growth.

Having grown at relatively low rates in the late 1980s, the Chinese economy regained its high speed of growth in the early 1990s. This was once again driven by rapid expansion in investment and government spending and reached the highest growth rates to 14% in 1992-93. However, the economy grew relatively slow in the late 1990s. GDP expanded by just 7.7% in 1998-99. In part, it was affected by the Asian Financial Crisis of 1997-98. It also resulted from the disparity of resource allocations between the state sector and private enterprises.

Rapid economic growth was accompanied by an increase in household consumption. During the 1990s, China's GDP almost tripled and the level of household consumption almost tripled, too. At the beginning of the 1990s, households experienced a great decline in consumption because of high inflation. Then the growth rate of household consumption rose to 14% in 1992. After a strong rate of 14.4% in 1993 it rose slowly by 5.8% in 1994. Between 1995 and 1999, the growth rate of consumption gradually decreased from 11.7% to 7.8%, which resulted from fears of unemployment and of deflation.

Undoubtedly China has been exceptionally successful in attracting foreign investment because it has relatively cheaper labour costs and other low production costs. It became the largest recipient of foreign direct investment (FDI) among the developing countries in the early 1990s. Back in 1980, China had established 4 Special Economic Zones in the south to attract foreign investment by giving privileges to foreign investors. In the early 1990s, the Chinese leadership practiced a so-called socialist market economy: local governments and authorities were competing with each other to attract foreign investors by offering the most attractive conditions. Between 1982 and 1994, the total value of FDI reached $2.3bn.
However, the growth rate of foreign investment actually began to slow down in the mid-1990s. The nominal rate of FDI growth rose steadily by 5% and 4.2% in 1996-97, then followed by a fall of 0.5% in 1998, and finally a further fall of 5.3% in 1999. There were 2 reasons for this decreasing rate of growth in foreign investment. One was that the rising costs from the prosperous coastal areas and provinces diminished some investors' incentives. The other was increasing competition from other countries.

Nevertheless, there were still huge inflows of foreign investment. The government still offered incentives to attract foreign investment to the inland regions of the country. In addition, the prospect of the vast Chinese domestic market was considered as a powerful attraction to foreign investors.

Government spending increased sharply between 1990 and 1993, its growth rate rose from 8.1% to 18.3%. The increase in government spending led on the subsidies of both urban consumer prices and loss-making state enterprises, and deficiency of the tax base and failures of collecting taxes. After 1994, the growth rate of government spending slowed down gradually to 12% in 1999.

After experiencing a trade deficit (at current prices) for most of the 1980s, the total value of net trade (exports minus imports) remained in surplus in the 1990s - apart from 1993 thanks to a quick rise in domestic demand. The trade surplus arose partly from a slashing fall of the import bill in 1989-90 and partly from the rise of export-oriented manufactures which was largely funded by foreign investment. The average rate of export growth was around 11.9% in the 1990s. It should be noticeable that the growth rates of exports in 1995-96 rose modestly by 6.4% from a robust rate of 25.2% in 1994 and then contracted by 0.7%, and in 1998 was only 7.2% compared to 22.9% in 1997. What happened in 1995-96 resulted from changes in the value-added tax rebate system which led to the distortion of the comparison base. Moreover, the slowdown in 1998 was because of loss of increased competition and the downturn in Asian export markets. On the import side, merchandise trade was dominated by manufactures and the import services were dominated by costs.
of shipments.

Since 2000, real GDP growth started to pick up its momentum, it rose steadily from 8.4% in 2000 to 11.6% in 2006 with an average growth rate of 9.7% per year. In 2000, the economy grew at 8.4% which was driven by investment and exports on the demand side. But the economy was hit by the external shock – the 2001 slowdown in the US. In the following years from 2002 to 2006, the economy continued to grow rapidly, even taking the impact of severe acute respiratory syndrome (SARS) into account in 2003.

Consumption was stagnant in 2000-03 due to slow growth in rural incomes and the fear of unemployment in the urban areas, in addition to the outbreak of SARS, the growth rate of consumption increased around 6.3%. Although the public sector tried to stimulate domestic demand by policy moves such as lowering interest rates, encouraging consumers to borrow from banks to purchases, investing on infrastructure, the effects were limited. From 2004, consumption picked up as a result of strong income growth in both urban and rural areas.

There was a small reduction in foreign investment in 2000 (-0.4%) followed by a sharp increase by 6.2% in 2001. This was because of the opening up of previously restricted areas, as China joined the WTO in 2001. This again attracted foreign investors interests. In 2002, FDI continued to rise at a lower rate of 4.7% compared to 2001. FDI once again dropped to -2% in 2003, which might have been caused by the outbreak of SARS. From 2004 to 2006, FDI grew substantially at an average rate of 7.3% per year. This robust investment growth originated from overseas demand for Chinese-made goods.

The growth rate of government spending was relatively steady during 2000-2006, about 9.4% per year. From 1997 to 2001, the government spent a great value of money on investment and infrastructure. The government expanded spending on investment in 2002 to support GDP growth which was hit by the US downturn in 2001. In 2003-04, government expenditure shifted to social welfare spending as the economy began to build up. Between 2005-2006, the government spent a
considerable amount of money on capital investment.

Exports grew strongly by 30.6% in 2000 for the first time after the Asian crisis, but in the meantime growth of imports was 10.8% which was driven by restoring inventories and investment and importing inputs for export manufacturing goods. In 2001, export growth was only 9.6% and grew less than import growth which was 10.8%. Consequently, the trade surplus in nominal terms had been shrunk. Export and import growth was impressive during 2002-03 (Export growth rates were 29.4% in 2002 and 26.8% in 2003, and import growth rates were 27.5% in 2002 and 24.8% in 2003, respectively) which were mainly driven by "new economy" — machinery and electronic equipment. Even if exports grew strongly at average of 25.3% in 2004-06, the deceleration of import growth (decreased from 22.5% in 2004 to 14.3% in 2006) might suggest that the world economy started to hold back.

3.1:3 Trading structure and markets

China's foreign trade is mainly fueled by output from foreign-invested enterprises. Meanwhile, output that produces by private domestic enterprises has also increased the shares in trade. Additionally, the services account is generally in deficit, even though income from the tourism sector has increased in recent years, it is still not enough to cover the costs of the shipping account. Furthermore, Hong Kong, Japan and Korea are three main export markets in Asian area which account for about 30% of China's total exports. Japan is the largest China's import market. Besides, Taiwan, Korea, Hong Kong and Malaysia are also major import markets to China.

3.2 Hong Kong

3.2.1 Economic policy and structure

Hong Kong is the well-known as a trading centre. Due to Hong Kong's geographical position, it has no natural resources. As a result, raw materials, food and fuel are
dependent on imports. Additionally, its domestic market is limited by the size of the population and economic growth is largely driven by exports.

Hong Kong’s overall economic growth fluctuates quite a bit. This results partly from the economic policy of “positive non-interventionism” that is pursued by the Hong Kong government. The policy advocates that the government should not spend any government expenses on industries and commerce, besides essential support services, such as education, housing and health-care, while keeping low taxes. It also results from a high degree of openness to foreign trade.

Hong Kong has fixed its currency exchange rate at around HK$7.8:US$1 through a currency board system since October 1983 (between 1992 and 1998, the exchange rate had been appreciated to HK$7.7:US$1). This means that the Hong Kong Monetary Authority (HKMA) only issues notes and coins when there is enough foreign exchange reserves to support. Under the system, if there is an external shock to the economy, interest rates will automatic rise or fall to shrink or increase the supply of Hong Kong dollars, in order to maintain the fixed rate. Although this currency board system has achieved to stabilise the Hong Kong economy over the past two decades, the system has its shortcomings as its currency links with the US dollar. In other words, monetary policy and interest rates are actually determined by the economic conditions in the US rather than that in the territory. In 1991-96, negative real interest rates (due to low nominal rate and high consumer price inflation) resulted in high asset prices and inflation rates. The soaring property prices damaged Hong Kong’s international competitiveness as a commercial centre and made it difficult for many residents to buy their own houses. It was the opposite case during the Asian Financial Crisis of 1997-98. Nominal rates were high (corresponding to growth in the US economy) and consumer price inflation fell. Consequently, real interest rates rose even though the territory was in severe recession. Thus, the consequences were losses for banks and in the property market. Nevertheless, the importance of economic stability that is provided by the currency board system overcomes its weaknesses, and this deters the government from abandoning the system.
Hong Kong uses its advantages of geographical location, outstanding infrastructure, convenient transport system and the policy of non-intervention of the government to attract FDI, in particular financial services, regional headquarters and companies doing business with the mainland of China. These developments have changed the economic structure from manufacturing towards services, for instance, financial services, trade and tourism. In 1984, the manufacturing sector contributed 24.3% of the total GDP, by 2005 it was only 3.4% of the total whereas the tertiary sector accounted for 90.6% of that. Additionally, Hong Kong's manufactories have largely been shifted to the mainland of China to exploit lower production costs.

Furthermore, Hong Kong faces challenges from Singapore as a trade and financial centre. Singapore also implements policies to attract FDI, such as more fund management business through tax incentives, accompanying with lower residential and commercial property prices.

### 3.2.2 Growth of GDP and its expenditure components

In the 1980s, the cyclical pattern of the Hong Kong economy was moderately volatile, but with upward trend. The annual average GDP growth rate was 7.4% in real terms. However, the actual rate dipped to only 0.8% in 1985 owing to the appreciation of the US dollar, which hurt Hong Kong's export competitiveness. Moreover, after a strong rebound in the economy with a real GDP growth rate of 13.4% in 1987, the economy once again dropped to 2.2% in 1989, which was caused by a dramatic slowdown in the mainland of China.

The holding back of the economy improved slightly in 1990, at about 3.9%. Nonetheless, when China and the world economy recovered between 1991 and 1994, Hong Kong's GDP growth varied from 5.7% to 6%. A decrease of 2.3% in GDP growth was caused by a sharp fall in retail sales which corresponded to a slowing of private consumption in 1995. Later on, as private consumption gathered strength, GDP growth was restored to 4.2% in 1996. GDP in the first three quarters of 1997 grew strongly as a result of a fast increase in property prices, although the stock
Figure 3.2: Hong Kong: Annual growth rates of real GDP and GDP expenditure components in 1970-2006

Notes: Data source: WB, World Development Indicators (2009)
market crashed in October, overall GDP growth in 1997 was still high, at 5.1%. After the crash of the stock market in late-1997, the economy went into recession and contracted by 6% in 1998. It improved gradually to 2.6% in 1999.

Hong Kong’s private consumption is very sensitive to the climate change in business confidence. Private consumption rose around 7.6% per year between 1990 and 1994, as the stock and property markets were in expansion. Then it was followed by a moderate decline to average of 3.6% in 1995-97. Because of the collapse in asset prices, private consumption decelerated by 5.5% in 1998 and a slight recovery of 1.2% in 1999.

Hong Kong’s real GDP grew significantly in 2000 by 8%. Unfortunately, the recovery did not last very long, as the economy was hit by the US-led global economic downturn in 2001, and grew only 0.5%. A slow recovery in 2002 let GDP rise to 1.8%. Afterwards, the recovery in GDP growth was depressed by the outbreak of SARS in 2003, which led to the deceleration of the tourism industry and hence the slowdown of retail sales. From 2004 to 2006, GDP growth revived robustly and averaged at 7.5% in real terms year on year, thanks to growth of retail sales which was pulled up by tourists from the mainland of China, as well as growth in domestic demand.

Private consumption growth recovered gradually to 5.1% in 2000 and was sluggish in 2001 at 1.8%. Subsequently, owing to the slowdown in the US, private consumption growth fell once more to contraction levels of 0.9% in 2002 and 1.3% in 2003. When the global economy was in a recovery, it boosted private consumption which grew 7% in 2004 before growth declined to 3% in 2005 and finally increased by 6% in 2006.

Hong Kong’s FDI figures were not available until 1998, but according to other countries’s reports, there had been rapid growth in FDI for the past decade. FDI growth in nominal terms contracted sharply in 2001, 2002 and 2005, with 41.6%, 39% and 0.5% respectively. Hong Kong’s outflows of FDI have been synthetically increased by “round-tripping” – entities in mainland China reinvest money in the
mainland through Hong Kong in order to take the tax advantages that are approved
for foreign investors. Therefore, Hong Kong is the largest foreign investor in the
mainland of China. Besides, it is also a major investor in Taiwan, Malaysia and
Thailand. Furthermore, mainland China, Britain, Japan and the US are the main
foreign investors in Hong Kong.

Government spending of Hong Kong has concentrated on fundamental support
services, mainly on housing, environment, education and social welfare. On the
other hand, government revenue is primarily stemmed from three sources, which are
taxes on property transactions (particularly, land premiums), corporate taxes and
personal income taxes. However, the volatility of property prices affects certainly the
size of government income. Furthermore, other non-property-related tax revenues
depend on the state of the economy which are also vulnerable. Of course, when
the economy is in a recession, government income streams from corporate tax and
personal income will shrink. Total government revenue fell from $36.3bn in 1997 to
$31.8bn in 2006 after three depressions in 1997-98, 2001-02 and 2003. In some circles,
these volatile income streams are used as an argument to convince the government
to widen the tax base.

Hong Kong’s exports have grown fast since 1980. In the first half of the 1990s,
export growth averaged around 12.4%. This was followed by a slowdown to 5.2%
in 1996-97 as a result of a fall in exports of mainland China. Exports contracted
by 4.5% in 1998. This was partly due to weakness of external demand, it also owed
to the appreciation of the Hong Kong dollar relative to the currencies of trading
partners. Growth of exports recovered steadily by 4.5% in 1999 thanks to growth
of re-exports. There was a relative strong growth rate in exports at 16.3% in 2000.
Because of the September 11th terrorist attacks on the US, the global economy
held back, therefore, this led to a contraction in exports by 1.7% in 2001. Average
growth in exports was 11.5% from 2002 to 2006, mainly supported by strong growth
in re-exports as well as rising exports of services.
3.2.3 Trading structure and markets

Trade is the life-support of Hong Kong. As the government promotes the policy of non-intervention, the government imposes minimum restrictions on trade, and tries to abstain from protecting and funding industries with the intention of generating trade surplus.

Hong Kong's export goods used to be dominated by low value-added and low cost labour-intensive manufacturing sector. However, in the past two decades, lots of these goods were no longer produced in Hong Kong. Instead, they are produced in mainland China where Hong Kong companies have shifted manufacturing processes so that they can exploit cost advantages. Even so, many of these products are still exported to Hong Kong before they are exported to final destinations. As a result, although domestic export growth has fallen significantly (fell by 36.6\% in 1996-06), re-export growth has increased even rapidly (rose by 96.2\% over the same period). More recently, while mainland China is becoming more developed and efficient in product processing and supplementary services, there is a tendency of shifting away from re-exporting to transshipment through Hong Kong. Furthermore, exports of services have also increased extraordinary in recent years which correspond to an increase demand for business, financial, legal and logistics services from the mainland of China.

As mentioned earlier Hong Kong has no natural resources and, as a result, industrial inputs like raw materials and semi-finished products, food, fuel as well as capital and consumer goods depend on imports. Imports are a mirror image of exports in Hong Kong i.e. Hong Kong's imports are largely determined by exports. Moreover, although Hong Kong has experienced high speed growth in exports, it still runs considerable trade deficits (in nominal terms) owing to the greater value of imports.

During the past 20 years mainland China has slowly replaced the US as Hong Kong's largest trade partner (both in terms of imports and exports). In 2006, the mainland took 47\% share of Hong Kong's total exports and supplied 45.9\% of its
imports. The US was the second largest export market with 15.1% of the total, and followed by Japan (4.9%) and Germany (3.1%). In addition, Japan was the second largest source of imports at 10.3%. Taiwan and Singapore were also important import markets with 7.5% and 6.3%, respectively.

3.3 Indonesia

3.3.1 Economic policy and structure

When the New Order government took over political power, it defined three principle economic objectives which were stability, growth and equity. A series of five-year development plans that define development priorities and specific growth target are designed to achieve the objectives. However, there was a conflict about adopting a specific development strategy. There were basically two types of approaches. One (advocated by ‘technocrats’) recommended the efficiency of resource allocation and the maintenance of macroeconomic balance and international competitiveness. The other one (advocated by ‘technologists’) encouraged the development of sophisticated technologic industry regardless of economic costs. The control of making economic policy shifted back and forth between the two groups for past decades. In recent years, the conflict between the two groups has been gradually faded under the pressures from repaying debts, restructuring and sustaining macroeconomic stability.

In 1967-68, the New Order government adopted two basic laws on foreign and domestic investment to free investors from the regulatory framework. Rather unhelpfully, the sharp rise in the oil price and a simultaneous strong expansion of economic nationalism led to tight controls on foreign investment after 1974. In 1983, this control was abandoned, and in 1994, a free investment regime was restored under an issued reform package. Under the operation of this regime, foreign investors were allowed to access all sectors; wholly foreign-owned investment was permitted; foreign joint-venture enterprises were permitted to have 95% of the equity; and the
minimum requirement of capital was abolished. In 1999, certain sectors offered tax incentives to attract investment. Even though, investment started to fall since 1997 as a result of legal uncertainty, political unrest and rising costs.

The New Order government set up the balanced budget principle which was enforced by law. The principle stated that government consumption should not surpass revenues of government budget and flows of foreign aid. In the early 1990s, in order to seek a more efficient counter-cyclical fiscal policy, the government loosened this policy by allowing to run budget surpluses or deficits in individual years provided that the overall medium-term budget was in balance. The view of foreign aid as a source of revenue rather than that of financing deficits, and the use of government's balances for off-budget funds eroded gradually fiscal stability.

Since the international oil price experienced the first boom in 1973 the government's domestic revenue depended mainly on tax collections from oil company profits. Until the sharp fall in oil prices in 1983, the government decided finally to carry on delayed tax reforms. The first round of reforms was carried out between 1984 and 1985, aimed at simplifying the property tax structure and stamp duty regulations. The second round of tax reforms started in 1994 and intended to improve the existing tax provisions and procedures. The government hoped that by amending these regulations it could encourage profit reinvestment, investment in underdeveloped regions, growth of small and medium-sized enterprises, and the consolidation of the domestic banking sector. The reforms of domestic tax revenue reduced dependence on foreign aid.

Indonesia has a well diversified economic structure, all key sectors have an important contribution to economic development. The agriculture sector has a long history of dominating output and employment. A variety of abundant mineral resources have allowed the mining sector to play an important role in the balance of payment. Following a decline in oil prices in the mid-1980s, the manufacturing sector started to expand robustly and outweighed the share of agriculture in GDP in the early 1990s. In recent years, the services sector has boosted rapidly owing to
an expansion of the tourism industry. By 2005, it made up 41% of GDP and around one-third of total labour force was employed in the sector.

### 3.3.2 Growth of GDP and its expenditure components

The economic management practiced by the New Order government was undoubtedly successful between 1970 and 1996. Indonesian real output expanded by 7.6% per year on average during the period, in spite of a sequence of external shocks, for instance, a remarkable decrease in oil prices which affected trade balance and a widespread international currency rearrangement which had an effect on the value of its external debt. The country has promoted itself from a low-income country in the 1960s to a middle-income country with the GDP per head of US$1634.7 at current prices in 2006.

However, strong economic growth between the mid-1980s and the late-1990s prevented the call for economic reform, hence, this resulted in a series of deformations in the economy. First of all, the rapid expansion and lack of regulations of the banking sector caused investment largely focused on the manufacturing sector which relied heavily on imports, and on the development of property. Whereas, backward relations between manufacturing and agriculture which were created by investment was overlooked. Second, rapid growth induced large deficits in the current account and high levels of foreign borrowing (mainly short-term) by firms and banks. The requirement of financing the deficits and repayment obligations distorted the domestic interest rate structure, which in turn damaged the real economy. Third, the strong link of the rupiah to the US dollar and restraints of both external and internal trade decelerated export growth considerably. Furthermore, a false signal of the secure currency that given by the link between the rupiah and the US dollar persuaded debtors to look for creditors overseas in order to hedge their borrowing. The hurry of covering unhedged debts generated the conditions of rising domestic interest rates, falling inflation rates and an appreciation of the real exchange rate before the collapse of the rupiah in 1997.
Figure 3.3: Indonesia: Annual growth rates of real GDP and GDP expenditure components in 1970-2006

Notes: Data source: WB, World Development Indicators (2009)
Concerns of political stability and fears of economic overheating turned into the collapse of the rupiah in 1997 which was triggered by the sharp fall in Thai currency. This currency crisis spread quickly to the capital market as investors questioned about the ability of the corporate sector meeting large unhedged external debts. Moreover, the difficulties of the government fulfilling the conditions that attached to the IMF rescue package deterred the IMF bailout, which caused a collapse of public confidence and accordingly intensified downward pressure on the market. Consequently, real GDP growth slowed from 7.6% in 1996 to 4.7% in 1997, and contracted deeply by 13.1% in 1998 which was the worst record since the data begun to be recorded. In consideration of expenditure components on GDP, investment was hit the most serious among others, with a devastating contraction of 33% in 1998 from a growth rate of 8.6% in 1997. This was in response to a sharp fall in the construction and manufacturing sectors. Then it was followed by government consumption which declined by 15.4%, due to the depreciation of the rupiah and the economic recession affected particularly social spending and debt services. Household consumption fell by 6.2% as a result of rising inflation and unemployment. The external sector was the only component that contributed a positive effect on GDP growth as a steady rise of 11.2% in exports and a fall of 5.3% in imports. This was because of the depreciation of the rupiah and weak domestic demand. In 1999, the economy was back to the growth track but it expanded slowly by only 0.8%.

Economic growth speeded up in 2000 and grew by 4.9%, mainly driven by exports (which grew by 26.5%), in addition to the survival of private consumption (rose by 1.6%) and investment (increased by 16.7%). However, real GDP growth decelerated to 3.6% in 2001. On the expenditure side, although private consumption grew by 3.5%, the survey showed a drop in consumer confidence which stemmed from domestic political uncertainty, inflationary pressure and weak currency. Investment and exports were slowdown to 6.5% and 0.6%, respectively. The reason for this was the depressed global economy. Furthermore, the decrease in investment caused import growth dropped to 10.9%. Even though, net exports remained in surplus.
Government spending expanded by 7.6%, which reflected the rise in fuel subsidies and the weak rupiah pushed up costs of external debt service.

A steady recovery in economic growth took place between 2002 and 2006, with an average rate of 5% per year. Private consumption grew generally around 4% year on year as a consequence of low consumer credit rates. Investment growth soared in 2004-05 with rates of 14.7% and 10.9% individually, which reflected a long-awaited recovery. Nonetheless, it grew by only 2.5% in 2006 which suggested the failure of reforms to attract greater investment. Government spending fell from 13% in 2002 to 4% in 2004, and then rose to 9.6% in 2006. Export growth was disappointing with a contraction rate of 1.2% in 2002, thanks to weak earnings from merchandise exports and a fall in tourism revenue. In contrast, export growth expanded strongly by 13.5% and 16.6% between 2004 and 2005, respectively. Import growth, on the other side, contracted even further in 2002 by 4.2%, due to shortage demand from investment and weak demand from the export industry. In 2004-05, import growth exceeded growth of exports, rose by 26.7% and 17.8% respectively. This was attributed to high global oil prices and strong demand of capital goods. In the view of overall net exports, the trade balance in nominal terms was always in surpluses, although there was a contraction by a sharp rate of 9.4% in 2004, in response to growth in imports outpaced growth in exports far ahead.

3.3.3 Trading structure and markets

Indonesian trade has conventionally been imposed a number of levies and controls. A variety of taxes, quantity controls, sole trading licences and other constraints have been enforced on foreign trade. Domestic trade has also been under controls. Foreigners and foreign enterprises have been banned on retail trade; Chinese national entrepreneurs have been disapproved from trading in rural areas; and a quantity of goods have been given exclusive trading privileges to public or private-owned monopoly enterprises. Following the sharp fall in incomes from exporting oil (as the oil price declined in the mid-1980s), the government began to replace steadily
non-tariff barriers with a more transparent tariff regime and to reduce slowly the degree of tariff protection for domestic producers. These restrictions were abolished reluctantly in 1998, and currently the government preserves broadly a market-based trade policy. Meanwhile, some basic commodities are still strictly regulated, such as rice and main food staples, in order to protect domestic agriculture. However, the introduction of regional autonomy in 2001 has damaged liberalisation of domestic trade, as it has been disturbed by local regulations.

From the 1970s to the 1980s, exports were the main driving force of economic growth. Before the mid-1970s, a limited range of primary commodities, such as natural rubber, coconut oil, tin and crude oil, were accounted for the major share of exports. Since the fall in oil prices in 1983, the economy concentrated on the development of industrialisation, therefore, semi-finished and manufactured products became major export goods. In the meantime, the promotion of the tourism industry has increasingly contributed an important influence on services export earnings since then. On the import side, the composition of import goods and services remained relatively consistent. In merchandise imports, intermediate goods and raw materials played a dominant part, followed by capital goods which indicated high rates of investment. Imports of consumer goods rose significantly corresponded to improved disposable incomes. Freight and insurance and transportation were main import services. Moreover, in response to a rise in consumer's disposable incomes and investment, domestic consumption became a main engine of economic growth since the late 1990s as it accounted for 60.6% of total GDP in 2006.

In addition, Indonesian exports are mainly destined to four markets, which are Japan, Singapore, the US and South Korea; these accounted for 57.1% of total exports in 2006. Exports to China have also increased substantially in recent years. At the same time, Singapore is the largest import supplier. It supplied 45% of total imports in 2006. China, Japan and Malaysia are also important import sources.
3.4 Japan

3.4.1 Economic policy and structure

Before the collapse of fixed exchange rates and the first oil price shock in the early 1970s, the Japanese economy grew at a high speed. These high growth rates were the result of Japan's economic, political and social factors.

One feature of the Japanese economy is the similarities of some components of its economic structure to the developed European countries. Like Germany, Japanese firms were used to depend heavily on bank financing rather than on equity and bond issues in the past. Besides, employees at large corporations normally stick around for their entire careers. Another feature of the economy is that it comprises the large and influential multinational companies on a high level and many small and inefficient firms, many of them are run by families, on a low level. This feature enables the vitality of some industries as small firms are flexible and innovative which are deficient in large companies. Moreover, high levels of domestic savings and investment are also the characteristic of the economy. Great savings supported investment in industrial building and the development of manufacturing productivity as necessary conditions to catch up with the high-income countries in the 1960s and 1970s. During the 1990s, Japan had already become a high-income country, the levels of savings and investment were still high and a large share of investment was invested in low-return projects. Recently, Japanese companies concentrate investment on high value-added schemes to maintain the leading position and on reconstructions.

On the other hand, foreign investment was strictly restricted in Japan and outward flows were very small amount until the 1970s. As soon as capital restraints were loosened in the late 1970s, and the currency (the Japanese yen) was appreciated in the 1980s, outward investment flows have grown rapidly, especially investment in the Asian countries by overtaking Europe as the second largest market of Japanese investment. This is owing to low labour costs and the growth potential of the market in Asia. In particular, China has become increasingly one of the most popular coun-
tries to invest in recent years. However, inward FDI is still limited by its high costs of starting business compared with the rest of the region. Major foreign investors are from the US and Europe.

For many years after the postwar, Japanese economic policy pursued high economic growth as a principal objective. Until the 1980s, the Ministry of International Trade and Industry (MITI) provided low-interest loans and drafted a range of regulations to foster certain sectors. At that moment, this intervenient economic management was viewed as the most important reason for the country’s "economic miracle", regardless of other factors such as high levels of savings, educated labour force and mature technologies. Therefore, the continuous pursuit of this intervenient management resulted in the high-cost of business structure, for instance uneconomical lifetime employment, interdependent relationships between firms and banks. In the manufacturing sector, large producers purchased components from long term contractors and passed final goods through appointed wholesalers. In the non-manufacturing sector, competition and new candidates were impeded by numerous regulations in some industries. Additionally, a cross-shareholding relationship between banks and corporations, namely keretsu, which was a financial institution focused its lending mainly on a number of allied companies that held equity of each other, rather than investment.

In the late of the first half of the 1980s, as Japan’s economy become gradually mature, the persistency of high growth started to fall and closed to that of developed countries. However, the primary objective of pursuing economic growth drove the government to loose the monetary policy in order to inspire domestic demand. Consequently, stock and land prices rose sharply, in turn, companies invested tremendously in production capacity as never before. This increased indeed GDP growth in the late 1980s. This is known as the bubble economy.

Nonetheless, the sustained GDP growth could not rely on building production capacity permanently. In order to restraint increasing undue speculative in asset values, the Bank of Japan (BOJ) tightened monetary policy by raising interest rates
robustly. As a result, this brought the end of the bubble economy, in turn it caused many problems followed deflation of asset prices. An immediate response of this tight monetary policy was the slump in the stock market by nearly half of the value, hence, wealth of households and firms were eroded, in sequence, this reduced demand of wholesale and retail. Subsequently, this damaged margins of companies, and many firms were forced to claim bankruptcies. The bankrupt firms translated into financial troubles and then transmitted these troubles through the link of cross-holdings to other connected companies and financial institutions. Additionally, some of financial institutions even themselves invested large amount of money in the stock market. Therefore, they made huge losses both directly and indirectly.

The collapse of asset prices left huge amount of non-performing loans (NPLs) and put pressure on many financial institutions. Many banks were less agreeable to lend, thereby the shortage of credit availability restrained firms, especially those small and medium-sized, to entry the domestic capital markets, so investment activities were slowed to a great extent together with the slowdown in the economy. In order to fix the problems in the banking sector and to regain economic growth, the government started to reform the sector in 1998. The government began with making those unviable banks public and setting up large funds for banks recapitalization purpose. Then it followed by pressuring banks to abandon NPLs forcefully and promoting rationality of the major banks. Owing to these actions, by 2003 the government eliminated all threats to the stability of the banking sector, and by 2006 the size of NPLs was considerably narrowed.

At the same time, the problem of damaged position of public finances arose noticeably. This was partly because of the government's attempt of reviving the economy in the 1990s, alongside the costs of the Fiscal Investment and Loans Programme (FILP) (the FILP attracts savings by more favourable interest rates and lending by low cost of borrowing than commercial banks, therefore, it needs the government to finance from the general account) and pension contribution as the rapid aging of the population. It was also partly because government tax revenue
was stagnation as the economy was slowdown in the same period. In the light of this deteriorating fiscal position, the government has already adopted some actions, for instance, increasing consumption tax and lowering the minimum tax threshold.

### 3.4.2 Growth of GDP and its expenditure components

In the early 1970s, Japanese economic growth sustained fast rates of around 8% per year until the first oil shock. In 1974, the oil price shock induced a recession in real GDP growth of 1.2%. The economy regained its strength quickly, responding to tight monetary policy, cost reduction in the manufacturing sector, as well as...
expansion in non-traditional industries. In addition, owing to these factors, Japan was able to pass through the second oil price shock smoothly, even if the pace of economic expansion was slowdown in the first half of the 1980s, about 2.6%. When the yen appreciated in 1985, Japan's exports were hurt severely, in sequence, GDP growth was sluggish to 3% in 1986. In order to stimulate the economy and resume high growth, the government loosened monetary policy in 1987. The result was that the economy quick picked up to average of 5.8% from 1988 to 1990, but it accompanied with high inflation in asset prices. The bubble economy burst when the government perceived massive speculation by increasing interest rates dramatically. The consequence of this was that the economy stagnated throughout the 1990s. From 1992 to 1995, GDP growth was only 1.1% on average.

Real GDP grew moderately by 2.7% in 1996 but this was the fastest growth rate since the collapse of the bubble economy. Breaking down to the expenditure components on GDP, the biggest positive contribution was the external sector. Export growth picked up by a modest rate of 5.9% which was largely attributed to the depreciation of the yen resulted in growth in exports of goods. However, the weak yen caused an increase in the value of imports, in addition to strong growth in the reverse imports, therefore, imports grew robustly by 13.4%. Even though, import growth was faster than export growth, net exports were still in surplus but the value (at current prices) shank. This contracted surplus was partly due to high prices of imported goods and was partly owing to a rise in tourism deficit. Private consumption rose slowly from 1.9% in 1995 to 2.5% in 1996, owing to a slow recovery in consumer confidence and rising household's real incomes. Investment growth rose by 4.6% due to an expansion in private capital investment and housing investment, but this boom tended to be temporary as weak business confidence among companies, overcapacity of production and rising investment in overseas markets. Government spending grew by 2.9% which matched with the fiscal injection by the government to stimulate the economy.

Economic growth slowed to 1.6% in 1997. Household spending remained sluggish
The holding up of private consumption was the result of pessimistic prospects about the future. Consumers concerned about job security, wages and health care, all of these led people to save rather than consume. Investment contracted slightly by 0.3%, as a result of adjustment in capital spending and stagnant economic growth. Japan had accumulated a very high level of investment as the share of GDP, because of improper planning methods and cheap capital in the 1980s. Before this unsustainable level of investment diminished to a stable level, investment on plant and machinery was not likely to contribute too much growth in the economy. Government consumption rose slightly by 0.8%. The external sector continued to contribute positive effects on GDP growth. Net exports were improved as export growth expanded strongly by 11.1% which was because of the relative weakness of the yen to the currencies of major developed countries (made Japanese goods more competitive in the global market). Whereas, import growth slowed to 0.5%, thanks to the depreciation of the national currency (made other countries' import goods more expensive) and the decline in domestic demand.

Real GDP growth contracted by 2% in 1998. Private consumption contracted by 0.9%, which resulted from numbers of reasons such as rising unemployment, falling wages, deflation of asset prices. Gross fixed capital investment contracted strongly by 7.2%. The contraction was led by the worsening situation of earnings and credit when the economy dampened further as well as the financial sector. Moreover, this was also because of structural change to invest less since there was over investment in the 1980s. Government spending grew by only 1.8%, due to poor financial status as the government attempted to inspire the economy through fiscal spending. Once again, net exports were the major driving source of preventing the economy from slipping down further. Although export growth declined by 2.7%, largely owing to weak demand in the region. Fortunately, import growth fell even sharper by 6.8%, in the light of depressed domestic demand.

In 1999, GDP growth declined slightly by 0.1%. Household consumption increased modestly by 1% as households started to spend their savings. Investment
growth kept on falling but in a slower pace of 0.8% as the overproduced capacity continued to diminish until companies could run more efficient and more profitable. Growth in government spending made a positive contribution to economic growth which increased by 4.2%. This was the consequence of fiscal stimulus package conducted in November 1998. Most of spending was concentrated on public infrastructure. Net trade attributed the positive impact on GDP growth as usual, although export growth fell behind import growth which were 1.9% and 3.6%, respectively. Slow growth in exports of goods and services was caused by the rising value of the yen. On the other hand, import growth was pushed up by relative stronger domestic demand.

In 2000, the economy rebounded dramatically by 2.9%. Government consumption rose by 4.3%, mainly owing to the rising spending on social security and defence. A surplus in net exports (in nominal terms) narrowed which was due to rapid expansion in import growth, despite the falling in the services deficit. Exports expanded strongly by 12.7%. This was partly because of strong demand for Japanese goods as the countries in the region recovered from the financial crisis, and was partly because of strong global demand for IT products. Import growth grew by 9.2%, largely thanks to high prices of oil pushed up the import bill. Private consumption still stagnated by 0.7% since weak consumer confidence persisted, and investment grew by 1.2%.

Real GDP growth slowed to 0.2% in 2001, mainly because the external sector dragged down growth. Household consumption rose weakly by 1.6%, contributed to price deflation, wage stagnation and rising unemployment discourage consumer's willingness to spend. Growth in gross fixed capital formation fell by 0.9%. This decline was depressed by weak domestic recovery, continuing deflation (which resulted in companies trying to pay off debt rather than investing) and a fall in exports (which resulted from the economic downturn in the US in late-2001). Exports of goods and services contracted by 6.9%, primarily owing to some of Asian economies besides the US economic downturn drag down the value of merchandise exports.
Meanwhile, imports of goods and services rose slightly by 0.6%, in spite of weak domestic demand. The driving force behind this growth was reverse imports in addition to the weak yen. Consequently, surplus in net trade (in nominal terms) narrowed down further.

Economic growth contracted by 0.3% again in 2002. Private spending remained weak with a rate of 1.1%, given that falling wages and poor employment environment. Investment declined by 4.9% year on year. Private investment was saddened by pressures from deflation and the gloomy business outlook, whereas public investment was depressed by the local governments’ financial situation. Government spending growth was 2.4%. The foreign trade balance (in nominal term) expanded and made a positive contribution to economic growth. Export growth grew by 7.5% as the result of robust export growth to China. Growth in imports reduced slightly by 0.9%, which reflected weakness in domestic demand.

Growth in real GDP recovered gradually by 1.4% in 2003. Private consumption growth continued to be sluggish at 0.4%, on account of the persistence of unsatisfied employment and incomes. Gross fixed capital formation reduced by 0.5% which was largely driven down by the fall in public investment. This reflected the insufficient financial state of both the central and local governments, since government spending growth was still 2.3%. Net exports kept on expanding in nominal terms. Growth in exports of goods and services was still driven by demand from China which grew by 9.2%. Imports of goods and services grew also by 10.4% which stemmed from reverse imports.

Economic growth continued to recover in 2004 by 2.7%. Expansions spread across the broad. Private consumption showed a sign of recovery as it rose by 1.6%, owing to improved employment environment and the relaxation of deflationary pressures. Fixed capital investment expanded by 1.4% which was stimulated by strong growth in exports. Government consumption growth was still restrained by the poor financial state with a slow rate of 1.9%. Both export and import growth rose strongly by 13.9% and 8.1%, respectively. The driving force of exports was
demand from other Asian countries, particularly China, and the EU. Import growth was pushed up by rising costs of raw materials and commodities in the light of strong resource demand from China. The overall trade surplus (in nominal term) rose as a consequence of the strong performance in exports.

Real GDP expanded at a slight lower rate of 1.9% in 2005 than in 2004. Household spending increased by 1.3%, and investment growth rose by 3.1%. This indicated the likelihood of the end of price deflation. Exports of goods and services grew by 7%, thanks to the depreciation of the yen and strong Chinese demand. Import growth also grew strongly by 5.8% which was resulted from high global prices for fuels. Hence, the overall trade surplus narrowed sharply.

The economy expanded by 2.2% in 2006. Private consumption rather continued to rise by 2% year on year, corresponding to the improvement of employment environment and incomes. Investment maintained the expansion with a modest rate of 0.3%. This growth was supported by the strong profit growth and a recovery among small and medium-sized enterprises. Government spending growth declined by 1.3%, since the economy showed the sign of self-sustaining. Surpluses in net exports continued to shrink in nominal terms. However, real export growth expanded robustly by 9.5%, driven by strong demand from other Asian countries. Real import growth grew at a strong rate of 4.2%. High global oil prices and the strength of domestic demand pushed up the values of imports.

3.4.3 Trading structure and markets

It is interesting that Japan is relatively close to foreign trade. The limited openness to trade results mainly from protectionism of inefficient industries (like textiles, food, etc). Japan has a long history of running a merchandise trade surplus since the 1980s. There are several reasons for this. One reasons which has been paid more attention by the media is that its structure barriers to imports. Such as the tight linkage between producers and wholesalers so that foreign companies cannot easily break in; the government depresses discount retailers and shopping malls through laws; and
privileged agreements among the *kerestu* pattern of organization are unfavourable to outsiders. The other reason that is always ignored is that Japan’s high levels of savings. Any excessive capital will flow out of the country, hence the balance of trade will be in surplus. Moreover, Japan was used to rely on importing raw materials for producing manufactured goods. Along with rising markets in other Asian countries, machinery and parts are shipped to Japanese-owned companies in those Asian countries, then finished goods are shipped back to Japan, this is so-called reverse imports. As a result, this boosts the Asian trade. Furthermore, Japanese merchandise imports are highly affected by fluctuated oil prices. The US was used to be Japan’s largest trading partner in both exports and imports. But in 2002, China replaced the US and became the largest import supplier, while the US remained the largest export market. In 2006, the US (accounted for 22.5% of total exports), China (14.3%), South Korea (7.8%), Taiwan (6.8%) and Hong Kong (5.6%) were the five largest export markets. Above all, China (accounted for 20.5% of total imports), the US (11.8%) and Saudi Arabia (6.4%) were the three major import suppliers. In addition, Japan has run persistent trade deficits in net services income. This is largely owing to high costs of transporting merchandise goods and growing deficits on tourism.

3.5 Malaysia

3.5.1 Economic structure

Malaysia used to rely heavily on exporting mineral and agricultural products, such as tin, natural rubber, tropical timber etc, as the source of its prosperity and economic income. For the past 30 years, Malaysia is highly industrialised and has transformed into a manufacturing and services-dominated economy. By 2006, manufacturing made up 29.8% of nominal GDP, and services made up 46.2% of that. However, for some of agricultural commodities, like rubber and palm oil, Malaysia is still a dominant producer in the global market.
3.5.2 Growth of GDP and its expenditure components

High growth of the Malaysia economy is supported by high domestic savings and FDI. The combination of the two has helped to sustain high economic growth without high inflation rates. Moreover, the economy is exposed to changes in world demand while it depends strongly on exporting manufactured goods. During the 1970s, the Malaysian economy attained the highest growth levels of 11.7% in 1973 and 11.6% in 1976, while it sank to 0.8% in 1975. In the 1980s, the economy was in a recession with a contracted GDP growth rate of 1.1% in 1985 and hardly grew by 1.2% in 1986, but since then it grew quickly above 5%. This reflected that the economy was intensively responsive to world commodity trade cycles.

In order to keep up high economic growth, a high level of investment is required and this is mainly financed by high rates of domestic savings and FDI, as mentioned earlier. The rates of investment were strong during the 1970s when Malaysia started to concentrate on the development of industries, the annual growth rate averaged 13.9%. Although investment grew strongly at the beginning of the 1980s, it performed disappointingly after that, and even contracted continuously for three years (from 1985 to 1987). Even through it revived robustly in the late of the 1980s, the overall average growth rate was only 8.1% per year.

From 1990 to 1997, the economy of Malaysia enjoyed consistently fast growth with average annual growth rate of 9.2%, mainly supported by manufacturing investment and exports, except for relative slower growth about 8.9% in 1992 when private consumption was reduced by the government’s deflationary actions which was to correct a rising current account deficit, and the dramatic slowdown of 1997 (which grew by 7.3%) as a consequent of a collapse of the Malaysia dollar (or ringgit) and share prices. In 1998, the economy was further down and went into a recession with a deep contraction of 7.4%, which was exacerbated by a continuous effect of the regional financial crisis. GDP growth rebounded by an expansion of 6.1% in 1999, due to strong demand for information and communication technology goods.

Investment growth continued to accelerate by 18.9% per year in the first half
Figure 3.5: Malaysia: Annual growth rates of real GDP and GDP expenditure components in 1970-2006

Notes: Data source: WB, World Development Indicators (2009)
of the 1990s, but it slowed sharply since 1996. Fixed investment growth slowed from 22.8% in 1995 to 8.2% in 1996, as a result of the high interest rate dampening investment activities. Investment grew slightly higher than the level in 1996 to 9.2% in 1997. A devastating fall in investment by a contracted rate of 43% in 1998 was due to a deep decline in manufacturing investment and large withdrawal of foreign investment. The slide in investment kept on contracting by a further 6.5% in 1999. This was owing to the persistence of excess production capacity, especially in the construction and transport sectors, in addition to the caution of foreign investors.

Exports expanded by 8.2% and 9.2% on average in the 1970s and the 1980s, respectively. Afterwards, in the first half of the 1990s, export growth grew strongly by 15.9% year on year. In contrast, since 1996 export growth fell significantly year by year. It dropped from 19% in 1995 to 9.2% in 1996. This owed firstly to the appreciation of the US dollar and the Japanese yen which weakened the competitiveness of Malaysian exports since the US and Japan are the most important import sources of manufacturing component parts. Second, high stocks of electronic goods in the main electronics markets reduced the supply of electronic goods. Finally, demand was reduced by the slowdown in world trade growth. An additional slowdown in export growth as it increased by 5.5% in 1997, was a result of the continuous disappointing sales performance of manufacturing products. Export growth stagnated by 0.5% in 1998, which indicated weak demand in major export markets and low world prices for many goods. Picking up growth in exports was led undoubtedly by strong sales of manufacturing goods and rose by 13.2% in 1999.

Malaysian growth in imports grows normally at a similar pace to export growth. The average import growth rate was 10.9% which was roughly around average export growth level in the 1970s. Import growth averaged 9.3% in the 1980s which was almost the same as the average export growth rate. Since 1988 import growth tended to outpace export growth. This reflected a high import content of manufactured exports. This characteristic of the manufacturing industry affected trade position and in turn economic growth. In 1996-97, import growth was stagnation around
4.9% and 5.8%, individually. The main reason of this stagnant growth rate was weak demand for export electronics, plus a reduction in import consumer goods which was led by a suppressed private consumption. A deep contraction in import growth by 18.8% in 1998 followed sluggish growth in exports. In 1999, import growth recovered by 10.6% year on year as a rise in exports.

GDP increased by 8.9% in 2000, which was boosted by fixed capital investment and exports. A sharp downturn in the Malaysian economy with an only 0.5% rise in 2001, which was attributable to a fierce drop in the global demand for investment goods. Economic growth accelerated by 5.4% in 2002, although consumption of both household and government as well as investment pushed up growth, it was pulled down by the under-performance of overall foreign trade. The rate of economic growth continued to speed up in 2003, rising to 5.1% year on year. The main factor of this increase was a rise in private consumption and stocks, plus a continuous expansion in government spending on boosting disposable incomes in private and public sectors, but economic growth was still limited by the unsatisfactory growth of exports. For the first time in four years, the economy expanded by 6.8% in 2004 which was still led by private and government consumption and was backup by exports. However, it reduced to 5.3% in 2005. The main drivers of growth were private consumption and manufactured exports. Economic growth for the whole of 2006 was steady at 5.8% as a result of strong growth across broad.

Fixed capital investment was remarkable, expanded by 26.4% in 2000. This was attributable to a sharp increase in government investment, particular on physical and social infrastructure, as well as upward trend in private investment. A dramatic decline in investment growth by a depressing negative rate of 2.1% in 2001. In part, it was a fall in private investment which led by a reduced business confidence as the US economy went into the recession and a reduction in corporate profits. In 2002, there was a sign of a recovery in investment although overall gross fixed investment grew by just 0.6%. This was stimulated by a persistent high level of public capital investment. High public investment prolonged to drive growth of total gross fixed
capital formation, up to 2.8% in 2003. Growth of investment recovered slowly in 2004 by 3.6%, as private investment revived gradually but there was a substantial increase in FDI. In 2005, investment was back to the level (in nominal terms) before the crisis and grew by 5%. This was mainly supported by private investment on expanding capacity, upgrading facilities and investing new production activities. Investment expanded by 7.9% year on year in 2006, because of strong growth in both private and public investment.

FDI as an important source of rapid economic growth in Malaysia is high, especially in the manufacturing sector. Regarding well-built infrastructure and administration, well-educated labour force as well as low internal costs, these are incentives to attract FDI. The major foreign investors come from the US, Japan, Singapore, Taiwan and South Korea. Nonetheless, the economy is at risk when foreign investment changes to invest in other countries, in order to take advantage of more attractive terms. This was what happened during 1993-95 when the major foreign investors focused on investing in China, FDI (the following of all FDI growth rates are calculated in nominal terms) decelerated from 1.5% in 1993 to 6.2% in 1994, and further down by 1.7% in 1995. FDI growth recovered in 1996 by 8.5% but in 1997 growth was sluggish which was due to the wake of the Asia Financial Crisis. It was followed by a further sharp contraction in FDI, about 37.6% in 1998. Another devastating contraction in FDI happened in 2001 by 83.5%, mainly owing to a decline investment in manufacturing sector. Fortunately, FDI growth rebounded fast by 76.2% in 2002. A strong reduction of 11.2% in FDI growth in 2003 was possibly resulted from structural changes in the Malaysian economy. However, by 2006, it grew robustly by 18.4%. Additionally, Malaysia is expecting to attract higher-knowledge-content investment with the purpose of developing a knowledge-based economy and higher value-added manufacturing.

This strong upward growth in exports kept on accelerating by 16.1% in 2000, which was boosted by high prices of crude oil as well as growth in electronic and electrical goods. Exports contracted by 6.8% in 2001, mainly due to a fall in elec-
tronic and electrical goods as demand for these goods diminished, in addition to low prices of oil. Between 2002 and 2003, export growth recovered gradually by 5.4% and 5.1%, individually. Such a slow recovery in exports was restrained by several factors. One was gradually lost competition to China. Second, it was partly because of weak confidence and excess production capacity in other Asian countries. Moreover, unsurprisingly, sluggish demand for manufacturing goods. Export growth soared in 2004 by a robust rate of 16.1%. This was accelerated by exports of both traditional (agriculture and minerals) and non-traditional (manufacturing) products, in particular, the performance of the manufacturing sector was outstanding. However, this high speed growth of exports was short-lived, in 2005-06, export growth slowed to 8.3% in 2005 and 7% in 2006. This was because of holding up in demand for manufacturing goods. On the contrary, high prices for mineral (high oil and gas prices in 2005) and agricultural (high prices for rubber and palm oil in 2006) exports helped to boost overall export growth.

The recovery in import growth was quick and outpaced export growth in 2000, grew by 24.4%, corresponding to strong export sales which stimulated a pick up in domestic demand. Import growth declined quickly by a contracted rate of 8.2% in 2001. This indicated that the reduction in manufactured exports which accounted for a large proportion of import content and weak domestic consumer demand. Since then, import growth expanded gradually and peaked in 2004 by 19.6%, and was slowdown to 8.7% on average in 2005-06. The main driver of import growth was exports – as almost always is.

### 3.5.3 Trading structure and markets

International trade plays a very important role in the Malaysian economic development. Before Malaysia industrialised, the economy relied primarily on exporting raw materials. After industrialisation, the country has become more open to the global market, since its economy is based on exported-oriented manufacturing industries. Many of these export production lines are built on the strength of low local
content. For the past four decades (1970-2006), for most of the time, import growth tends to follow the steps of export growth. During the 1970s and 1980s, Malaysia had run a considerable surplus in foreign trade, apart from 1982. However, this favourable trade position deteriorated in 1991 and again in 1994-97. To some extent, this was because electronic components, machinery and other manufacturing inputs of producing manufacturing products were heavily reliant on imports. Ever since, Malaysia has run constantly trade surpluses. Furthermore, on the services account, Malaysia runs consistently large deficits all along, principally thanks to the shortage on services related to merchandise trade, even if income from tourism on the travel account has been improved recently.

The US was the Malaysian largest export market and the second largest import market in 2006. Japan was the largest import market with 17.3% of total imports, and it was also the third largest export destination which accounted for 14.2% of total exports. Singapore was another important source of exports and imports with 24.7% of and 15.3% of the total, respectively. Furthermore, China becomes increasingly an important trading partner in recent years. It accounted for 11.6% of total exports and 15.9% of total imports in 2006.

3.6 Philippines

3.6.1 Economic policy and structure

After decades of continuation of protectionism since the country was independent, which originated in the rentier economy during the colonial period, the government has started to undertake to restructure and liberalise the Philippine economy since 1986, by eliminating constraints that impede the economic development and growth. The major objectives of this transformation include: removing monopoly; extending foreign investment in those formerly restricted or banned sectors; privatising entire or partial government-owned corporate holdings and core services; simplifying and widening the tax structure; and reducing or revoking trade barriers. These objectives
aim at mobilising resources. One of the instruments used to achieve them is the build-operate-transfer (BOT) contract. Under this system, the burden of capital and management is swung from the public to the private sector. Other insufficient forms of physical infrastructure such as roads and rail services are extensively included, either because of its limitation to economic growth or scarcity of the government's budget to finance. In addition, the execution of these objectives are reinforced by the openness of retail trade and the liberalisation of the banking sector. However, under the pressures from the obstacle of Congress, some of policies are unable to put into practise because some of these may damage certain degrees of interests. This is the case for the liberalisation of the power sector. Moreover, the relaxation of restrictions on possession of land and foreign investment in media, education and natural resource are still slow in progress.

The other main pursuit of economic policy is the enhancement of budget revenue to a sustainable level that can support stable growth of the economy. The ratio of tax revenue to GDP has fallen from 15% to 13% in recent years. The short supply of tax revenue means that the government has not been capable of developing fully physical and social infrastructure, in sequence, this has blocked extensive resource mobilisation. The situation has been worsened by maintaining fiscal balance with careful calculated spending to make up for under-performance of the revenue side.

Progress in relieving unfavourable budget position was achieved under BOT or other similar contracts which related to rehabilitation and maintenance. More important, by selling government assets in forms of both physical and corporate boosted the government's income. This allowed the government's budget to register a small surplus in 1994-95. In 1996, another surplus was recorded. This was reinforced by a fall in interest payments on debt, which was the largest expenditure item, as the level of debt stock declined. However, the reliance of trading government assets was not a solution over the long term. Hence, the government had made a great effort to extend and to strengthen the tax base. Value-added tax (VAT) was widened in 1996, at the same time, a reform of tax structure was carried out and
targeted to ease the extent and motivation of corruption and evasion. The reform package made the personal and corporate tax system simpler and changed the excise system to prevent evasion. However, recent studies suggest that the reform has been essentially ineffective, and even has deteriorated tax evasion on personal income. It is realised that the basic solution is to improve tax administration and to reduce corruption.

Nevertheless, this achievement that brought in under the reform package did not last very long when the economy was hit by the financial crisis in 1997. The impact of the crisis on the fiscal balance was instant and harsh. The depreciation of the peso and the sharp rise in interest rates to retard the depreciation raised the cost of the government debt service, in the meantime, tax revenue was also reduced significantly due to the slowdown of the economy. Although the government expanded the budget in 1999, the slow recovery of GDP and the shortfall of tax revenue than expected did not narrow down the deficit to the target value. The enlargement of the deficit in 2000 was partly contributed to the above factors, and was partly contributed to the unrest of the polity which weakened investment sentiment and tax receipts. Until 2003, the government has finally been able to restrain the budget deficit and the deficit has declined every year since. In particular, it was considerably successful in 2006 as the deficit was narrowed by more than half of its level in 2005. In part, a rise in tax revenue which resulted from a package of tax increases, it was also because of a registered surplus from the balance of the public sector.

The attainment of stabilising monetary growth has been more successful. Traditionally, the Bangko Sentral ng Pilipinas (BSP, the independent central bank) set interest rates to accomplish the target which was supervised by the IMF, amid paying close attention to the fluctuations of the value of the peso and giving certain degree of backup while the peso was declining too fast. Between the beginning of 2000 and the early of 2005, the BSP switched the monetary policy to a lessening in monetary conditions, in response to the rapid fall in consumer prices in inflation (CPI), slow growth of money supply and credit, and the sharp fall in the US federal
funds rate. It was again introduced in the late of 2006.

The diversification of the Philippine economy is in the forms of both physical and human endowment. In 2006, the agriculture, the industry and the services sectors made up 14.2%, 31.6% and 54.2% of GDP, respectively. However, the economy is also highly inequalities, in respect of ownership of assets, levels of income, technologic contents in production, and the geographical concentration of activity. The National Capital Region (NCR, in the capital) produces over one-third of GDP, and is the richest region in the country (its GDP per head was 12.2 times richer than the poorest region - the Autonomous Region of Muslim Mindanao (ARMM) - in 2005). According to a report on income distribution in 2000, 10% of the richest population earned an income 23 times higher than 10% of the poorest. It was estimated that 34% of the population living was at or below the poverty level in the same year. This reflects the underdevelopment of the Philippine economy.

3.6.2 Growth of GDP and its expenditure components

The speed of economic growth was relatively stable, except for 1973 and 1976 with rates of 8.9% and 8.8% respectively, averaged around 5% in the 1970s. During the 1980s, growth fluctuated in a large range with GDP contraction by 7.3% in 1984-85, then rebounding to over 6% in 1988-89. The original driving force behind this rebound arose from a revival of private consumption in 1986-87, in addition to an increase in investment as a result of strong domestic and foreign demand in 1988-89.

However, economic growth fell to half of the rate in 1990 in relation to 1989. This was resulted from a sequence of shocks: the attempt of political takeover in the late of 1989; natural disaster worsened the power supply; the war in the middle-east pushed up oil prices and deteriorated the foreign balance further. A tight government budget pulled down GDP growth to a contraction rate of 0.6% in 1991. A slight recovery in 1992 was the result of an expansionary spending on the election campaign compensating the tight budgetary position. However, agriculture was hurt by drought and the underperformance of manufacturing was caused by a
Figure 3.6: Philippines: Annual growth rates of real GDP and GDP expenditure components in 1970-2006

Notes: Data source: WB, World Development Indicators (2009)
East and Southeast Asia: An Overview of the Economies

further and serious decline in the supply of power. Therefore, these factors impended GDP growth in 1992-93 with the rates of 0.3% and 2.1%, respectively. Between 1994 and 1997, strong growth in exports stimulated incentives to investment, GDP growth grew twofold in 1994, rose slightly to 4.7% in 1995 because of the depression resulted from drought, and increased to a peak of 5.8% in 1996 before a small fall back to 5.2% in 1997 when the economic crisis hit the region. GDP growth sunk by 0.6% in 1998. Gross fixed capital formation was down by 11.2%, owing to a sharp rise in interest rates and high peso value of the import bill. Government spending also dipped by 1.9%. A significant fall of 21% in exports exceeded the fall in imports which was 14.7%, but the trade deficit narrowed down in nominal terms. Private consumption, on the other hand, was the component that grew at a positive rate of 3.4%, due to the impact of changes in income tax and election campaign spending.

In the next two years, the economy recovered steadily from 3.4% in 1999 to 6% in 2000. In 1999, private consumption rose slowly by 2.6% and investment still fell but at a mild rate of 2.3%. Government consumption expanded strongly by 13.1% as the government started a programme to expand spending. Exports revived slowly by 3.6% whereas imports continued to fall by 2.8%, hence, there was a surplus recorded for the overall net foreign balance since 1974. In 2000, private consumption kept the pace around 3.5%. Gross fixed capital formation rebounded significantly by 19.9%. Exports also made a remarkable contribution of 17% to GDP growth, accompanied with a relative slow recovery in imports, by only 4.3%. Consequently, the net trade balance was still in the black.

All trends were turned around, except for household consumption and imports. Private consumption grew by 3.6% and was encouraged by strong growth in agriculture. Investment and exports both declined by 13% and 6.8% in the light of weak growth in the US economy as the terrorists attacked the US. Together with falling in government spending by 5.3%, as the government held back the spending within the range of the targeted deficit. While imports grew by 3.5%, the net foreign trade balance was in deficit. As a result, the economy rose just 1.8% in 2001. During
the following years, from 2002 to 2006, the economy picked up its strength, it rose from 4.4% in 2002, reached to a peak of 6.4% in 2004, and finally settled down at 5.4% in 2006. The driving forces behind this growth were mainly growth in private consumption and exports.

### 3.6.3 Trading structure and markets

The Philippine external trade balance has consistently run trade deficits, apart from 1973 (the first oil price shock) and 1999-2000. The country's merchandise exports are responsive to foreign demand for limited variety of manufactures and primary goods, meanwhile, merchandise imports are heavily reliant on foreign supply of capital goods and intermediates. Since the 1970s, the share of traditional commodity exports has declined gradually, whereas, that of non-traditional manufacturing exports has risen significantly. Especially, the electronic sector has outperformed than other sectors. In 2006, it accounted for two-third of total merchandise exports. This change in export structure by shifting away from primary goods to manufactures with high import content, has affected trends in import spending. The largest contributor of services exports is remittances from overseas Filipino workers. Inflows through conversions of foreign currency deposits were used to be another large contributor of services exports, but after the collapse of the currency in 1997-98, these conversions have not been classified individually. Additionally, tourism also makes an important contribution.

The US and Japan are Philippines' leading trading partners but the US share in Philippine exports has declined gradually, from 37.2% in 1994 to 18.3% in 2006. As import sources, these two countries have relatively close shares, and generally, Japan takes the lead as a dominant provider of aid funds and its investment in the Philippine manufacturing sector. Increasing trade links with the members of Association of South-East Asian Nation (ASEAN) (which include Indonesia, Malaysia, Philippines, Singapore, Thailand and other 5 countries, in particular, with Singapore), China, Hong Kong, South Korea and Taiwan have diversified its trade markets.
3.7 Singapore

3.7.1 Economic policy

Unlike the Hong Kong's government, the Singapore's government uses both macro- and microeconomic policies even through owning firms to manage economic development. During the 1970s, when the government wished to develop high value-added, capital-intensive industries, the government increased labour wages to force firms to use machinery. Since 1988, the government has encouraged the development of small and medium-sized enterprises and the services sector (in particular business and financial services). The government introduced a number of fiscal incentives and policy initiatives (especially, promoted Singapore's firms to invest in the Asian-Pacific region) in 1992. In 1996, the government injected a great value of money to help firms to establish research and development centre. Furthermore, it also encourages overseas firms to set regional headquarters in the country.

3.7.2 Growth of GDP and its expenditure components

Compared to Hong Kong, the overall picture of the GDP annual rates of growth are relatively stable. The same as other three newly industrialized economies (which are Hong Kong, South Korea and Taiwan), Singapore has experienced high speed of growth in the economy. During the 1970s, the growth rate averaged 9.2% year on year. In the 1980s, the annual rate of growth achieved 7.5% year and year, apart from a contracted growth of 1.4% in 1985. In the first half of the 1990s, Singapore grew faster than other newly industrialized economies. GDP growth was driven up by 9.2% in 1990 by a boom of the electronic industry, it fell to 6.6% in 1991 and 6.3% in 1992. After that, GDP picked up to a peak of 11.7% in 1993 and 11.6% in 1994, and it decreased to 8.2% in 1995. Those rapid growth rates resulted from an expansion in investment and exports. GDP was reported at 7.8% for 1996, owed to the shrinkage of stock levels and exports. Despite the effects of the Asian economic crisis, GDP growth was unexpectedly high and reached 8.3% in 1997. It was because
Figure 3.7: Singapore: Annual growth rates of real GDP and GDP expenditure components in 1970-2006


of fast growth in fixed investment and exports. The consequences of the Asian crisis started to affect the economy of Singapore, the growth rate decelerated by 1.4% in 1998. GDP growth rebounded strongly by 7.2% in 1999, due to robust growth in domestic demand and exports.

Relative to rapid GDP growth, private consumption growth was slower. Between the 1970s and 1980s, the growth rates averaged around 2.8% and 2.7% per year, respectively. In 1990-94, private consumption growth declined from 3.3% in 1990 to 2.6% in 1991-92, and pushed up to 3.5% in 1994. As individuals preferred to invest, for instance, in housing and the stock market, private consumption grew by 1% in 1995. An expansion in residential construction brought along private consumption...
growth on household equipment and furniture, hence, it grew at a higher rate of 2.2% in 1996. This factor continued to determine growth of private consumption at the nearly identical rate of 2.1% in 1997. The after-effect of the Asian crisis pulled down private consumption growth to a contracted rate of 2.4% in 1998. Growth in private consumption increased by 3.4% in 1999, owed to increasing spending on consumer goods.

Gross fixed capital investment grew reasonably well in the 1970s and 1980s, although it contracted in 1973 and 1985-86. However, it has been slowing gradually since the 1990s. Fixed investment grew at 4.2% per year from 1990 to 1995. There was an outstanding growth in fixed investment, by 8.8% in 1996, mainly due to investment in construction, machinery and plant. Investment growth reduced to 3.7% in 1997, owed to sluggish growth in investment in transport, construction and manufacturing facilities. The fall in those sectors persisted to affect the growth rate of overall investment, so investment growth contracted by 2.6% in 1998. Investment in manufacturing facilities grew strongly but that in transport and construction kept on falling further, therefore, overall investment contracted further by 3.9% in 1999.

During the 1970s, export growth (measured in current US dollar prices) was extremely high, at an average rate of 5.8% year on year. However, the average annual growth rate almost halved in the 1980s. Export growth dropped from 2.4% in 1990 to 1.5% in 1991, and slipped further to -0.3% in 1992, but grew remarkably by 5.3% in 1993, 7.8% in 1994 and slowed to 4.8% in 1995. The boom in export growth was pushed up by a boom in the electronics sector. But in 1996, exports expanded slowly to 1.6%. This was partly because that the prices of many electronic goods were lower, in addition to lower growth in re-exports. Export growth continued to grow gradually by 1.4% in 1997, due to a sharp fall in prices of many electronic goods. In 1998, Singapore’s exports decelerated even by 0.3%. There were two reasons for this poor performance in exports. First, in the light of the Asian economic crisis, demand for import goods in the Asian markets was still weak. Second, the supply of electronic goods exceeded far ahead world demand, therefore, this led to a fall in
prices of electronic goods. Export growth moderate recovered by 2.4% in 1999, as a result of a rise in domestic exports.

On the import side, import growth is primarily determined by export growth, as a great proportion of imports are ended as re-exports or inputs of domestic exports. Hence, the average annual rates of import growth in the 1970s and the 1980s were very close to export growth in the same period, which were 5.5% and 2.8% individually. During the first half of the 1990s, import growth declined from 4% in 1990 to 0.2% in 1991, sustained at 0.3% in 1992, then rose sharply by 5.9% in 1993 and 4.2% in 1994, and remained growth at 4.5% in 1995. Until 1999, import growth had fallen year by year in line with export growth. It fell to 1.5% in 1996, and a slightly higher pace of 1.7% in 1997 but was faster than export growth in the same year, which could be explained by a strong expectation about future growth in manufacturing. In 1998, imports shrunk remarkably by 5%, owed to in part a decrease in imports of electronic components, and also a fall in oil imports. Import growth outpaced export growth in 1999. It recovered by 3.2%, because firms increased stocks in order to catch up demand for exports.

GDP continued to grow strongly by 10.1% in 2000, which was boosted by private consumption and external demand for Singapore’s exports (mainly electronic goods). Economic growth was mainly pushed down by electronic exports thanks to weak global demand, in addition to a fall in fixed investment demand, consequently, it contracted by 2.4% in 2001. The economy recovered by 4.2% in 2002, owing to a strong expansion in manufacturing. The SARS outbreak accompanied with both weak domestic and external demand dragged down growth of the economy to 3.5% in 2003. In 2004, the economy expanded at 9%, largely contributed to a boom of exports and domestic consumption. A slight expansion in consumption and a deceleration in investment resulted in a fall in economic growth to 7.3% in 2005. GDP growth reached a high growth rate of 8.2% in 2006, due to strong growth in investment and moderate growth in exports.

An extremely strong expansion in private consumption by 6.6% in 2000, which
resulted from high real disposal income and the revival of consumer confidence. Private consumption grew moderately by 1.2% in 2001 and 2.2% in 2002, because of the slowdown of the global economy. The disruption of SARS was the major factor that pulled down private consumption growth in 2003, to only 0.2%. After the impact of SARS, private consumption recovered fairly by 1.7% in 2004, accelerated by increased expenditure on medical care, education and recreational activities. In 2005, private consumption growth was relatively the same at the rate of 1.4%. This sluggish was officially claimed by a fall in sales of motor vehicles. This might also be because of uncertainty of employment prospect. Private consumption increased by 1.1% in 2006, while there was slow growth in demand for motor vehicles, health care and financial services.

Fixed investment growth rebounded at a slower pace of 1% in 2000. This was due to a high level of investment in machinery and equipment which was manageable to outweigh the contraction in construction. A continuous drop in construction added to a fall in machinery and plant in manufacturing sector, thus, total fixed investment decelerated by 3.1% in 2001. These factors kept on dragging down fixed investment growth and led to a negative growth rate of 5.5% in 2002. Compared to 2002, investment growth was only contracted by 1.8% in 2003. As usual, this resulted from a decline in construction. Fixed investment growth rebounded robustly by 3.9% in 2004, primarily because of a sharp rise in private investment in machinery and equipment, as well as a slower rise in transport. In 2005, investment contracted slightly by 0.1%, as a consequence of a decline in transport investment. A strong expansion in construction, machinery and equipment, and transport, drove up total investment growth by 4.4% in 2006.

Additionally, foreign investment remains still an important key factor of Singapore's prosperity as it brings manufacturing and service facilities and technologies. However, growth of foreign direct investment is very volatile. FDI growth grew (or contracted) at double-digit levels between 1970 and 2006. What is more, limits on land and labour have led the government to encourage outward investment. The
most popular investment destinations are Malaysia and Indonesia. Besides that, Hong Kong, the mainland of China, and Thailand become also increasingly attractive to invest.

The excellent performance of exports in 2000 with a stunning rate of 8.2%, boosted by strong world demand for electronic goods and high oil prices led to high values of exports for producers, and strong growth of re-exports. Unfortunately, export growth was hit hard in 2001, thanks to low demand of the global market for electronic goods, with a contracted rate of 4.2%. In 2002, export growth revived by a moderate rate of 1.3%, in spite of the problems in the electronics sector, exports of many electronic components rose. A strong export growth rate of 4.8% was led by a recovery in the world economy, specially the electronics and chemicals sectors. There was an extraordinary growth in exports, at 11.9% in 2004, mainly driven by a boom in electronic exports. Exports continued to expand by 5.5% in 2005 and 4.8% in 2006, still led by the strong performance in exports of electronic goods, as well as an expansion in re-exports.

Import growth expanded slightly faster than export growth, by 8.5% in 2000, which indicated increasing exports, stocking and a rise in private consumption. Import growth reduced by 5.3% in 2001, as a fall in demand for imports of electronic components which resulted from massive reduction of stocks in the electronics sector. As export growth revived, so as import growth but less than export growth, which was only 0.3% in 2002. An increase demand for imported electronic components and parts boosted import growth by 2.7% in 2003. The rise in import growth expanded even faster in 2004, by 8.7% in 2004, as rapid growth of exports continued to determine import growth. Between 2005 and 2006, import growth grew faster than export growth, by strong growth rates of 7.9% and 5.1%, respectively.

3.7.3 Trading structure and markets

Singapore relies notably on foreign trade. The official record in 2006 reported that the total value of trade (exports plus imports) was equal to 382% of GDP. Around
47.3% of total exports were re-exports, which reflected the growing importance of Singapore as a port and regional centre. What is more, the major positive contributor to the services balance is the financial services industry, ship-repairing and bunkering are also important income sources. As Singaporeans are getting wealthy and adventurous, outflows of tourism exceed inflows so that travel services have been in deficits recently. Furthermore, transportation costs always drag down the balance of the services account. Overall net trade was constantly in deficits before 1998, since then it has run a continuous trade surpluses.

Traditionally, Malaysia is the largest trading partner (both exports and imports) for Singapore. It accounted for 13% of Singapore's both exports and imports in 2006. In particular, exports to Malaysia were largely re-exports and oil, once these were excluded, share of total exports to Malaysia fell. Hong Kong was other important export market, accounted for 10% of the total and many exported goods were going on to China. Moreover, there was also 10% of total exports traded directly with the mainland China. Hence, total exports to Hong Kong and the mainland China altogether made them the largest export market. Besides, Indonesia was the fourth largest export source, with 9.2% of the total. On the other hand, China was recorded as the third largest import market in 2006 with 11.4% of the total. Furthermore, Japan and Taiwan were also important import markets to Singapore, accounted for 8.3% and 6.4% respectively.

3.8 South Korea

3.8.1 Economic policy and structure

South Korea is one of the newly industrialising countries. Its economic structure focuses mainly on manufacturing and services sectors on the basis of the reduction in the share of the primary sector (agriculture, fishing and forestry). Manufacturing industry made up 33% of total GDP in 1988, but this share has fallen stabilised to about 25% of the total since then. The falling share of manufacturing in GDP does
not mean that manufacturing has a disappointing performance. Conversely, manufacturing grew by 8% per year on average in real GDP value added terms from 1996 to 2006. Alternatively, this is because the services sector has risen significantly in the share of GDP from 16.6% in 1991 to more than 50% in 2006, which indicates the economy has grown up from manufacturing-dominant industry to service-dominant industry.

South Korea's economic structure is also characterised by the dominance of the 'chaebol' or conglomerates. South Korea has an extensive proportion of small and medium-sized enterprises (SME). According to the OECD estimation, 99.8% of all firms belong to these types, they employ 87% of total employment and produce 50% of manufacturing output, plus their investment in business accounts for half of the total. Even though in spite of their total numbers, these SME are dominated by some large conglomerates. These conglomerates are the dominators of every economic activity, for instance, they account for 60% of total exports, although after a significant change in the background of the corporate business grouping since 1997 because of governmental reforms.

Similar to liberal domestic economic management in Hong Kong, South Korea imposes minimum government controls on economic activities. Fiscal and monetary policies are normally not the top priorities of political debate. In general, fiscal policy ensures that there is an overall budget surplus when the economy is in the peak of the business cycle, and the deficit is kept below 3% of GDP when the economy is in the trough of that. Consequently, total government spending was likely to vary with recurring economic conditions during the 1980s and the 1990s, except in 1998-99 that the government increased spending in order to finance reform of the financial sector and of social welfare. However, for monetary policy, since the Bank of Korea (BOK) was independent from the Ministry of Finance and Economy (MOFE) in 1998, the BOK has pursued more tighter policies, primarily concentrates on price and financial stability.

In recent years, more precisely, since the end of Asian Financial Crisis, South
Korea has focused on its economic management on reform of the financial and corporate sectors. Financial reform has been a great success. To some extent, this success was attributed to the tight government control in the financial area regardless the privatisation of most banks. During the reform, numbers of unfeasible banks were shut down, weak banks were enforced to emerge with strong ones. Meanwhile, there has been a progress made in the financial system on managing large stock of non-performing loans. However, reform of the corporate sector has been less successful. The government has promoted greater corporate transparency and shareholder rights, but there are still problems needed to be solved.

Before the regional crisis of 1997, the government controlled both inward and outward flows of capital. These were two reasons for this control. One was afraid of international competition. The other was afraid that too much inward foreign investment would appreciate the exchange rate (both in nominal and real terms), hence, this would damage exports. However, entry as a member of the OECD in 1996 boosted the deregulation process of the capital account, and the establishment of the bail-out fund by the IMF in the end of 1997 accelerated the openness of the capital account further. Thus, limits on capital flows have been almost fully removed by now. Since then, FDI has risen rapidly.

3.8.2 Growth of GDP and its expenditure components

South Korea sustained annual average growth rates of real GDP around 8.3% in the 1970s and 7.8% in the 1980s. High economic growth between 1990 and 1996 was led by growth of exports. During this period, South Korea's labour-intensive manufactured exports had moved up-market successfully. Those exports of the labour-intensive goods (such as clothing, toy and footwear), which were used to be dominant sales of exports in developed markets, became less competitive in international markets. This was partly due to the appreciation of the won against the US dollar, and was partly the result of a rapid increase in wages in 1987-89. Hence, some firms shifted their production lines to Southeast Asia, for example, Thailand
Figure 3.8: Korea: Annual growth rates of real GDP and GDP expenditure components in 1970-2006

Notes: Data source: WB, World Development Indicators (2009)
and Vietnam, and some of them went out of business. This also happened to the shipbuilding industry. In the meantime, South Korea’s exports of capital-intensive goods grew significantly.

Nevertheless, between 1997 and 1998, the economy experienced a downturn. Economic growth slowed from 9.2% in 1995 to 7% in 1996. Breaking down GDP on the basis of the expenditure components reveals a wide-ranging slowdown. Private consumption and fixed capital formation grew relatively slower in 1996 (with 8.4% and 6.7%, respectively) than in 1995 (with 13.1% and 9.9%, respectively), although government spending growth increased (8% in 1996 compared to 5% in 1995). Poor corporate earnings resulted in holding back of investment. Moreover, a sudden fall in export growth from 24.4% in 1995 to 12.2% in 1996 exacerbated the deceleration of economic growth, which was the result of falling prices in key exports, such as semiconductor, steel and chemicals. This was also accompanied by a sharp fall in import growth from 23% to 14.3%, which reflected the weakness of domestic demand, mainly due to the slow demand for machinery and transport equipment. Hence, the external sector made a negative contribution to GDP growth as the value of imports exceeded that of exports (because of high prices of oil).

Economic growth deepened further to 4.7% in 1997. Growth in private consumption declined further to 3.3%, and gross fixed capital investment growth decelerated by 2.3%. Additionally, government consumption growth declined more than half to 2.6%. Export growth was the only component that had upward trend and grew strongly by 21.6%, but it would not last since import growth increased slightly by 3.5%. Slow growth was thanks to the complete failure of labour legislation caused industrial instability, chaebol and the creditor banks associated with them were hurt by bankruptcies and gossips of collapse, in addition to falling demand and prices for leading exports.

Year 1998 was the worst year for South Korea’s economic growth for the past 28 years. It contracted by 6.9% year on year. Private consumption was dragged by the rising unemployment rate and low wages (both in real and nominal terms), hence, it
East and Southeast Asia: An Overview of the Economies

reduced from 3.3% in 1997 to a contracted rate of 13.4%. A deep fall in gross fixed capital formation from a negative rate of 2.3% in 1997 to an even deepened rate of 22.9%, resulted from slowing in the construction sector and the poor outlook for profits. Furthermore, export growth grew gradually by 12.7% as a result of slow in world trade growth. However, import growth contracted even fast by 21.8% because of weak consumer and private sector investment demand.

Conversely, GDP growth was unexpectedly strong in 1999, as it grew by 9.5% year on year. Private consumption grew at a fast rate of 11.5% as consumer confidence was stimulated by falling unemployment, low interest rates, as well as a boom in the stock market. Investment revived by growing at 8.3%. This was mainly boosted by investment in manufacturing. An upward trend in export growth by 14.6% also contributed a positive impact on the revival of the economy, although this was due to the effects of the earthquake in Taiwan in 1999. Meanwhile, import growth grew rapidly by 27.8%. This was partly because of low comparison base of last year. Strong export growth, the recovery in domestic demand as the return of consumer confidence and high oil prices all contributed to as the factors of the rapid increase in import growth. Government consumption growth kept steady at 2.9% while the government strengthened its efforts to limit the size of spending.

GDP growth remained buoyant in 2000, registering a rate of 8.5%. Private consumption grew comparably slower but still strong by 8.4%; this was pushed up by increasing spending on durable goods and services. Investment grew by 12.2% and was largely supported by investment in facility (mainly in machinery and equipment), whereas construction investment depressed the overall investment growth rate. The robust growth rate of 19.1% recorded by exports reflected strong demand for electronic and chemical exports, as well as restoration of demand for light-industrial goods. Import growth outpaced export growth, grew by 20.1%. This was largely resulted from strong growth in business investment and exports. Overall trade surplus was narrowed down as the value of imported industrial material and fuels increased.

GDP growth rose steadily by 3.8% in 2001. As lower interest rate, higher wages
and falling unemployment, consumers gained confidence which in turn led to a rise in consumption growth by 4.9%. Meanwhile, the government increased spending on public works and social infrastructure in order to stimulate domestic demand, hence government spending grew by 4.9%. However, sluggish growth in investment and a contraction in export growth contributed to slow economic growth. Investment decelerated slightly by only 0.2%, this was largely because of depressed global demand for information-technology (IT) products and the US economic downturn after the terrorist attack. The contraction in export growth by 2.7% was attributed to the same reasons which demand from two major export markets – the US and Japan – declined. Import growth also contracted by 4.2%, which was held back by the reduction in investment and exports.

GDP growth was in the state of a boom which accelerated by 7% in 2002. This expansion was supported by growth in GDP expenditure components across the board. Private consumption was boosted by the positive impact from South Korea’s hosting of the football World Cup with a robust rate of 7.9%. Investment growth rose by 6.6% as a result of an increased investment in construction and plants and machinery. Although growth in government spending was slower, thanks to the completion of the public work projects related to the football World Cup, it still increased by 6%. Exports revived by a strong rate of 13.3%. This was the result of strong demand for South Korea’s exports from China, particularly for IT goods. At the same time, this accompanied with a rise in import growth with 6.1%.

In 2003, output growth decelerated to 3.1%. The most noticeable change was the shrinkage of growth in private consumption which declined by 1.2%. This was partly due to the government control on overheating of consumer borrowing. The uncertainty of economic outlook and concerns about personal debts also spurred households to clear debts rather than to consume. Growth in investment slowed relatively to 4%. Government consumption growth reduced slightly to 3.8%. Other significant changes were export and import growth. They grew by 15.6% and 10.1%, respectively. The rapid increase in export growth was the result of a continuous
expansion of demand for South Korea's exports from China. The rise in import
growth was owing to the strong performance of key export goods and high oil prices.

Economic growth in 2004 was largely boosted by external demand. Private
consumption still decelerated at 0.3%. This was the consequence of continuing
adjustment of household balance sheets after the end of recent credit boom. Gross
fixed investment growth slipped to 2.1%. This was pulled down by SME concerned
about their prospects since domestic demand was miserable. The performance of
exports was outstanding. It grew by 19.6% year on year which was led by sustained
rapid demand growth from China and was backup by increasing demand from other
two important export market, the US and Japan. Import growth increased by 13.9%
which resulted from high values of imports of raw materials. The trade surplus was
widened as exports outperformed imports, hence contributed positive impact on
output growth.

GDP growth increased by 4% in 2005. A steady rise in private consumption by
3.6% indicated that the sign of a recovery of household balance sheets adjustment
accompanied with improved conditions in labour market and strengthened financial
health of consumers. Whereas, growth in gross fixed investment rose slightly but
remained weak at 2.4%. There were twofold, firstly, SME were still anxious about
their outlook while they were unable to earn enough income to cover their interest
expenses. Secondly, unrest growth in the construction sector which accounted for
great share of overall investment, also deterred investment growth. Government con-
sumption increased slightly to 5%, as the government intended to increase spending
on public works. There was a large slump in export growth as it grew by 8.5%.
The rise in export growth was mainly contributed to strong demand from China as
usual. Import growth, on the other hand, slowed much less than export growth. It
rose by 7.3%, which was driven by high prices of energy.

South Korea's economy expanded by 5% in 2006. The performance of private
consumption was disrupted by the government disorder and uncertainties in North
Korea. Hence, overall growth was just 4.5%. Investment growth was also disap-
pointing although it grew slightly higher than last year by 3.6%. This was because of a decline in business investment since SME still struggled to cover their expenses which was resulted from high won and high oil prices. Government spending rose by 6.2% as the government kept on pursuing the public works. Export growth pushed up to 11.8% which was primarily led by exports of machinery and equipment and petroleum products. Import growth was once again almost caught up export growth, rose by 11.3% year on year. Consequently, the trade surplus continued to shrink.

3.8.3 Trading structure and markets

Since South Korea pursued export-led industrialisation, the openness to international trade has been increasing. In 2006, total foreign trade accounted for 70% of GDP, which follows behind Taiwan but was ahead of the US and Japan. Exports are the main drivers of South Korea’s economic growth, but the economy depends heavily on energy imports as well. The reliance of energy imports makes the economy easily to be influenced by changes in energy prices which are interrupted by political issues in the leading supplier countries. Furthermore, the services account has been in general recorded deficits since the 1990s. This is mainly owing to a widening deficit in the travel account, except for 1998-99 which the recession depressed overseas traveling sharply.

Moreover, South Korea has gradually changed the route of trade in recent years. The US and Japan were the two largest trading partners. In 1996, the US accounted for 16.7% of total exports and 22.2% of total imports, Japan made up 12.2% of total exports and 20.9% of total imports. Recently, trading links with China have become increasingly important. In 2006, China replaced the US and Japan and became the largest export market; at the same time it also became South Korea’s second largest import source behind Japan. Furthermore, trade with members of ASEAN is also becoming increasingly important.
3.9 Taiwan

3.9.1 Economic structure

Taiwan has experienced three transformations of the economy. The first of the transformations happened in 1950s. The economy transited from an agrarian economy to rapid industrial development. Then it was followed by a boom of export-oriented industries in 1960s and 1970s, mainly producing cheap and labour-intensive consumer goods. Since the mid-1980s, the economy has concentrated on capital and technology-intensive industries, especially electrical goods and chemicals. Meanwhile, the services sector has grow more important. By 2006, the services sector’s share of GDP increased to 68.6% (from 39.6% in 1986). Whereas, the manufacturing sector’s share declined to 25.7% (from 47.3% in 1986).

3.9.2 Growth of GDP and its expenditure components

The economic growth rates of Taiwan were impressive in 1970s and 1980s. GDP growth averaged around 10.3% and 8.2% a year during the 1970s and 1980s, respectively. After a fall to 5.7% in 1990, GDP growth grew by an annual averaged of 7.4% between 1991 and 1994. The economy grew by 6.5% in 1995, down from 7.4% in 1994. This growth was supported by an acceleration in exports. In 1996, the economy sustained around 6.3% by a strong performance from net trade balance. Then it was slightly up to 6.6% in 1997 in real terms. This was largely attributed to the increasing gross fixed capital formation (from a modest rate of 1.8% in 1996 to 10.9% in 1997). Affected by the Asian Financial Crisis, Taiwan’s economy grew slowly by 4.6% in 1998 which was relatively minor compared with other affected economies. The economic recovery from the financial crisis was interrupted by the devastating earthquake on September 1999, hence it grew by just 5.6% year on year.

Private consumption grew comparably strong during the 1970s, 1980s and the first half of 1990s, with average annual rate of 8.9%. However, since 1995 private consumption growth has slowed. In comparison with 8.6% in 1994, private consump-
Figure 3.9: Taiwan: Annual growth rates of real GDP and GDP expenditure components in 1970-2006

Notes: Data source: DGBAS (2009)
tion rose by 5.6% in 1995, because of political uncertainty of the legislative and the presidential election. Private consumption increased by 6.7% in 1996, which relied on the strong performance of the stock market. In 1997, private consumption growth still increased by 7.1% despite of the Asian currency crises in October. This was followed by a continuous positive rate of 6.2% in 1998, although a decline in consumer confidence arose from the economic recession in the Asian countries. A continuous slowdown in private consumption dropped the growth rate to 5.5%, which was affected by the earthquake.

Taiwan’s investment accounts normally for over 20% of GDP’s share at current prices. For the period of 1970s, 1980s and the early period of 1990s, gross fixed capital formation increased remarkably. However, the situation was inverse afterwards. Fixed capital investment growth declined noticeably to 7.7% in 1994-95 from 18.7% in 1992, this resulted from weak investment by public sector. Then it rose by only 1.8% in 1996, due to the fall in business and consumer confidence as political uncertainty arose from the presidential election. Investment growth in 1997 was robust which rose by 10.9% and was attributed to the strong performance of the stock market. In 1998, investment grew in a slower but still strong rate by 8.9%, as a result of influences of the recession in the Asian regions. The fall in investment continued to decline in the first of three quarters of 1999, although it rose in the fourth quarter as growth in exports, hence, the overall investment growth rate was only 2.9% year on year.

Export growth has been very fluctuated over past decades. In the 1970s, export growth climbed robustly from a contracted rate of 6.6% in 1974 to a remarkable rate of 37.3% in 1976. During the 1980s, growth rose from a sluggish rate of 1.8% in 1982 to a strong rate of 18% in 1983-84, then went from a lower rate of 2% in 1985 to the highest rate of 28.6% in the following year, and finally settled down at 5% in 1989. In the 1990s, export growth was relatively slow but rather stable with the average annual growth rate of 7.7%. In the first half of the 1990s, export growth was exceptionally strong in 1991 and 1995 as it expanded by 13.5% and 12.6%,
individually. Export growth declined to 6.8% in 1996, because the exchange rate of Japanese yen against both the US dollar and the New Taiwan dollar depreciated, in turn, this suppressed growth of Taiwan’s exports. Exports were further depressed by the devaluation of currencies of Southeast Asian countries, specially light industrial exports. Even though, thanks to strong growth in heavy industrial exports, overall export growth was around 9.2% in 1997. In 1998, export growth eased further down to 2.8% year on year. However it rebounded robustly by 11.7% in 1999, it could actually be more rapid if the devastating earthquake did not happen. This rebound in exports in part was driven by the strong performance of the high-technology industrial exports, and was also because of the recovery of Asian economies.

Taiwan has limited natural resources, in order to keep up with large volume of export products, raw materials, industrial inputs and equipment depend on imports. In short, rapid growth of Taiwan’s exports is sustained by rapid growth of imports. Over past decades, Taiwan’s import growth seems to grow faster than export growth. This reflects that domestic demand, especially for consumer and capital goods, increases significantly. During the 1970s, import growth was extraordinary, the highest growth rate was 24% in 1976. Then it slowed cyclically during the 1980s, where it contracted at the lowest rate of 1.7% in 1982 and rose to the highest rate of 27.1% in 1987. Between 1990 and 1995, import growth fluctuated within the range from 3.6% to 15.5%. A fall in import growth to 6% in 1996, indicating reduced demand for consumer and industrial goods. Import growth rose by 13.6% in 1997, then slowed to 6.7% in 1998 which was due to the disruption of the Asian crisis. Strong export growth generated rising demand for imports as Taiwan firms increased demand for raw materials and industrial inputs, but this growth was slowed by the earthquake and finally up to 4.5% as a whole in 1999.

The economy was dragged by weak growth of domestic consumption due to the earthquake, at 5.8% in 2000. In 2001, economic growth fell further to a contracted rate of 2.2%, owing to a slowdown in the US economy and weak domestic demand. GDP picked up from the downturn of 2001 and expanded at 4.6% in 2002, which
was led by strong growth in exports. The outbreak of SARS affected the recovery of Taiwan’s economy, as a result, GDP growth was only 3.5% in 2003. In 2004, the economy recovered from all areas: a rise in export growth led to an increase in private investment, and further resulted in revival of consumer confidence. Thus, the economy grew by 6.2% in 2004. However, GDP growth slowed to 4.2% in 2005, and a slightly higher rate of 4.9% in 2006 which was held back by poor performance of domestic demand although export growth was high.

Private consumption growth was 4.6% in 2000, because of falling stock prices, rising unemployment rates and political uncertainty. Due to a downturn in the US economy and natural disasters (typhoon and flood), private consumption grew by just 0.7% in 2001. Private consumption was still weak and rose only by 2.6%, which was dragged by high unemployment and a downward trend in share prices in 2002. In 2003, private consumption was hurt by the outbreak of SARS, hence it grew by only 1.5% year on year. The performance of private consumption was boosted by the recovery in the economy, up to 4.5% in 2004. It expanded moderately by about 3% in 2005, as a result of decreasing unemployment and an improvement in the stock market. Credit restrictions were imposed by banks, led to private consumption dropped to 1.8% in 2006.

The growth rate of gross fixed capital formation regained by a strong rate of 9.2% in 2000. It was mainly driven by growth in private investment which a large proportion of this investment was invested on capital goods produced for overseas markets, while demand for Taiwan’s exports began to increase. The US economic downturn in 2001 hit the Taiwan’s investor confidence, thus investment decelerated sharply by 19.9%. Investment spending was sluggish and weak in 2002 about 1.1%. In 2003 investment was dragged by the SARS outbreak and the Iraq war which led to damp internal and external demand, consequently, it grew only 1.7%. The outstanding growth in investment resulted from the recovery in demand for Taiwan’s exports, it expanded by the fastest rate of 19.5% in 2004 for the past 12 years. Investment growth slowed at 1.2% in 2005 since rapid growth in 2004 was unsustainable.
Investment was pulled down partly by the decline in transport equipment investment and also by fragile business confidence stemmed from political uncertainty, in subsequence it grew by 0.9% in 2006.

Moreover, Taiwan was used to attract foreign investment in previous decades. Whereas, Taiwan has invested abroad markets rather than attracted investment in the domestic market in recent years. The US and Japan are the two largest investors of inward direct investment. On the other side, Taiwan has focused on investing directly across boundaries recently, primarily in the mainland of China and Southeast Asian countries, for example, Philippines, Malaysia, Thailand, Indonesia and Singapore. During the third transformation, Taiwan moved large share of the labour-intensive industrial production processes to the mainland in order to take the advantages of low costs, at the time as the island concentrated on producing capital and technology-intensive goods. Nevertheless, investment in the mainland is restricted due to political concerns by the Taiwan government. For this reason, the government promotes the "Go South" policy which encourages investors to invest in Southeast Asia, so as to diversify the markets of investment rather than to reduce the value of outward investment.

The performance of exports was incredible in 2000, it grew by 18.9%. Such extraordinary growth was as usual mainly due to strong demand for Taiwan's exports of electronic goods. In 2001, growth of exports was reversal, as growth contracted by 7.8%. It was pulled down by the shock to the US economy and the natural disaster (Typhoon Nari). Growth of Taiwan's exports expanded in 2002 by 10.6%, as it recovered from the contraction in 2001. Thereafter it continued to perform strongly at 10.4% in 2003, due to boosted demand of all categories of exports. Exports soared in 2004 and were back to the high expansion level that attained in 2000, with the growth rate of 14.4%. There was a fall in the growth rate of exports in 2005, where the rate was 7.6%. As usual, this was because of strong demand for machinery and electrical equipment. In 2006 exports grew higher than 2005 by 10.3%. These fluctuations in exports seem to suggest that Taiwan's exports
experience weaknesses of sectoral structure, since machinery and electric equipment take large share of exports.

A fast rise in the import growth rate with 15% in 2000. This was partly resulted from the high price of oil which in turn increased the cost of petroleum goods. In addition, export growth was still the main reason that drove imports. A disappointing performance of total imports in 2001 was the consequences of the fall in exports and weak domestic consumer demand. Thus, imports contracted by 13% so that imports were back to the level in 1999. Growth in imports in 2002 was moderate while it rose by 7.1%. This was because growth rates of import categories tended to offset each other. In 2003, import growth was relatively strong and rose by 8.1%, which stemmed from the rise in global oil prices. The performance of import growth was outstanding in 2004, as a consequence of rising oil prices and domestic investment. Hence, it rose by a rapid rate of 18.9%. These factors continued to accelerate growth in imports in 2005 up to 3.8%, in addition to a rise in consumer goods as the unemployment rate fell. Imports grew steadily in 2006 by 5.6% which were largely owing to high oil prices.

3.9.3 Trading structure and markets

Taiwan has run continuously trade surpluses since the 1980s. This is largely attributed to large surpluses in merchandise trade. When the Taiwan’s economy has transformed to export-oriented industries and has switched away from labour-intensive industry, exporting manufacturing goods becomes the primary source of Taiwan’s wealth, particularly, machinery and electronic products. However, trade in services is impeded by the merchandise trade and runs constantly deficits over time. In 2006, exports of services accounted for 13.1% of the total value of merchandise exports, and imports of services accounted for 16.7% of that of merchandise imports. Shipment, transportation and tourism are the major categories of the services account. This reveals that the significance of Taiwan’s leading position in the shipping industry.
Furthermore, as restrictions on exports and imports with mainland China are gradually relaxed, trade with the mainland grows at a fast speed. By 2006, the mainland was Taiwan's largest export market (which accounted for 23.1% of total exports) and replaced the US (which was 14.5% of the total and the third largest export market). Meanwhile, Hong Kong was the second largest export market (which accounted for 16.7% of the total). Additionally, part of exports was finally shipped to the mainland. Then it was followed by Japan (7.3%) and Singapore (4.1%). On the import side, Taiwan depended heavily on Japan's exports of machinery, equipment and consumer goods, therefore, Japan was Taiwan's largest import market (which supplied 22.8% of total imports in 2006). The mainland and the US were the second and third largest import sources, which were accounted for 12.2% and 11.2% of the total, respectively. South Korea was important supplier of capital goods, it supplied 7.4% of the total and followed behind the US.

3.10 Thailand

3.10.1 Economic policy and structure

The changes in the Thai economy are dramatic. In the 1960s, the government set up the Board of Investment (BOI) in the context of the import-substituting policy, with intention of stimulating both domestic and foreign investment which was shaded by high protectionism. The BOI concentrated mainly on the development of infrastructure which gave rise to the openness of new agriculture of cash crop cultivation and the provision of investment incentives for developing an import-substituting industrial sector. However, the skewness of focusing on infrastructure development discouraged growth of small firms and of technical innovation.

During the 1970s, Thailand came safely through the first oil price shock in 1973 and grew strongly until the second oil price shock in 1979. Nevertheless, a series of problems were revealed, including the growing underemployed labour force, the continual expanding gaps of development and wealth between the capital area,
Bangkok, and the surrounding regions, as well as the enlargement of the current account and budget deficits. The second oil crisis deepened these problems. Meanwhile, the government was persuaded that import-substituting policy with its favour of domestic orientation had pushed the limits of the domestic market. Under these circumstances, the government carried out structural adjustment that was represented by the Fifth Five-year National Development Plan (1981/82-1985/86). It included that reducing poverty in the rural areas; maintaining a balance between development and preservation; improving the balance of payments by increasing exports; strengthening energy preservation and extending alternative sources; reducing the fiscal deficit through increasing government revenue. The progress of adjustment was slow and inconsistent with the policy guidelines, but it was still successful, due to small foreign debt, consistent capital inflows and the absence of serious price and other distortions.

After a severe economic recession in 1984-85, the government began to implement fully the main objectives that set in the fifth plan and to promote the export-led policy. It was continued to undertake under the sixth (1985/86-1990/91) and seventh (1991/92-1995/96) plans, in addition to an increasing tendency of the role of the private sector involving in the national development. This shift in the economic policy contributed to high growth of the economy in 1986-95. Certainly, several favourable external factors also made contributions, such as weak oil prices, the strong yen, remittances from abroad and a boom in the tourism industry. Consequently, the fiscal balance ran consistently surpluses from 1988 to 1997; individual distortions were eliminated, especially, rice and energy prices achieved market levels; deregulation of the financial sector and the opening of the Bangkok International Banking Facility (BIBF) enhanced domestic savings and built up the availability of competitive corporate funds.

However, in spite of high growth rates, this structural adjustment is far from completion, and the government has paid a huge price for the failures of ignoring the necessity of structure reforms since 1996. Full concentration on industrial in-
Frastructure rather than human resource left industry with limitation of upgrading production with high value-added. Reliance on short-term capital inflows generated trade and payments imbalances, threatening the stability of the financial sector. Moreover, the continuation of fixing the exchange of the baht to the US dollar damaged the competitiveness of low-cost goods and worsened the gap between import-dependent high value-added exports. In the meantime, lack of sufficient regulations and supervision caused financial intermediaries and corporate entities to blindfold invest without careful consideration. Ultimately, overcapacity brought about falling rents and prices sharply so that many investments made losses. A step further, this led to growth in debt in both the financial and banking sectors, which set off the 1997 financial crisis. The sharp depreciation of the baht rose the cost of debt service, subsequently, the government had to seek for the help from the IMF.

Although the need for structural reforms grew and the government was successful of forcing some reforms, a gradual recovery in 1999-2000 cooled the passion of the government practicing reforms. The economic slowdown in 2001 re-emphasized the essentiality of structural reforms, but strong economic growth since 2002 has once again put off the government’s motivation of promoting reforms.

Fiscal policy had traditionally shown the nature of expansion, but high economic growth allowed high levels of revenue receipts which enabled the government to register surpluses until the 1997 economic crisis. Hence, free-spending public policies had generally been approved. According to the IMF agreement in 1997, the government had to run budget surpluses by trimming spending and increasing revenue. Nonetheless, the tight fiscal policies on already sluggish private activities further discouraged domestic demand and dragged the economy deeper down to the recession. At the same time, an extensive rise in interest rates made lots of debt-burden companies and banks to claim bankruptcy. Therefore, this led to a relaxation of fiscal policy in 1998. From 1997 to 2001/02, the government ran continual budget deficits. From 2002/03 to 2005/06, the government had managed to run small budget surpluses which were supported by strong growth in the economy.
The economy of Thailand has historically depended on exporting a limited variety of agricultural goods, but it has transformed significantly over the past decades. By the 1970s, the encouragement of investment activities had generated an import-substituting industrial sector. During the 1980s, Thailand started to develop an export-led manufacturing sector which was based on labour-intensive goods. Since 1990, high-technology products have become the fastest growth in industry. Although agriculture now only accounts for about 10% of GDP, there is no doubt that it is still important as Thailand still remain its leading position in agricultural exports. Industry accounts for 47% and services account for the rest. Furthermore, the capital region, Bangkok, is highly concentrated on industrial activity, leaving elsewhere underdeveloped.

3.10.2 Growth of GDP and its expenditure components

Economic growth of Thailand has been extraordinary over last three decades. In spite of the oil price shock in the early 1970s, average economic growth was around 7.5% per year. After 1978, economic growth was slowdown about 5.5% every year until 1986, owing to the country carried out structural adjustment to adapt the requirement of further economic development. After several years of slow growth, in the late 1980s, the Thai economy expanded robustly by an average rate of 11.7% per year in 1987-89. This outstanding economic performance was supported by vigorous growth in investment and exports.

In the first half of the 1990s, this impressive economic growth continued at the average annual rate of 9%, which was fueled by domestic demand that was reflected by rapid import growth, and exports. However, GDP growth started to decline since 1996, it fell to 5.9% in that year. On the expenditure side, household consumption and gross fixed capital formation were slowdown. Exports and imports both contracted by 5.5% and 0.6%, respectively. This was pulled down by Thai exports of traditional labour-intensive products as they were less competitive. At the same time, the services account was in deficit as well. Thus, this left an enlarged
Figure 3.10: Thailand: Annual growth rates of real GDP and GDP expenditure components in 1970-2006

*Notes: Data source: WB, World Development Indicators (2009)*
deficit of net trade. In the following years from 1997 to 1998, the economy contracted from a modest rate of 1.4% to a rapid rate of 10.5%. Private consumption and investment declined sharply during the period, in addition to higher import prices as the collapse of the baht, subsequently, import growth contracted by 21.6% in 1998. However, the depreciation of the baht pushed up growth of the export sector, on the other hand, the potential structural problems constrained export growth, so that it grew by just 8.2% a year. Meanwhile, the service account remained in deficit in 1997 but registered a surplus in 1998. As result, net exports ran a relative small deficit in 1997 and a surplus in 1998. In 1999-2000, Thai GDP growth recovered steadily by 4.4% and 4.8%, respectively, thanks to strong demand for manufactured exports and a slow recovery in domestic demand.

In 2001, economic growth slowed to 2.2%. This was partly owing to sluggish domestic demand, and was partly owing to a decline in exports in response to weak global demand, in particular in the US market. From 2002 to 2006, the Thai economy grew robustly from 5.3% in 2002, to a peak of 7% in 2003, then fell gradually to 4.5% in 2005 and finally rose by 5% in 2006. Exports continued to be one factor of driving the economic expansion, but during this period, domestic demand had also played an important role of expanding the economy. An increase in income and growing consumer confidence strengthened private consumption growth by 6.1% a year in 2002-04. At the same time, low interest rates and the restoration of business confidence, gross fixed capital formation growth averaged around 10.6% per year. Nonetheless, private consumption slowed to 4.5% in 2005 because of rising interest rates and further down to 3.2% in 2006 as a result of the unstable political environment. Investment growth also slumped sharply to 3.8% in 2006 from 10.6% in 2005, owing to rising interest rates and political unrest. However, thanks to relative strong growth in exports and a sharp reduction in imports, GDP growth in 2006 was still robust.
3.10.3 Trading structure and markets

Since the 1980s, while the economy has transformed to export-led development, foreign trade has increasingly played an important role in economic growth. Exports of goods and services accounted for 63% of current-price GDP in 2006 in comparison with 22% in 1984. This reveals that Thai exports have become more complicated and refined. Those traditional labour-intensive exports have been gradually lost their dominant position in exports since the mid-1990s. Meanwhile, Thailand has expanded new and high value-added production lines. However, those advanced export sectors have found that they are limited by the deficiency of required infrastructure and educated labour force which is not sufficient to compete with other competitors, such as Singapore and Malaysia. Additionally, manufactured goods have made up for almost 90% of total exports in recent years, in particular, computer components, electronic consumer goods and vehicles are leading exports. On the other side, imports of goods and services were equivalent to 62% of current-price GDP in 2006 compared to 26% in 1984. While Thailand has moved away from an agricultural to an industrial base, it has increasingly depended on importing intermediate and capital goods. Recently, imports of consumer goods have also increased sharply, which reflects a relief of long constrained demand in line with loose macroeconomic policy.

During the expansionary years in the 1990s, Thai investment and trade attached closer within the Asian region than the traditional developed markets (such as the US and the EU). Between 1995 and 1996, the ASEAN countries were the largest trading partner. But during the economic crisis in 1997-98, this trend reversed back to the traditional developed markets, the US and the EU. Since then, the ASEAN countries have become the largest buyer of Thai exports once again which accounted for 20.8% of total exports in 2006, due to strong economic growth and increasing regional integration. Furthermore, the share of exporting to the US declines slowly, it only accounted for 15% of total exports in 2006 in contrast to 22.2% in 2001, although it is still the largest single export market. Japan and China are the second
and third largest export markets, they made up of 12.7% and 9% of total exports in 2006 respectively. Then following by Singapore and Hong Kong, they accounted for 6.8% and 5.5%, individually. Moreover, Japan is the largest import partner providing 22.1% of total imports in 2006. Other important import suppliers include China and the ASEAN countries, making up of 10.6% and 18.4% of total imports in 2006, respectively.

3.11 Regional overview

To this point, we have sketched the overall picture of the economic structure and performance for each country and district in the sample for the last three decades. Growth in these countries and districts has been impressive despite the effect of the financial crisis in the late 1990s. For the period 1970-2006, real GDP growth varied between 3.15% (for Japan) and 9.18% (for China), and real GDP per capita growth varied between 1.31% (for Philippines) to 7.72% (for China) annually (see Table 3.1.) Differences in living standards among different economies are noteworthy. GDP per capita in 2006 varied from about US$2027 in China mainland to US$27709 in Hong Kong, and US$1635 in Indonesia to US$34253 in Japan, and US$18390 in South Korea to US$5989 in Malaysia and US$1363 in Philippines, and US$31028 in Singapore and US$16111 in Taiwan to US$3258 in Thailand. Accordingly, GDP per capita in Japan is 25 times greater than that in Philippines. Moreover, during the second half of the last century, these economies moved from low income level to middle income or even high income level.
Table 3.1: Average annual growth rates for selected East and Southeast economies

<table>
<thead>
<tr>
<th>Country</th>
<th>GDP</th>
<th>GDP per capita</th>
<th>C</th>
<th>I</th>
<th>G/GDP</th>
<th>EX</th>
<th>IM</th>
<th>Trade/GDP</th>
<th>CPI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hong Kong</td>
<td>6.55</td>
<td>4.9</td>
<td>6.24</td>
<td>6.54</td>
<td>7.65</td>
<td>10.56</td>
<td>11.08</td>
<td>236.14</td>
<td>4.83</td>
</tr>
<tr>
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<td>4.17</td>
<td>6.32</td>
<td>6.92</td>
<td>8.75</td>
<td>6.72</td>
<td>7.11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Japan</td>
<td>3.15</td>
<td>2.50</td>
<td>3.11</td>
<td>2.63</td>
<td>14.54</td>
<td>6.69</td>
<td>8.55</td>
<td>22.13</td>
<td>3.4</td>
</tr>
<tr>
<td>South Korea</td>
<td>6.99</td>
<td>5.74</td>
<td>6.14</td>
<td>9.14</td>
<td>11.63</td>
<td>15.42</td>
<td>10.37</td>
<td>64.32</td>
<td>8.51</td>
</tr>
<tr>
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<td>6.14</td>
<td>9.44</td>
<td>14.01</td>
<td>9.53</td>
<td>10.79</td>
<td>140.36</td>
<td>3.84</td>
</tr>
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<td>Philippines</td>
<td>3.78</td>
<td>3.78</td>
<td>3.9</td>
<td>4.3</td>
<td>10.14</td>
<td>7.66</td>
<td>6.53</td>
<td>67.39</td>
<td>11.39</td>
</tr>
<tr>
<td>Singapore</td>
<td>7.65</td>
<td>5.44</td>
<td>2.5</td>
<td>3.87</td>
<td>10.73</td>
<td>4.04</td>
<td>3.65</td>
<td>287.56</td>
<td>5.05</td>
</tr>
<tr>
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<td>7.48</td>
<td>2.3</td>
<td>7.34</td>
<td>8.57</td>
<td>12.71</td>
<td>13.92</td>
<td>10.79</td>
<td>77.59</td>
<td>0.77</td>
</tr>
<tr>
<td>Thailand</td>
<td>6.38</td>
<td>4.78</td>
<td>5.39</td>
<td>6.51</td>
<td>11.07</td>
<td>10.75</td>
<td>9.53</td>
<td>74.55</td>
<td>5.55</td>
</tr>
</tbody>
</table>

Notes: Most of the values are average percentage growth for the period of 1970-2006. Values for Singapore are calculated at current prices, except the GDP and the GDP per capita growth rates which are estimated on the basis of constant prices. Taiwan's GDP per capita growth is calculated at current prices. Data source: WB, World Development Indicators (2009), and IMF, IFS (2008).

The following points summarise the common macroeconomic characteristics among these economies.

1 Although these selected countries’ and districts’ economic performance is remarkable, most of them keep the inflation rate at a manageable level, with the exception of Indonesia and Philippines.

2 Government spending has also been maintained at a 'reasonable' size relative to overall GDP.

3 The carefully managed monetary and fiscal policies have provided a stable environment for economic development.

4 Table 3.1 also reports high levels of domestic investment, especially in the developing countries. This implies that the domestic savings rate in these economies is also considerably high. The high savings rate accompanied by high investment give rise to the possibility of sustaining rapid economic growth.

5 Except Japan and South Korea, most of economies have attracted sizeable amounts of foreign direct investment in order to assist their industrialisation transfor-
FDI opens up a technology transfer from the advanced economies to a country's own domestic underdeveloped industries.

Moreover, trade has been the engine of driving economic growth for these countries and districts for the past decades. Until now, trade is still the life support for some economies, for instance, the share of trade to GDP is 236.14% in Hong Kong, 140.36% in Malaysia, and 287.56% in Singapore. In some other economies, the share of trade weights also more than half of their GDP, such as Indonesia (51.41%), South Korea (64.32%), Philippines (67.59%), Taiwan (77.59%) and Thailand (74.55%). The region's economies promotes export-oriented industries in order to attain minimum efficient production scales. However, these economies diversify in the stages of development in line with the starting time of emerging to exports. Japan is the first country in the region who became known as an exporter in the 1960s. Then this was followed by Hong Kong, South Korea, Singapore and Taiwan in the 1970s. Indonesia, Malaysia, Philippines and Thailand pursued afterwards in the 1980s, and finally China emerged to exports in the 1990s. Therefore, Japan moved up from producing low price consumer goods to specialising in capital goods. The second followers took advantage of foreign technology which was transferred through the advanced economies moving their labour-intensive manufacturing processes to these economies, as a source of generating innovations in their own right. Consequently, these economies have successfully upgraded themselves to a higher chain of production. The rest of the economies played as subcontractors by producing labour-intensive goods at first in international trade. Eventually, they have turned into more sophisticated in producing components and intermediate goods for the first two initiators. This diversification in production processes across the different economies within the region, not only expanding economic scales but also strengthening the economic integration.

Meanwhile, this export-oriented growth strategy has not only increased the volume of trade but also has deepened the integration of trade among East and Southeast economies in recent decades. Table 3.2 and 3.2 report average trade share
(imports plus exports) of the the selected economies from 1990-2006. According to the table, the most noticeable change is trade share with China. Compared to the 1990s, all other economies increased substantially the shares of trade with China in 2000-2006, on average. Moreover, the percentages of intra-regional trade of all other economies with Japan were relatively high and stable over the period. Also, the levels of trade share of other 4 members of ASEAN with Singapore were comparably higher than other non-membership economies. Furthermore, the shares of intra-regional trade of these economies increased steadily for the last 17 years, in general.

Table 3.2: Average trade share from 1990 to 2006 (%)

<table>
<thead>
<tr>
<th>Partner economy</th>
<th>China</th>
<th>Hong Kong</th>
<th>Indonesia</th>
<th>Japan</th>
<th>Korea</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
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<td>NA</td>
<td>19.9</td>
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<td>1.2</td>
</tr>
<tr>
<td>Hong Kong</td>
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<tr>
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<td>1.5</td>
<td>NA</td>
</tr>
<tr>
<td>Japan</td>
<td>6.9</td>
<td>14.5</td>
<td>3.3</td>
<td>3.4</td>
<td>3</td>
</tr>
<tr>
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<td>3.6</td>
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</tr>
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</tr>
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<td>4.4</td>
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</tr>
<tr>
<td>Singapore</td>
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<td>5.8</td>
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</tr>
<tr>
<td>Taiwan</td>
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<td>11.4</td>
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</tr>
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<td>Thailand</td>
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<td>7.2</td>
<td>2.8</td>
<td>3.4</td>
<td>1.2</td>
</tr>
</tbody>
</table>

1 Available in 2003-06.  
2 Not available in 1990.

Data source: Asian Development Bank (ADB), Asian Regional Integration Centre (2010).

Table 3.3: Average trade share from 1990 to 2006 (%)

<table>
<thead>
<tr>
<th>Partner economy</th>
<th>Malaysia</th>
<th>Philippines</th>
<th>Singapore</th>
<th>Taiwan</th>
<th>Thailand</th>
</tr>
</thead>
<tbody>
<tr>
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</tr>
<tr>
<td>Hong Kong</td>
<td>1.3</td>
<td>1.7</td>
<td>0.7</td>
<td>1.2</td>
<td>3.8</td>
</tr>
<tr>
<td>Indonesia</td>
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<td>3.7</td>
<td>0.7</td>
<td>1.1</td>
<td>8.4</td>
</tr>
<tr>
<td>Japan</td>
<td>2.9</td>
<td>2.8</td>
<td>1.4</td>
<td>1.8</td>
<td>3.2</td>
</tr>
<tr>
<td>Korea</td>
<td>2.1</td>
<td>2.2</td>
<td>0.9</td>
<td>1.3</td>
<td>2.8</td>
</tr>
<tr>
<td>Malaysia</td>
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<td>NA</td>
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<td>2.1</td>
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</tr>
<tr>
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<td>NA</td>
<td>5</td>
</tr>
<tr>
<td>Singapore</td>
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<td>15.5</td>
<td>1.4</td>
<td>2.2</td>
<td>NA</td>
</tr>
<tr>
<td>Taiwan</td>
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<td>2.8</td>
<td>1.2</td>
<td>2.1</td>
<td>3.1</td>
</tr>
<tr>
<td>Thailand</td>
<td>3.7</td>
<td>5.3</td>
<td>0.8</td>
<td>1.8</td>
<td>8</td>
</tr>
</tbody>
</table>

Data source: Asian Development Bank (ADB), Asian Regional Integration Centre (2010).

However, it is a mixed picture of capital flows in the region as represented in
the tables. Table 3.4 and 3.5 present the average shares of FDI inflows. From 1990 to 2005, other economies increased extensively the amount of FDI to China, except Thailand. There were extraordinary increases in the average shares of FDI inflows from China and Thailand to Hong Kong between 2000 and 2005. In contrast, Thailand decreased FDI inflows to Singapore remarkably during the same period. In the meantime, Malaysia and Indonesia also lowered the shares of FDI inflows to Singapore. Moreover, the ASEAN economies rose FDI inflow shares to Hong Kong (apart from Philippines as the data was not available) in 2000-2005. Whereas, the shares of FDI inflows from other economies to Philippines (excluding Malaysia and Singapore) dropped slightly. It was also the case for Malaysia (with the exception of Philippines and Thailand).

Table 3.4: Average FDI inflows share from 1990 to 2005 (%)

<table>
<thead>
<tr>
<th>Partner economy</th>
<th>China</th>
<th>Hong Kong</th>
<th>Indonesia</th>
<th>Japan</th>
<th>Korea</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
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<td>NA</td>
<td>87.8</td>
<td>117.6</td>
<td>48.5</td>
</tr>
<tr>
<td>Hong Kong</td>
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<td>362.8</td>
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<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Japan</td>
<td>-0.2</td>
<td>0.02</td>
<td>1.5</td>
<td>1.2</td>
<td>0.3</td>
</tr>
<tr>
<td>Korea</td>
<td>0.3</td>
<td>4.9</td>
<td>0.2</td>
<td>0.4</td>
<td>0.4</td>
</tr>
<tr>
<td>Malaysia</td>
<td>0.5</td>
<td>0.1</td>
<td>3.3</td>
<td>2.9</td>
<td>19.8</td>
</tr>
<tr>
<td>Philippines</td>
<td>2.6</td>
<td>-0.0001</td>
<td>0.4</td>
<td>0.2</td>
<td>16.6</td>
</tr>
<tr>
<td>Singapore</td>
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<td>1.4</td>
<td>0.6</td>
<td>151.5</td>
</tr>
<tr>
<td>Thailand</td>
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<td>0.4</td>
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<td>2.3</td>
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</tr>
</tbody>
</table>

1 Available in 1998-99.
3 Available in 2000-04.
5 Not available in 2003.
7 Not available in 2000 and 2003.
8 Not available in 1990.
9 Not available in 2002.
11 Not available in 2004.
12 Not available in 2000.

Data source: Asian Development Bank (ADB), Asian Regional Integration Centre (2010). Notes: Data for Indonesia and Taiwan are not available.
Table 3.5: Average FDI inflows share from 1990 to 2005 (%)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
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<td>29.5</td>
<td>54.1</td>
<td>73.1</td>
<td>34.1</td>
<td>45.8</td>
<td>53.8</td>
<td></td>
<td>-81.4</td>
</tr>
<tr>
<td>Hong Kong</td>
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<td>24.0</td>
<td>-0.9</td>
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</tr>
<tr>
<td>Japan</td>
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<td>1.1</td>
<td>-0.4</td>
<td>1.9</td>
<td>1.5</td>
<td>3.9</td>
<td>-0.6</td>
<td>-11.8</td>
<td>-11.8</td>
</tr>
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<td>31.6</td>
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<td>0.1</td>
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</tr>
<tr>
<td>Malaysia</td>
<td>NA</td>
<td>NA</td>
<td>5.5</td>
<td>9.8</td>
<td>41.3</td>
<td>26.6</td>
<td>3.9</td>
<td>4.4</td>
<td></td>
</tr>
<tr>
<td>Philippines</td>
<td>0.4</td>
<td>0.4</td>
<td>NA</td>
<td>NA</td>
<td>1.4</td>
<td>1.7</td>
<td>0.6</td>
<td>0.4</td>
<td></td>
</tr>
<tr>
<td>Singapore</td>
<td>-3.7</td>
<td>-18.3</td>
<td>-18</td>
<td>46.1</td>
<td>NA</td>
<td>NA</td>
<td>13.8</td>
<td>-170</td>
<td></td>
</tr>
<tr>
<td>Thailand</td>
<td>2.3</td>
<td>2.4</td>
<td>2.4</td>
<td>4.7</td>
<td>12.7</td>
<td>22</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
</tbody>
</table>

1 Available in 1998.
2 Available in 2001-04.
3 Available in 1998.
5 Available in 1999.
6 Available in 2002-04.
8 Not available in 2003-04.
9 Not available in 1997 and 1999.
11 Not available in 2003.
12 Not available in 2003.
14 Not available in 1991.

Data source: Asian Development Bank (ADB), Asian Regional Integration Centre (2010). Notes: Data for Indonesia and Taiwan are not available.

What is more, Table 3.6 gives the average shares of intra-regional portfolio between 2001 and 2006. The largest share of portfolio investment in the table was made by Singapore to Malaysia which was 20% on average. The shares of intra-regional portfolio investment made by China to Hong Kong (7.8%), Singapore to Indonesia (8.8%), Hong Kong to Indonesia (5.2%), Hong Kong to Malaysia (5.1%), Hong Kong to Singapore (5.3%), Japan to Singapore (5%), Malaysia to Singapore (6.8%) and Singapore to Thailand (6.9%) were fairly high. Again, the shares of intra-regional portfolio investment between the members of ASEAN were generally higher than other non-member economies.

In the late 1990s, there was an unexpected and widespread economic crisis across Asian economies. In June 1997, the Thai government dispelled the commitment to saving a major finance company, Finance One, which triggered a large withdrawal of foreign funds and the speculative attack on the currency. On 2 July, the Thai baht was depreciated and this led to ‘contagion’ in the rest of East and Southeast
Table 3.6: Average portfolio share in 2001-2006 (%)

<table>
<thead>
<tr>
<th></th>
<th>China</th>
<th>Hong Kong</th>
<th>Indonesia</th>
<th>Japan</th>
<th>Korea</th>
<th>Malaysia</th>
<th>Philippines</th>
<th>Singapore</th>
<th>Taiwan</th>
<th>Thailand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hong Kong</td>
<td>7.8</td>
<td>NA</td>
<td>0.1</td>
<td>3.5</td>
<td>2.7</td>
<td>0.3</td>
<td>1.5</td>
<td>6.6</td>
<td>0.5</td>
<td>0.6</td>
</tr>
<tr>
<td>Indonesia</td>
<td>1.3</td>
<td>5.2</td>
<td>NA</td>
<td>0.4</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>Japan</td>
<td>0.3</td>
<td>0.4</td>
<td>0.02</td>
<td>NA</td>
<td>0.4</td>
<td>0.1</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>Korea</td>
<td>0.9</td>
<td>1.0</td>
<td>0.3</td>
<td>2.6</td>
<td>NA</td>
<td>1.0</td>
<td>0.4</td>
<td>1.3</td>
<td>0.4</td>
<td>0.1</td>
</tr>
<tr>
<td>Malaysia</td>
<td>0.2</td>
<td>5.2</td>
<td>1.3</td>
<td>1.6</td>
<td>3.1</td>
<td>NA</td>
<td>1.1</td>
<td>5.0</td>
<td>0.9</td>
<td>1.1</td>
</tr>
<tr>
<td>Philippines</td>
<td>0.3</td>
<td>2.5</td>
<td>0.1</td>
<td>0.3</td>
<td>0.8</td>
<td>1.9</td>
<td>NA</td>
<td>4.2</td>
<td>0.3</td>
<td>0.2</td>
</tr>
<tr>
<td>Singapore</td>
<td>1.9</td>
<td>5.3</td>
<td>2.1</td>
<td>5</td>
<td>4</td>
<td>6.8</td>
<td>0.7</td>
<td>NA</td>
<td>1.4</td>
<td>2.1</td>
</tr>
<tr>
<td>Thailand</td>
<td>0.4</td>
<td>4.2</td>
<td>2.6</td>
<td>0.9</td>
<td>1.3</td>
<td>1.4</td>
<td>0.1</td>
<td>5.9</td>
<td>0.1</td>
<td>NA</td>
</tr>
</tbody>
</table>

Data source: Asian Development Bank (ADB), Asian Regional Integration Centre (2010). Notes: Data for China and Taiwan are not available.
Asia. The currencies of Indonesia, Malaysia and Philippines were all devalued subsequently (as shown in Table 3.7, 3.8 and 3.9). Later on, both the local currencies of Taiwan and Singapore were forced to depreciate so as to maintain the stock of foreign reserves, despite the fact that they had sound economic fundamentals. The devaluation of the New Taiwan dollar did not lead to the depreciation of Hong Kong dollar whom is a competitive exporter, on account of its currency board system. On the contrary, another competitive exporter, South Korea, was inevitably affected.

The crisis became so severe (and within a very short period) that the GDP growth rates of all these economies that, up to that point, had experienced high economic growth plunged sharply; in particular, Indonesia and Thailand (-13.13% and -10.51% in 1998, respectively). The fall in GDP growth was accompanied by a rise in unemployment in all these economies (Table 3.10). Moreover, some of them also suffered an increase in inflation. In this case, Indonesia was the worst affected as its consumer prices jumped by 58.39% in 1998. Other than these, as we mentioned in the previous sections, consumption, investment, government spending and trade were also affected to some extent.

The unusual feature of this financial crisis is that it transmitted from a comparatively small economy (Thailand) to large economies, such as Japan. More accurately, the role of Japan in this crisis was twofold. Firstly, sluggish economic growth of Japan in the early 1990s reduced the demand for imports. Meanwhile, Japanese banks lent heavily to other foreign banks in these fast-growing Asian economies because of low interest rates in the domestic market. The recall of these foreign loans (after the Japanese increased the consumption tax) intensified vulnerability of Asian economies and aggravated the financial crisis. Secondly, the financial crisis also deteriorated the already weak economy of Japan.

The studies\(^3\) on the Asian financial crisis have offered a number of possible explanation as to what triggered a rapid and large withdrawal of foreign capital

Table 3.7: External sector from 1990 to 1998

|                      | China Average 90-96 | 97 | 98 | Average 90-98 | 97 | 98 | Average 90-98 | 97 | 98 | Average 90-98 | 97 | 98 | Average 90-98 | 97 | 98 | Average 90-98 |
|----------------------|---------------------|----|----|---------------|----|----|---------------|----|----|---------------|----|----|---------------|----|----|---------------|----|----|---------------|
| Current account (% of GDP) | 1.15                | 3.28 | 3.09 | -             | 4.4 | 1.1 | -2.40         | -2.27 | 4.29 | 2.35          | 2.37 | 3.08 |
| Inward FDI (US $ billions) | 22.33               | 44.24 | 43.75 | -             | -   | -  | 2.72         | 4.08 | -0.24 | 3.01          | 3.2  | 2.27 |
| Portfolio investment (US $ billions) | 1.29               | -0.94 | -0.73 | -2.88        | 22.06 | 2.08 | -0.63         | -1.18 | 13.17 | 23.13          | -29.17 | 3.08 |
| Export growth rate         | 20.56               | 22.93 | 7.16 | 11.08        | 4.51 | -4.46 | 0.6         | 7.8  | 11.18 | 4.66          | 11.17 | -2.71 |
| Nominal exchange rate (per US dollar) | 6.67               | 8.29 | 6.26 | 7.75         | 7.74 | 7.75 | 3094.55      | 2939.36 | 10012.82 | 11749.49        | 12029.99 | 130.91 |

Data source: IMF, IFS (2010).

*Not available in 1995.
<table>
<thead>
<tr>
<th></th>
<th>Korea</th>
<th>Malaysia</th>
<th>Philippines</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average 90-96</td>
<td>97</td>
<td>98</td>
</tr>
<tr>
<td><strong>Current account (as % of GDP)</strong></td>
<td>-1.61</td>
<td>-1.22</td>
<td>11.69</td>
</tr>
<tr>
<td><strong>Inward FDI (US $ billions)</strong></td>
<td>1.17</td>
<td>2.94</td>
<td>5.41</td>
</tr>
<tr>
<td><strong>Portfolio investment (US $ billions)</strong></td>
<td>7.48</td>
<td>14.38</td>
<td>1.25</td>
</tr>
<tr>
<td><strong>Exports growth rate</strong></td>
<td>13.26</td>
<td>21.58</td>
<td>16.05</td>
</tr>
<tr>
<td><strong>Nominal exchange rate (per US dollar)</strong></td>
<td>771.94</td>
<td>931.29</td>
<td>1401.44</td>
</tr>
</tbody>
</table>

*Data source: IMF, IFS (2010).*
Table 3.9: External sector from 1990 to 1998 (Cont.)

<table>
<thead>
<tr>
<th></th>
<th>Average 95-96</th>
<th>97</th>
<th>98</th>
<th>Average 95-96</th>
<th>97</th>
<th>98</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current account (% of GDP)</td>
<td>4.09</td>
<td>2.55</td>
<td>1.26</td>
<td>-3.46</td>
<td>-2</td>
<td>-2</td>
</tr>
<tr>
<td>Inward FDI (US $ billions)</td>
<td>1.31</td>
<td>2.25</td>
<td>0.22</td>
<td>2.05</td>
<td>3.85</td>
<td>7.31</td>
</tr>
<tr>
<td>Portfolio investment (US $ billions)</td>
<td>0.15</td>
<td>-7.7</td>
<td>-3.29</td>
<td>2.39</td>
<td>2.33</td>
<td>-3.08</td>
</tr>
<tr>
<td>Real GDP growth rate</td>
<td>2.12</td>
<td>2</td>
<td>-4.57</td>
<td>11.36</td>
<td>7.23</td>
<td>8.24</td>
</tr>
<tr>
<td>Nominal exchange rate (per US dollar)</td>
<td>36.93</td>
<td>28.7</td>
<td>33.48</td>
<td>25.31</td>
<td>31.56</td>
<td>41.55</td>
</tr>
</tbody>
</table>


### Table 3.10: Social indicators between 1996 and 1998

<table>
<thead>
<tr>
<th>Year</th>
<th>China</th>
<th>Hong Kong</th>
<th>Indonesia</th>
<th>Japan</th>
<th>Korea</th>
<th>Malaysia</th>
<th>Philippines</th>
<th>Singapore</th>
<th>Taiwan</th>
<th>Thailand</th>
</tr>
</thead>
<tbody>
<tr>
<td>96</td>
<td>2.32</td>
<td>3.1</td>
<td>6.23</td>
<td>1.37</td>
<td>4.55</td>
<td>3.49</td>
<td>7.51</td>
<td>5.59</td>
<td>2</td>
<td>0.4</td>
</tr>
<tr>
<td>97</td>
<td>2.81</td>
<td>5.9</td>
<td>6.23</td>
<td>1.77</td>
<td>4.45</td>
<td>2.65</td>
<td>5.59</td>
<td>2</td>
<td>0.3</td>
<td>0.5</td>
</tr>
<tr>
<td>98</td>
<td>-0.54</td>
<td>2.83</td>
<td>58.39</td>
<td>0.87</td>
<td>7.51</td>
<td>5.27</td>
<td>9.27</td>
<td>-0.27</td>
<td>1.68</td>
<td>8.07</td>
</tr>
<tr>
<td>99</td>
<td>3</td>
<td>2.8</td>
<td>4.4</td>
<td>3.4</td>
<td>2</td>
<td>2.5</td>
<td>7.4</td>
<td>3</td>
<td>2.6</td>
<td>1.1</td>
</tr>
</tbody>
</table>

**Note:** The GDP growth rates and Gini coefficients for China are not available for the years specified.

Date source: IMF, IFS (2010) and National statistics, Republic of China (Taiwan) (2010).
from the region, which in turn led to the collapse of the currencies and economic turmoil. The origins of the crisis are the shortcomings of the financial and the external sectors (Goldstein (1998) and Corsetti et al. (1999b)).

During the previous period, a large amount of foreign funds flowed into the region. High economic growth, extensive deregulation in the financial sector, the pegging of local currencies to the US dollar and the encouragement of borrowing from abroad by governments, in addition to low interest rates in Japan and the US and capital markets liberalisation in the developed countries, were the factors behind this. However, deregulation in the financial sector was accompanied by lenient supervision in these economies (except Hong Kong and Singapore). Under the stress of sustaining high-speed economic growth, governments assured customarily investment projects of favoured industries and firms or interfered in those troubled firms through banks that were owned or supported by governments, without assessing costs and risks. As a result, Indonesia, Malaysia, Philippines and Thailand (the ASEAN-4) experienced a lending boom in the 1990s. Such excessive bank lending was financed by external funds (for instance, from Japan and the US) which were taken on short maturities and foreign currency.

Furthermore, although high levels of lending indicated a large quantity of loans, the quality of many loans was considerably low. On the one hand, private loans tended to invest mainly in speculative sectors (for example, real estate) or industries with the potential problem of overload in the near future. On the other hand, public loans were largely invested in inefficient and low profitable projects. Consequently, this gave rise to a growing share of non-performing loans.

In the external sector, concerns arose from current account imbalances. Table 3.7 - 3.9 show clearly that in the 1990s the ASEAN-4 and Korea ran persistent and sizeable current deficits, corresponding to the high levels of capital inflows. First of all, apart from Korea and Taiwan, the currencies of the ASEAN-5 (the ASEAN-4 plus Singapore) and Hong Kong all appreciated in real terms. This implied a decline in competitiveness. Second, a remarkable deceleration in export growth
due to stagnation growth of the Japanese economy and a temporary fall in the demand of electronics in 1996 also had an adverse effect. Third, there was an increasing pressure of export competition from China. Fourth, there were worries about overproduction in some industries which were important to these economies. Finally, possible protectionism and the likelihood of a tight monetary policy in the US in 1997 might have put downward pressures on the external sectors of these economies.

After all, the weaknesses of the financial and the external sectors left these economies vulnerable to sudden changes in market expectations and confidence.

Since the 1990s, there has been an interesting development in these East and Southeast Asian economies, namely international reserves have increased significantly. In the early 1990s, Japan increased the holding of international reserves more than twofold. Shortly, the striking change in hoarding of international reserves occurred in the aftermath of the 1997-98 Asian financial crisis in China. Holdings of international reserves in China rose from 21.2 SDR billions in 1990 to 710.9 SDR billions in 2006. This sizeable change is illustrated in Figure 3.11, showing that its international reserves tripled between 2000 and 2006. During the same period, the holding of reserves in Japan, Korea, Singapore and Taiwan increased substantially as well.

The motivations of holding large-scale of international reserves are studied in numerous papers (such as Aizenman and Marion (2003), Aizenman and Lee (2007,2008), Dooley et al. (2005), Garcia and Soto (2004), Jeanne and Ranciere (2005)and Lee (2004)). In general, there are two explanations for this phenomenon: the precautionary demand/self-insurance and the mercantilist approach. The former views international reserves as a stabiliser against future sudden declines in output growth which are induced by potential adverse shocks. The latter considers the accumulation of international reserves as a by-product of development strategies of export promotion. Aizenman and Lee (2007) examine empirically the important roles of the two motives in holding international reserves by means of associated factors in de-
Figure 3.11: International reserves in 1990-2006 (SDR billions)

Notes: Data source: IFS, IMF (2010)
veloping economies. Empirical results find evidence of the precautionary approach. Specially, the degree of capital account liberalisation has an significantly positive effect on reserves holdings.

Additionally, Aizenman (2008) provides that hoarding international reserves plays as self-insurance in the role of stabilisation in the background of growing financial integration after the 1997 crisis. Nonetheless, the self-insurance motive fails to explain the trends after 2000. He argues that the recent trends are more than just self-insurance, which are accounted for competing the holding of reserves in order to improve competitiveness in exports in the light of the emerging decentralised global economic architecture.

Furthermore, Aizenman and Lee (2008) reexamine the existence of the mercantilist motive in the case of China, Japan and Korea. They suggest that financial mercantilism is the force behind the hoarding of reserves during the state of fast growth in Japan and Korea. However, financial mercantilism is related to growing financial fragility, which is likely to prevail during financial crises. Consequently, it can cause the hoarding of international reserves under the guideline of precaution. Moreover, monetary mercantilism may have been a way to maintain a competitive exchange rate during the difficult time of growth in the two countries. Nevertheless, it may result in competing hoarding of reserves, which drives away any competitive gains. Furthermore, in the case of China, financial mercantilism is one of impetuses of holding large reserves owing to greater adverse risks that are faced by China, although it has not gone through a dramatic decline in economic growth. Evidence of monetary mercantilism is ambiguous in China.

To sum up, the economic development of the selected economies in the region is impressive. Each economy is so different as an individual, while they seem to be integrated with each other through production, investment and trade within the region.
3.12 Final remarks

This chapter has provided a detailed background of the sample countries and districts in terms of their growth patterns, their policies and particular characteristics, as well as their openness to trade and foreign investment. This macroeconomic review has made it clear that these economies vary widely, as they are at different stages of development. This is explained by the fact that they adopted a market economy at different times. Japan started the development of its market economy in 1885, whereas other economies started after World War Two. The NIEs (Hong Kong, Singapore, South Korea and Taiwan) started off in the 1960s; they were followed by the initial ASEAN members (Indonesia, Malaysia, Philippines and Thailand), which set off in the 1970s, and finally pursued by China in the 1980s.

Since the late-1980s, these economies have faced a sequence of domestic and global challenges and have succeeded in maintaining high economic growth as either a single economic entity or the region as a whole. The driving force behind this rapid growth is the catching-up mechanism which the economy brings in new products through imports and matures domestic products in order to replace imports and then exports to overseas markets. Consequently, when the latecomers catch up, the starter reduces the share of the products and switches to reverse imports. The catching-up mechanism is also revealed by FDI by the starting economies, as they establish firms in the catching-up economies.

Through the combination of trade and investment, the linkages among the economies are becoming stronger. As a result, there is a great probability of the distinct economies sharing common business cycles. This underlying probability will be investigated in Chapter 5.
Several economic time series exhibit a cyclical property and aggregate economic activity is one of them, as the economy goes through recurrent periods of expansion and recession. Burns and Mitchell (1946) characterise the behaviour of business cycles in terms of the classification of states (revivals, expansions, contractions and recessions), the duration of states, the turning points of states and the amplitude of the cyclical swings. They suggest that the identification of these features is sufficient to understand the nature of business cycles. Defining these intrinsic asymmetries of the business cycle is imperative.

A wide range of linear and nonlinear time series models have been employed to sketch the characteristics of business cycles. Although the low order linear stochastic difference equations can imitate asymmetric behaviour of business cycles, it is not superior method to capture the features of business cycles. In actual fact, linear models (for example, autoregressive integrated moving averages (ARIMA) and vector autoregressive moving averages (VARMA)) can only mimic movements of business cycles when shocks are introduced; therefore, they are not appropriate to estimate these asymmetric characteristics of business cycles.
Non-linear models that can account for different behaviour of the series at different periods or points in time are more suitable for purposes of modelling the business cycle. The competitive non-linear models are threshold models (Tiao and Tsay 1994), smooth transition autoregressive models (STAR) (Teräsvirta and Anderson 1992) and Markov-switching (MS) models. The MS model has been widely employed to investigate the business cycle since Hamilton (1989) developed the univariate model with fixed transition probabilities (FTPs) to account for the cycle's asymmetric features.

In contrast to the FTP model, Durland and McCurdy (1994) expanded Hamilton's model by allowing transition probabilities to be duration-dependent (DDMS); and Filardo (1994) extended it to time-varying transition probabilities (TVTP) by incorporating economic indicators. Irrespective of how transition probabilities are modelled, the MS regression describes a process that is subject to discrete regime shifts and its dynamic behaviour is distinctively different across time. It makes inference about the timing and the nature of regime switching from the combination of all potential information that can be gathered over time (such as the past values of the observations, economic indicators).

Given the MS model’s attractive features for analysing the attributes of business cycles it is employed in this study to investigate the characteristics of business cycles in East and Southeast Asian countries and districts\(^1\). In this chapter, I discuss the FTP, the DDMS and the TVTP models in detail.

The outline of this chapter is as follows. The next section presents the basic framework of the three different MS models (FTP, TVTP and DDMS). Section 3 summarises the general procedures of the Expectation-Maximization (EM) algorithm that can be used to estimate these models and offers a discussion of parameter estimation that is obtained by the EM algorithm in the context of the FTP and TVTP models. Section 4 discusses the alternative Bayesian approach and the Gibbs-sampling method used in the estimation of the DDMS model. Section 5 pro-

\(^1\)The reason of dismissing the threshold and the STAR models is that they do not seem to produce acknowledged results about business cycles.
vides a summary of the empirical literature on modelling business cycles using the MS model (I also discuss the determination of the number of the states). Section 6 concludes the chapter.

4.1 Markov-switching models

4.1.1 The FTP model

The Markov-switching model with time-invariant transition probabilities was introduced by Hamilton (1989). He used this model to model the US real GNP series. It is successful in dating turning points and forecasting business cycles, given that it allows the variation in mean and the duration to capture unique characteristics possessed by a certain regime, and takes account of probabilities of switching among different regimes. Each discrete shift has its own process as identified by the Markov process. The most attractive feature of this model is that it does not require any prior information, for instance when the economy is in each regime. Next, the basic structure of the FTP model is outlined.

The regime generating process

The unobservable regime variable $S_t$ with a finite number of states $S_t = 1, 2, \ldots, M$ is governed by a discrete time, discrete state Markov stochastic process, which is defined by the transition probabilities $p_{ij}$

$$p_{ij} = Pr(S_t = j|S_{t-1} = i), \quad i, j = 1, 2, \ldots, M$$

(4.1)

$$Pr(S_t|S_{t-1}, S_{t-2}, \ldots, y_t, y_{t-1}, \ldots) = Pr(S_t|S_{t-1})$$

(4.2)

$$p_{i1} + p_{i2} + \cdots + p_{iM} = \sum_{j=1}^{M} p_{ij} = 1$$

(4.3)

where $y_t$ is the observation at time $t$, and $Pr(\cdot)$ represents the probability function.

Equation (4.1) denotes the probability that the system switches from regime
Methodology

$i$ to regime $j$, and equation (4.2) states that the probability distribution of $S_t$ is independent of past state values that beyond the value $S_{t-1}$ and is independent of $y_t, y_{t-1}, \ldots$. The final equation says that the sum of the transition probabilities of the $M$ states is 1.

Alternatively, (4.1) and (4.3) can be put in the following transition matrix notation

$$P = \begin{bmatrix}
    p_{11} & p_{12} & \cdots & p_{1M} \\
    p_{21} & p_{22} & \cdots & p_{2M} \\
    \vdots & \vdots & \ddots & \vdots \\
    p_{M1} & p_{M2} & \cdots & p_{MM}
\end{bmatrix}$$

where $i'_M P = i'_M$ with $i_M = \begin{pmatrix} 1 & 1 & \cdots & 1 \end{pmatrix}'$. It is normally assumed that the Markov process is ergodic\(^2\). Let $\xi_t$ denote a vector of $M \times 1$ ergodic or unconditional probabilities as

$$\xi_t = \begin{bmatrix}
    \Pr(S_t = 1) \\
    \vdots \\
    \Pr(S_t = M)
\end{bmatrix} = \begin{bmatrix}
    \xi_{1t} \\
    \vdots \\
    \xi_{Mt}
\end{bmatrix}$$

and $\xi_{mt} \in (0, 1)$.

It is important to notice that the transition probabilities as described above are time-invariant or fixed, so that the transition probabilities do not depend on how long the economy has been in regime $m$, or other sources of information which indicate the future movements of the economy.

Markov-switching models with fixed transition probabilities

The idea of the MS model is that the parameters which are used to generate the observed time series $y_t$ are subject to the unobservable regime variable $S_t$. Consider a finite $r$-th order autoregressive model with $M$-regime Markov-switching mean and

\(^2\)A stochastic process is ergodic if no sample helps meaningfully to predict values that are very far away in time from that sample, i.e. the time path of the stochastic process is not sensitive to initial conditions. A Markov process is said to be ergodic if exactly one of the eigenvalues of the transition matrix $P$ is unity and all other eigenvalues are inside the unit circle.
Methodology

variance

\[
(1 - \phi(L))(y_t - \mu_{S_t}) = e_t \quad e_t \sim NID(0, \sigma_{S_t}^2) \tag{4.4}
\]

\[
\mu_{S_t} = \mu_1 S_{1t} + \mu_2 S_{2t} + \cdots + \mu_M S_{Mt}
\tag{4.5}
\]

\[
\sigma_{S_t}^2 = \sigma_1^2 S_{1t} + \sigma_2^2 S_{2t} + \cdots + \sigma_M^2 S_{Mt}
\tag{4.6}
\]

where

\[
S_{mt} = \begin{cases} 
1 & \text{if } S_t = m \\
0 & \text{otherwise}
\end{cases}
\]

and \(\phi(L) = \phi_1 L + \phi_2 L^2 + \cdots + \phi_r L^r\).

Model (4.4) implies an immediate one-time jump in the mean after a shift in regime.

There are varieties of specifications for the MS model which are based on parameters that are conditioned on the regime generating process. If the mean is regime-variant as stated in equation (4.5), but the variance is regime invariant, i.e. variance is homogeneous, then equation (4.4) gives the Markov-switching mean (MSM) specification. If both the mean and the variance are regime-dependent, then the model is the Markov-switching mean heteroskedastic (MSMH) specification. Moreover, if equation (4.4) is specified in terms of the intercept rather than the mean we have

\[
(1 - \phi(L))y_t = u_{S_t} + e_t \quad e_t \sim NID(0, \sigma_{S_t}^2) \tag{4.7}
\]

\[
u_{S_t} = v_1 S_{1t} + v_2 S_{2t} + \cdots + v_M S_{Mt}
\tag{4.8}
\]

which implies that a regime shift in the mean approaches a new level smoothly. In this case, if the intercept term is varying with the regime but the variance is regime invariant, this gives the Markov-switching intercept (MSI) specification. If both the intercept and the variance are regime-dependent, then it is the Markov-switching intercept heteroskedastic (MSIH) specification. Furthermore, autoregressive coefficients can also be regime-dependent, and this gives additional Markov-switching
specifications. In the following sections models consider where the mean or the intercept is subject to regime shifts, the regime-dependent variance is considered as an additional characteristic, since those specifications are widely applied in the empirical research.

The Hamilton model

In this part, I discuss the Hamilton (1989) model. He uses a Markov-switching model with fourth-order autoregression and regime-dependent mean (MSM(2)-AR(4)) to estimate the US business cycle from 1953 to 1984. The regression model is as follows:

$$
\Delta y_t = \mu(S_t) + \phi_1[\Delta y_{t-1} - \mu(S_{t-1})] + \cdots + \phi_4[\Delta y_{t-4} - \mu(S_{t-4})] + \epsilon_t
$$

$$\epsilon_t \sim NID(0, \sigma^2)$$

$$\mu(S_t) = \begin{cases} 
\mu_1 > 0 & \text{if } S_t = 1 \quad \text{(Expansion or Boom)} \\
\mu_2 < 0 & \text{if } S_t = 2 \quad \text{(Contraction or Recession)}
\end{cases}$$

where $\Delta y_t$ is the logarithmic first difference of real GNP.

In the above model, the mean growth rate of real output depends on a stochastic unobserved regime variable $S_t$, which is represented by the dummy variables 1 and 2. Therefore, the growth rate of output switches between the regimes of expansion and contraction. Additionally, the variance $\sigma^2$ is constant in both regimes.

The transition probabilities $p_{ij}$ in the Hamilton model are given by

$$
P = \begin{bmatrix}
p_{11} & p_{12} \\
p_{21} & p_{22}
\end{bmatrix}
$$

which $p_{11}$ gives the probability of entering and staying in an expansion and $p_{22}$ denotes the probability of entering and continuing in a recession.
The MS-VAR model

In the following paragraphs, I outline the structure of the FTP model in the context of a vector autoregression. Consider the generalisation of a finite $r$th order autoregression of the equation (4.4) for the $K$-dimensional time series vector $y_t = \left( y_{t1} \ldots y_{tk} \right)'$, $t = 1, \ldots, T$.

$$y_t - \mu_{S_t} = \Phi_1(y_{t-1} - \mu_{S_{t-1}}) + \Phi_2(y_{t-2} - \mu_{S_{t-2}}) + \cdots + \Phi_r(y_{t-r} - \mu_{S_{t-r}}) + e_t; \quad (4.9)$$

this is known as the mean adjusted form of a vector autoregressive (VAR) model (MSM-VAR).

Alternatively, if the mean moves towards a new level smoothly after a shift from one state to another, the VAR process with a regime shift in the intercept term $\nu_{S_t}$ (MSI-VAR) is used

$$y_t = \nu_{S_t} + \Phi_1 y_{t-1} + \cdots + \Phi_r y_{t-r} + e_t \quad (4.10)$$

where in both cases, $e_t$ is normal distributed with a zero-mean and a variance-covariance matrix $\Sigma$, i.e. $e_t \sim NID(0, \Sigma_S)$, $\Phi$ is the matrix of autoregressive coefficients. Moreover, $\mu_{S_t}$ and $\nu_{S_t}$ remain the same as described by the equations (4.5) and (4.8). The unobservable realisation of the regime variable $S_t$ is already demonstrated early.

The two models have two components: 1) a linear autoregression represents the spill-over effects of country- or region-specific shocks; and 2) the regime-dependent mean growth rate represents large global shocks. Furthermore, if the variance-covariance is regime-dependent, changes in regimes can affect the correlation of the innovations $e_t$, and hence can alter the diffusion of country- or region-specific shocks and the regimes of the global business cycle simultaneously.
4.1.2 The DDMS model

In Chapter 2, we reviewed some papers on duration dependence using non MS models (Diebold and Rudebusch 1990, Sichel 1991, Diebold et al. 1993, Castro 2008). Durland and McCurdy (1994) extend the univariate MS autoregression model in the Hamilton’s (1989) model to allow state transition probabilities to be duration dependent. In the latter, Pelagatti (2005) extends the analysis to a multivariate duration-dependent MS model (DDMS). The present section reviews the fundamental structure of the DDMS model.

As usual, a time series is described by the following stochastic process

\[ y_t = \mu_0 + \mu_1 S_t + \sum_{i=1}^{P} \phi_i(y_{t-i} - \mu_0 - \mu_1 S_{t-i}) + e_t \quad e_t \sim NID(0, \sigma^2) \]  \hspace{1cm} (4.11)

where \( y_t \) is an observed variable, the unobservable state variable \( S_t \) is defined by the discrete values \((0,1)\), \( \phi \)s are autoregressive coefficients of a stable AR process, and \( e_t \) is a gaussian white noise with mean zero and variance \( \sigma^2 \).

With the intension of taking duration dependence into account, the extended state variables are defined as \((S_t, D_t)\) in this case, where \( D_t \) is the duration variable, which takes integer values and is summarised as

\[ D_t = \begin{cases} 
1 & \text{if } S_t \neq S_{t-1} \\
1 + d & \text{if } S_t = S_{t-1} \text{ and } d < \tau \\
d & \text{if } S_t = S_{t-1} \text{ and } d = \tau 
\end{cases} \]  \hspace{1cm} (4.12)

where \( d \) is the number of periods the economy has been in the current state, and \( \tau \) is the maximum length of the period that the economy can attain and is fixed to a prior variable.

It is assumed that \((S_t, D_t)\) is a first-order Markov-switching process with the
following state transition probabilities

\[
Pr[S_t = i | S_{t-1} = i, D_{t-1} = d] = p_i(d) \quad i = 0, 1 \quad (4.13)
\]

\[
Pr[S_t = j | S_{t-1} = i, D_{t-1} = d] = p_j(d) = 1 - p_i(d) \quad i \neq j \quad (4.14)
\]

\[
Pr[S_t, S_{t-1}, S_{t-2}, \ldots, D_{t-1}, D_{t-2}, \ldots] = Pr[S_t | S_{t-1}, D_{t-1}] \quad (4.15)
\]

Equation (4.13) declares that the state transition probability is a function of the inferred state in the previous period and the number of periods the economy has been in this state. Equation (4.14) represents the sum of all possible values of \( S_t \) must be equal to 1 at each time \( t \). Moreover, Equation (4.15) implies that the probability distribution of \( (S_t, D_t) \) is independent of \( (S_{t-k}, D_{t-k}) \) with \( k = 2, 3, \ldots \) beyond \( (S_{t-1}, D_{t-1}) \).

Accordingly, the finite state space at time \( t \) is given as

\[
\{(S_t = 0, D_t = 1), (S_t = 0, D_t = 2), \ldots, (S_t = 0, D_t = \tau),
(S_t = 1, D_t = 1), (S_t = 1, D_t = 2) \ldots, (S_t = 1, D_t = \tau)\}
\]

The advantage of this structure is that the inferred duration variable \( D_{t-1} \) absorbs the effects of long lags of the Markov states.

The complete transition probability matrix \( P \) is written as

\[
\begin{pmatrix}
0 & 0 & p_{00}(1) & 0 & 0 & 0 & \cdots & 0 & 0 \\
p_{01}(1) & 0 & 0 & 0 & 0 & \cdots & 0 & 0 & 0 \\
0 & p_{10}(1) & 0 & p_{11}(1) & 0 & 0 & \cdots & 0 & 0 \\
p_{01}(2) & 0 & 0 & 0 & p_{00}(2) & 0 & \cdots & 0 & 0 \\
0 & p_{10}(2) & 0 & 0 & 0 & p_{11}(2) & \cdots & 0 & 0 \\
\vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\
p_{01}(\tau - 1) & 0 & 0 & 0 & 0 & 0 & \cdots & p_{00}(\tau - 1) & 0 \\
0 & p_{10}(\tau - 1) & 0 & 0 & 0 & 0 & \cdots & 0 & p_{11}(\tau - 1) \\
p_{01}(\tau) & 0 & 0 & 0 & 0 & 0 & \cdots & p_{00}(\tau) & 0 \\
0 & p_{10}(\tau) & 0 & 0 & 0 & 0 & \cdots & 0 & p_{11}(\tau)
\end{pmatrix}
\]
Notice that when the economy reaches the maximum period \( \tau \) in a particular inferred state, the extra periods of staying in the same state have no impact on transition probabilities; formally

\[
(S_t = i, D_t = \tau)| (S_{t-1} = i, D_{t-1} = \tau) \quad i = 0, 1
\]

\[
(S_t = j, D_t = 1)| (S_{t-1} = i, D_{t-1} = \tau) \quad i \neq j \quad \text{and} \quad i, j = 0, 1
\]

For the purpose of simplifying the calculation process in the presentation of a model with \( p \)-order autoregression, the state variable can be redefined as

\[ S_t^* = (D_t, S_t, S_{t-1}, \ldots, S_{t-p}) \]

which gathers all the possible groupings of the state of the economy in the last \( p \) periods. When \( \tau \geq p \), the transition probability matrix \( P^* \) of the Markov chain \( S^* \) is a \( u \times u \) matrix, where \( u = 2(2^p + \tau - p - 1) \).

Furthermore, in order to reduce the number of estimated parameters, it is desirable to standardise transition probabilities. Functions that represent transition probabilities should satisfy several conditions. First, the values obtained from the functions must lie in the interval \((0,1)\). Second, all calculated possible values of \( S_t \) must sum to 1. Third, for the sake of performing statistical tests, it is useful to isolate the duration variable. Either a logistic (like Durland and McCurdy 1994) or a probit function satisfies these restrictions, in here, the latter form is employed.

First of all, consider the linear model

\[
z_t = (\beta_1 + \beta_2 D_{t-1})S_{t-1} + (\beta_3 + \beta_4 D_{t-1})(1 - S_{t-1}) + \varepsilon_t \quad \varepsilon_t \sim N(0,1) \quad (4.16)
\]

Then, define the latent variable \( z_t \) as

\[
Pr[z_t \geq 0|S_{t-1}, D_{t-1}] = Pr[S_t = 1|S_{t-1}, D_{t-1}] \quad (4.17)
\]

\[
Pr[z_t < 0|S_{t-1}, D_{t-1}] = Pr[S_t = 0|S_{t-1}, D_{t-1}] \quad (4.18)
\]
Therefore, it is straightforward to illustrate that

\[ p_{00}(d) = Pr[S_t = 0|S_{t-1} = 0, D_{t-1} = d] = \Phi(-\beta_3 - \beta_4 d) \] (4.19)

\[ p_{11}(d) = Pr[S_t = 1|S_{t-1} = 1, D_{t-1} = d] = 1 - \Phi(-\beta_3 - \beta_4 d) \] (4.20)

where \( \Phi(\cdot) \) is the standard normal cumulative distribution function.

Note that if both \( \beta_2 \) and \( \beta_4 \) equal to 0, then the process breaks down to the Hamilton model.

### 4.1.3 The TVTP model

Filardo (1994) has further extended the Hamilton model in the analysis of modelling business cycles by explicitly incorporating the values of leading economic indicators to business cycle states. In particular, he extends transition probabilities to be time-varying: shifts in regimes vary with movements in leading indicator variables. He points out three advantages of using the TVTP model. First of all, in the TVTP model transition probabilities either rise before the start of an expansion or a contraction or fall after reaching a peak or trough; thus, it gives more flexibility to classify asymmetric variations in regime switching. Second, the TVTP model extends the complexity of the persistence of business cycles. The persistence of business cycles is revealed by the autoregressive parameters and the transition probabilities. The allowance of the time-varying transition probabilities expands the character of the persistence. Third, the time-varying transition probabilities also imply inherently the variation in expected durations. The framework of the TVTP is discussed below.

As usual, let \( y_t \) denote aggregate output growth in period \( t \) and its mean growth rate depends on an unobservable state variable \( S_t \). Following Hamilton (1989), departures of output growth from its mean are captured by an autoregressive (AR) process of order \( r \):

\[ [1 - \phi(L)](y_t - \mu(S_t)) = \epsilon_t \] (4.21)
where

\[ \phi(L) = \phi_1 L + \phi_2 L^2 + \cdots + \phi_r L^r \]

\[ \varepsilon_t \sim N(0, \sigma^2) \]

\[ S_t \in (0, 1) \]

\[ \mu(S_t) = \begin{cases} 
\mu_0 & \text{if } S_t = 0 \\
\mu_1 & \text{if } S_t = 1 
\end{cases} \]

In this case, \( S_t = 1 \) denotes an expansion and \( S_t = 0 \) denotes a contraction. Furthermore, the state variable \( S_t \) is assumed to follow a first-order Markov process with the time-varying transition probabilities defined as

\[ p_{mn,t} = Pr[S_t = n | S_{t-1} = m, Z_{t-1}] \quad \text{where } m, n = 0, 1 \]

(4.22)

where \( z_t \) represents the history of the leading economic indicator variables\(^3\), \( Z_{t-1} = (z_{t-1}, z_{t-2}, \cdots) \). Moreover, \( p_{00,t} = 1 - p_{01,t} \) and \( p_{11,t} = 1 - p_{10,t} \). The probabilities of entering and remaining in regime 0 and regime 1 are \( p_{00,t} \) and \( p_{11,t} \) respectively. The probabilities of transiting from regime 0 to regime 1 or from regime 1 to regime 0 are \( p_{01,t} \) and \( p_{10,t} \) individually. From equation (4.22), the probability of the current regime is conditional on the lagged regime variable \( S_{t-1} \) as well as on the lagged leading indicator variables, \( Z_{t-1} \).

In addition, the time-varying transition probabilities require the leading indicator \( Z_{t-1} \) to fall within the open interval \((0,1)\) so as to assure a well-defined log-likelihood function and to gratify the necessary conditions for adopting the maximum likelihood (ML) method. Therefore, such as logit and probit functions are suitable applicants while they are flexible and have a reasonable economic interpretation. The adoption

\(^3\)The definition of a leading indicator is that it changes before the economy has changed. It can be used to predict and signal future economic movements.
of the former is the most prevailing as the TVTP function, such as Filardo (1994), Diebold et al. (1994), Simpson et al. (2001) and De Medeiros and Sobral (2007); whereas Kim and Yoo (1995) and Filardo and Gordon (1998) adopted the latter. In this chapter, I adopt the logit function for the transition probabilities, which are defined as

\[
p_{00,t} = \frac{\exp(\beta_{00} + \sum_{j=1}^{J_1} \beta_{0j} z_{t-j})}{1 + \exp(\beta_{00} + \sum_{j=1}^{J_0} \beta_{0j} z_{t-j})}
\]

\[
p_{11,t} = \frac{\exp(\beta_{10} + \sum_{j=1}^{J_2} \beta_{1j} z_{t-j})}{1 + \exp(\beta_{10} + \sum_{j=1}^{J_1} \beta_{1j} z_{t-j})}
\]

(4.23)

In this specification, when \( \beta_{0j} \) and \( \beta_{1j} \) are equal to zero, \( \beta_{00} \) and \( \beta_{10} \) are the constant transition probabilities in regime 0 and regime 1. In that case, we are back to the FTP model. Moreover, \( \beta_{0j} \) and \( \beta_{1j} \) are the coefficients on the lagged leading indicator variables that affect the transition probabilities of business cycle regimes.

Following these variations in the probabilities, it is also implied that the expected durations of business cycle regimes will vary from time to time. That is, at any time \( t \), the expected duration of a regime, \( D_t \), is computed as conditional on the current state \( S_t \); formally

\[
E(D_t | S_t = 0) = \sum_{t=1}^{\infty} d \times (1 - p_{00,t+d}) \prod_{i=1}^{d-1} p_{00,t+i}
\]

\[
E(D_t | S_t = 1) = \sum_{t=1}^{\infty} d \times (1 - p_{11,t+d}) \prod_{i=1}^{d-1} p_{11,t+i}
\]

(4.24)

where \( D_t = \{D_t | d = 1, 2, \cdots, \infty\} \) is the length of how long a regime persists, and \( p_{00,t+i} \) and \( p_{11,t+i} \) are the \( l \)-period-ahead forecast transition probabilities. As \( i \) gets large, these future transition probabilities gradually will converge to their
unconditional means, so the above equations become

\[ E(D_t|S_t = 0) = 1 \cdot (1 - P_{00,t}) + 2 \cdot (1 - P_{00,t+1})P_{00,t} + 3 \cdot (1 - P_{00,t+2})P_{00,t+1}P_{00,t} + \cdots \]

\[ \approx 1 + P_{00,t} + P_{00,t}P_{00,t+1} + \cdots + (P_{00,t} \cdots P_{00,t+i}) + A_1 P_{00} + A_2 P_{00} + \cdots \]

\[ = 1 + \sum_i \prod_{t=1}^{i} P_{00,t} + A_1 \left( \frac{1}{1 - P_{00}} \right) \]

\[ (4.25) \]

where \( p_{00,t+i} = \Pr[S_{t+i}|S_{t+i-1}, Z_{t+i-1}; \beta] \) and \( A_1 = \prod_{i=1}^{t} p_{00,i} \), given conditional forecasts \( Z_{t+i} \).

Similarly,

\[ E(D_t|S_t = 1) = 1 + \sum_i \prod_{t=1}^{i} p_{11,t} + A_2 \left( \frac{1}{1 - P_{11}} \right) \]

\[ (4.26) \]

where \( p_{11,t+i} = \Pr[S_{t+i}|S_{t+i-1}, Z_{t+i-1}; \beta] \) and \( A_2 = \prod_{i=1}^{t} p_{11,i} \).

In order to estimate the parameters described, equations (4.21) and (4.23) are jointly estimated by the EM algorithm. Therefore, the conditional density of \( y_t \) conditioned on past observations is the sum of the conditional joint density distribution of \( y_t \) and \( (S_t, S_{t-1}, \ldots, S_{t-r}) \), which is given as

\[ f(y_t|Y_{t-1}, Z_{t-1}) = \sum_{S_t=0}^{1} \cdots \sum_{S_{t-r}=0}^{1} f(y_t, S_t, S_{t-1}, \ldots, S_{t-r}|Y_{t-1}, Z_{t-1}) \]

\[ = \sum_{S_t=0}^{1} \cdots \sum_{S_{t-r}=0}^{1} f(y_t|S_t, S_{t-1}, \ldots, S_{t-r}, Y_{t-1}) \times \Pr[S_t, S_{t-1}, \ldots, S_{t-r}|Y_{t-1}, Z_{t-1}] \]

\[ = \sum_{S_t=0}^{1} \cdots \sum_{S_{t-r}=0}^{1} f(y_t|S_t, S_{t-1}, \ldots, S_{t-r}, Y_{t-1}) \times \Pr[S_t|S_{t-1}, Z_{t-1}] \Pr[S_{t-1}, \ldots, S_{t-r-1}|Y_{t-1}, Z_{t-2}] \]

\[ (4.27) \]
where $Y_{t-1} = (y_{t-1}, y_{t-2}, \ldots, y_1, y_{-1}, \ldots, y_{-r})$ and

$$f(y_t|S_t, \ldots, S_{t-r}, Y_{t-1}) = \frac{1}{\sqrt{2\pi}\sigma} \exp\left(\frac{-\left(y_t - \mu(S_t) - \phi(L)\mu(S_t)\right)^2}{2\sigma^2}\right)$$

Note that

$$Pr[S_t|S_{t-1}, S_{t-2}, \ldots, S_{t-r}, Y_{t-1}, Z_{t-1}] = Pr[S_t|S_{t-1}, Z_{t-1}]$$

by the assumption of the first-order Markov process.

The final line of equation (4.27) reveals how the information in aggregate output growth and economic indicator variables alters the model’s estimation both directly and indirectly by means of the inference of the past states. First, the information included in the time series of output growth, $y_t$ and its lagged values, affects directly the likelihood function via the normal density function $f(y_t|S_t, \ldots, S_{t-r}, Y_{t-1})$; alternatively, the lagged values of output growth influence indirectly the likelihood function through the information embodied concerns the distribution of the past states, i.e. $Pr[S_t, \ldots, S_{t-r-1}|Y_{t-1}, Z_{t-1}]$. Second, the leading indicator variables determine the transition probabilities directly, and the probability distribution of the past states indirectly.

Consequently, the log-likelihood function of the sample conditional density of $y_t$ is

$$L(\theta) = \ln f(Y_T|Y_A, Z_{T-1}; \theta) = \sum_{t=1}^{T} \ln f(y_t|Y_{t-1}, Z_{t-1}; \theta)$$

where $Y_A = (y_{t-1}, y_{t-2}, \ldots, y_1, y_{-1}, \ldots, y_{-r})$, $Y_T = (y_T, y_{T-1}, \ldots, y_1)$ and $Z_{T-1} = (z_{T-1}, z_{T-2}, \ldots)$. This function is maximized with respect to $\theta = (\mu, \phi, \sigma^2, p_{mn,t}, \beta)$, where $\mu = (\mu_0, \mu_1)'$, $\phi = (\phi_1, \phi_2, \ldots, \phi_r)'$, $\beta = (\beta_0j, \beta_1j)'$ and $j = 0, 1, 2, \ldots$, and is subject to the constraint that $p_{00} + p_{11} + \cdots + p_{MM} = 1$.

So far, I have discussed the basic framework of the three models. The features of business cycles (by Burns and Mitchell which mentioned in the introduction)
are explicitly expressed in all models. In the following section, I consider the EM algorithm as a way to estimate the parameters that we are interested in the FTP and TVTP models.

4.2 The EM algorithm

The EM algorithm was introduced by Dempster, Laird and Rubin (1977). The advantage of this method is its numerical robustness regarding to badly selected starting points: it can rapidly converge to a rational state of the likelihood surface. Moreover, in the case of unobserved regime switching, problems like multiple local maxima, essential singularities, local increases in the likelihood function and the non-concave likelihood surface may occur during the estimation procedure, the EM algorithm can find a logical interior solution for each subproblem.

Hamilton (1990) and Krolzig (1997a) discuss the EM algorithm to estimate unknown parameters which are denoted by a vector $\theta = (\mu_s, v_s, \phi_1, \ldots, \phi_r, \sigma_{\delta_s}^2, p_i)$ in the MS model. Maximum likelihood (ML) estimation of the model is performed with the EM algorithm which is introduced for models with missing observations or unobserved variables. The EM algorithm is an iterative estimation technique. Each iteration consists of two steps: an expectation step and a maximisation step. In brief, in the expectation step, the formation of the expectation of the unobserved variables is calculated by using the estimated parameters $\theta^{k-1}$ obtained from the $(k - 1)th$ iteration; in the maximisation step, the estimation of parameters of the model $\theta$ is derived from solutions of the first order condition of the likelihood function which condition on the expectation of unobserved variables that obtained in the last expectation step. According to these two steps, each EM iteration is updated and results to an increase in the value of likelihood function. The iteration continues until $\theta$ converges. In what follows I explain the above procedures in detail.
4.2.1 The FTP model

The expectation step

In the expectation step, we obtain the smoothed probabilities of the unobserved state $S_t$, i.e. $Pr(S_t|Y_T)$, where $Y_T = (y_1, y_2, \cdots, y_T)'$, and $t = 1, 2, \cdots T$. The calculation of these probabilities is using the filtered and the smoothed probabilities of the parameter estimators that are obtained from the last maximization step. In order to obtain $Pr(S_t|Y_T)$, we first of all need to calculate the filtered probability.

The filtered probability The filtered probability that is introduced by Hamilton (1989) makes inferences about the unobserved state $S_t$ conditional on the partial information set which consists of the history of the observed values of $y$ through date $t$, namely $Y_t = (y_t, y_{t-1}, \cdots, y_0, y_{-1}, \cdots, y_{1-r})'$. In other words, it calculates the probability of $S_t$ conditioned on $Y_t$, $Pr[S_t|Y_t]$.

We start with the AR(1) model with the switching mean, then for the AR($r$) case, it will be straightforward. To solve the problem, first of all, we need to compute the joint conditional probability of $S_t$ and $S_{t-1}$, i.e. $Pr[S_t = j, S_{t-1} = i|Y_{t-1}]$. To derive the desired output for $Pr[S_t|Y_t]$, the algorithm is as follows.

Step 1 $Pr[S_{t-1} = i|Y_{t-1}], i = 1, 2, \cdots, M$, is given at the beginning of time $t$, thus

$$Pr[S_t = j, S_{t-1} = i|Y_{t-1}] = Pr[S_t = j|S_{t-1} = i]Pr[S_{t-1} = i|Y_{t-1}] \quad (4.30)$$

where $Pr[S_t = j|S_{t-1} = i], i, j = 1, 2, \cdots, M$, are the transition probabilities given by (4.1). The equation says that the joint probability of state $j$ at time $t$ and state $i$ at time $t - 1$ given the information set up to time $t - 1$ is the product of the transition probability from state $i$ to state $j$ and the probability of the state is in regime $i$ at time $t - 1$ given information up to $t - 1$.

Step 2 Once $y_t$ is observed at the end of time $t$, calculate the joint conditional
Methodology

density distribution of \( y_t \) and \( (S_t, S_{t-1}) \)

\[
f(S_t = j, S_{t-1} = i, y_t | Y_{t-1}) = f(y_t | S_t = j, S_{t-1} = i, Y_{t-1}) \Pr[S_t = j, S_{t-1} = i | Y_{t-1}]
\]  
(4.31)

where

\[
f(y_t | S_t = j, S_{t-1} = i, Y_{t-1}) = \frac{1}{\sqrt{2\pi \sigma_S^2}} \exp\left\{- \frac{[(y_t - \mu_s) - \varphi_t(y_t - \mu_{s_{t-1}})]^2}{2\sigma_s^2}\right\}
\]  
(4.32)

Step 3 Calculate the marginal density function of \( y_t \) conditional on \( Y_{t-1} \) by integrating \( S_t \) and \( S_{t-1} \) out of the summation of the joint density of \( y_t, S_t \) and \( S_{t-1} \)

\[
f(y_t | Y_{t-1}) = \sum_{S_t=1}^{M} \sum_{S_{t-1}=1}^{M} f(y_t, S_t = j, S_{t-1} = i | Y_{t-1})
\]

\[
= \sum_{S_t=1}^{M} \sum_{S_{t-1}=1}^{M} f(y_t | S_t = j, S_{t-1} = i, Y_{t-1}) \Pr[S_t = j, S_{t-1} = i | Y_{t-1}]
\]  
(4.33)

Step 4 Thus

\[
\Pr[S_t = j, S_{t-1} = i | Y_t] = \Pr[S_t = j, S_{t-1} = i | Y_{t-1}, y_t]
\]

\[
= \frac{f(S_t = j, S_{t-1} = i, y_t | Y_{t-1})}{f(y_t | Y_{t-1})}
\]

\[
= \frac{f(y_t | S_t, S_{t-1}, Y_{t-1}) \Pr[S_t, S_{t-1} | Y_{t-1}]}{\sum_{S_t=1}^{M} \sum_{S_{t-1}=1}^{M} f(y_t | S_t, S_{t-1}, Y_{t-1}) \Pr[S_t, S_{t-1} | Y_{t-1}]} 
\]  
(4.34)

and

\[
\Pr[S_t = j | Y_t] = \sum_{S_{t-1}=1}^{M} \Pr[S_t = j, S_{t-1} = i | Y_t]
\]  
(4.35)

Iterating the above steps repeatedly for \( t = 1, 2, \cdots, T \).
It is worth to note that the initial start of the filter is calculated in a different way as follows

\[ Pr[S_0, S_{-1}|y_0, y_{-1}] = \rho_{S_0, S_{-1}} \]  \hspace{1cm} (4.36)

This initial probability is uncorrelated to \( P \) and \( \theta \). Moreover, its element sums up to unity and can also be estimated by the maximum likelihood method.

For the AR(\( r \)) process with the switching mean, calculating the joint conditional probability of \( y_t, S_t, S_{t-1}, \ldots, S_{t-r} \) as \( S_t, S_{t-1}, \ldots, S_{t-r} \) are included in the model.

**The smoothed probability**  The filtered probability uses information up to time \( t \) to estimate the unobserved state, however, this technique delivers limited information as observations are available up to time \( T \). Hence, the smoothed probability uses full-sample information to make inferences about \( S_t, t = 1, 2, \ldots, T \), mathematically, \( Pr[S_t = j|Y_T] \).

Unlike the filter iteration which is forward estimation from \( t = 1 \) to \( t = T \), the smoothed probability is backward iteration which starts from the end time point \( t = T \), and this algorithm is introduced by Kim (1994).

The smoothed inferences \( Pr[S_t = j|Y_T] \) can be obtained by deriving the joint probability of \( S_t = j \) and \( S_{t+1} = k \) based on full information. Mathematically,

\[ Pr[S_t = j, S_{t+1} = k|Y_T] = Pr[S_{t+1} = k|Y_T]Pr[S_t = j|S_{t+1} = k, Y_T] \]  \hspace{1cm} (4.37)

Define \( Y_{t+1,T} = (y_{t+1}, y_{t+2}, \ldots, y_T)' \), for \( t < T \), that is \( Y_{t+1,T} \) is a vector of observations from time point \( t+1 \) to \( T \). So the second term of (4.37) can be written as

\[
Pr[S_t = j|S_{t+1} = k, Y_T] = \frac{f(S_t = j, Y_{t+1,T}|S_{t+1} = k, Y_t)}{f(Y_{t+1,T}|S_{t+1} = k, Y_t)}
\]

\[
= \frac{f(Y_{t+1,T}|S_t = j, S_{t+1} = k, Y_t)Pr[S_t = j|S_{t+1} = k, Y_t]}{f(Y_{t+1,T}|S_{t+1} = k, Y_t)}
\]
Methodology

If $S_{t+1}$ is known, then $y_{t+1}$ reveals no information about $S_t$, in other words, $f(Y_{t+1}|S_{t+1} = k, S_t = j, Y_t) = f(Y_{t+1}|S_{t+1} = k, Y_t)$. Therefore, the above equation can be simplified to

$$\Pr[S_t = j | S_{t+1} = k, Y_T] = \Pr[S_t = j | S_{t+1} = k, Y_t]$$  \hspace{1cm} (4.38)

Substituting (4.38) into (4.37) and according to the filtered probability, it becomes

$$\Pr[S_t = j, S_{t+1} = k | Y_T] = \frac{\Pr[S_{t+1} = k | Y_T] \Pr[S_t = j | S_{t+1} = k, Y_T]}{\Pr[S_{t+1} = k | Y_T]}$$

$$= \frac{\Pr[S_{t+1} = k | Y_T] \Pr[S_t = j | Y_T] \Pr[S_{t+1} = k | S_t = j]}{\Pr[S_{t+1} = k | Y_T]}$$

(4.39)

So

$$\Pr[S_t = j | Y_T] = \sum_{k=1}^{M} \Pr[S_t = j, S_{t+1} = k | Y_T]$$ \hspace{1cm} (4.40)

Given $\Pr[S_T | Y_T]$ which is the last iteration of the filtered probability, iterating backwards for $t = T - 1, T - 2, \cdots, 1$, to obtain the smoothed probabilities, $\Pr[S_t | Y_T], t = T - 1, T - 2, \cdots, 1$.

The maximization step

For the sake of simplicity, consider a so-called Markov model of switching regression introduced by Goldfeld and Quandt (1973):

$$y_t = x_t \beta_{S_t} + e_t \quad e_t \sim NID(0, \sigma_{S_t}^2)$$ \hspace{1cm} (4.41)

$$\beta_{S_t} = \beta_1(1 - S_t) + \beta_2 S_t$$ \hspace{1cm} (4.42)

$$\sigma_{S_t}^2 = \sigma_1^2(1 - S_t) + \sigma_2^2 S_t$$ \hspace{1cm} (4.43)

$$\Pr[S_t = 1 | S_{t-1} = 1] = p_{11} \quad \Pr[S_t = 0 | S_{t-1} = 0] = p_{22}$$ \hspace{1cm} (4.44)
where $S_t = 0$ or 1, $x_t$ is exogenous or predetermined variable and is conditional on $S_{t-1}$ but $S_t$ is independent of $x_t$. Denote $\theta_1 = [\beta_1 \beta_2 \sigma_1^2 \sigma_2^2]'$ and $\theta_2 = \begin{bmatrix} p_{11} & p_{12} \\ p_{21} & p_{22} \end{bmatrix}'$, thus, $\theta = [\theta_1 \theta_2]'$. In addition, let $\bar{S}_T$ represents a vector of unobserved regime variables, i.e. $\bar{S}_T = \begin{bmatrix} S_1 & S_2 & \cdots & S_T \end{bmatrix}'$.

Therefore, the joint density function for $Y_T$ and $\bar{S}_T$ is given by

$$f(Y_T, \bar{S}_T; \theta) = f(Y_T|\bar{S}_T; \theta_1)p(\bar{S}_T; \theta_2) = \prod_{t=1}^{T} f(y_t|S_t; \theta_1) \prod_{t=1}^{T} Pr[S_t|S_{t-1}; \theta_2]$$

Consequently, the log-likelihood function is written as

$$\ln f(Y_T, \bar{S}_T; \theta) = \sum_{t=1}^{T} \ln[f(y_t|S_t; \theta_1)] + \sum_{t=1}^{T} \ln Pr[S_t|S_{t-1}; \theta_2] \quad (4.45)$$

According to Hamilton (1990), we maximize the expected log-likelihood function conditioned on $\theta^{k-1}$

$$Q(\theta^k; Y_T, \theta^{k-1}) = \int_{\bar{S}_T} \ln[f(Y_T, \bar{S}_T; \theta^k)] f(Y_T, \bar{S}_T; \theta^{k-1})$$

$$= \int_{\bar{S}_T} \ln[f(Y_T|\bar{S}_T; \theta_1)p(\bar{S}_T; \theta_2)] f(Y_T, \bar{S}_T; \theta^{k-1}) \quad (4.46)$$

where $\int_{\bar{S}_T} = \sum_{S_1} \sum_{S_2} \cdots \sum_{S_T}$.

Accordingly, taking the first order condition with respect to $\theta_1$

$$\frac{\partial Q(\theta^k; Y_T, \theta^{k-1})}{\partial \theta_1} = \int_{\bar{S}_T} \frac{\partial \ln[f(Y_T|\bar{S}_T; \theta_1)]}{\partial \theta_1} f(Y_T, \bar{S}_T; \theta^{k-1}) = 0$$

\(^4\text{Parameter superscripts stand for iterations.}\)
Divide both sides of the above equation by \( f(Y_T; \theta^{k-1}) \), it gives

\[
\int_{\tilde{S}_T} \frac{\partial \ln[f(Y_T|\tilde{S}_T; \theta_1)]}{\partial \theta_1} f(Y_T, \tilde{S}_T; \theta^{k-1}) = 0
\]

\[
\int_{\tilde{S}_T} \frac{\partial \ln[f(Y_T|\tilde{S}_T; \theta_1)]}{\partial \theta_1} P_T[\tilde{S}_T|Y_T; \theta^{k-1}] = 0
\]

\[
\int_{\tilde{S}_T} \sum_{t=1}^{T} \frac{\partial \ln[f(y_t|S_t; \theta_1)]}{\partial \theta_1} P_T[\tilde{S}_T|Y_T; \theta^{k-1}] = 0
\]

\[
\sum_{t=1}^{T} \sum_{S_t=0}^{1} \frac{\partial \ln[f(y_t|S_t; \theta_1)]}{\partial \theta_1} P_T[S_t|Y_T; \theta^{k-1}] = 0
\] (4.47)

where \( \ln f(y_t|S_t = j; \theta_1) = \frac{1}{2} \ln(2\pi) - \frac{1}{2} \ln \sigma_j^2 - \frac{1}{2} \frac{(y_t - x'_t \beta_j)^2}{\sigma_j^2} \) and \( P_T[S_t|Y_T; \theta^{k-1}] \) is the smoothed probability.

Next, taking the first order condition of equation (4.46) with respect to \( \theta_2 \)

\[
\frac{\partial Q(\theta^k; Y_T, \theta^{k-1})}{\partial \theta_2} = \int_{\tilde{S}_T} \frac{\partial \ln[p(\tilde{S}_T; \theta_2)]}{\partial \theta_2} f(Y_T, \tilde{S}_T; \theta^{k-1})
\]

\[
= \int_{\tilde{S}_T} \sum_{t=1}^{T} \frac{\partial \ln P_T[S_t|\tilde{S}_{t-1}; \theta_2]}{\partial \theta_2} f(Y_T, \tilde{S}_T; \theta^{k-1})
\] (4.48)

More specifically, given equation (4.47), the first-order condition with respect to the coefficients \( \beta_j \) and the variances \( \sigma_j^2 \) \((j = 0, 1)\) are calculated by

\[
\sum_{t=1}^{T} \sum_{S_t=0}^{1} \frac{\partial \ln[f(y_t|S_t; \theta_1)]}{\partial \beta_j} p(S_t|Y_T; \theta^{k-1})
\]

\[
= \sum_{t=1}^{T} \frac{x'_t(y_t - x'_t \beta_j)}{\sigma_j^2} p(S_t = j|Y_T; \theta^{k-1}) = 0
\]

\[
\beta_j^k = \frac{\sum_{t=1}^{T} x_t y_t p(S_t = j|Y_T; \theta^{k-1})}{\sum_{t=1}^{T} x_t^2 p(S_t = j|Y_T; \theta^{k-1})}
\] (4.49)
Likewise, given equation (4.48), for a particular transition probability $p_{ij}$

\[
\int_{\mathcal{S}_T} \sum_{t=1}^{T} \frac{\partial \ln P_r[S_t|S_{t-1}; \theta_2]}{\partial p_{ij}} f(Y_T, \tilde{S}_T; \theta^{k-1})
= \int_{\mathcal{S}_T} \left\{ \sum_{t=1}^{T} \frac{\partial \ln P_r[S_t = j|S_{t-1} = i; \theta_2]}{\partial p_{ij}} \right. \\
\left. \times \delta_{[S_t = j, S_{t-1} = i]} \right\} f(Y_T, \tilde{S}_T; \theta^{k-1})
\]

where $\delta_{[S_t = j, S_{t-1} = i]}$ is the Kronecker delta$^5$.

Notice that

\[
\frac{\partial \ln P_r[S_t = j|S_{t-1} = i; \theta_2]}{\partial p_{ij}} = \frac{1}{p_{ij}}
\]

and

\[
\int_{\mathcal{S}_T} \delta_{[S_t = j, S_{t-1} = i]} f(Y_T, \tilde{S}_T; \theta^{k-1}) = P_r[S_t = j, S_{t-1} = i|Y_T; \theta^{k-1}] f(Y_T; \theta^{k-1})
\]

where

\[
f(Y_T; \theta^{k-1}) = \int_{\mathcal{S}_T} f(Y_T, \tilde{S}_T; \theta^{k-1})
\]

$^5\delta_{[A]} = 1$ if the event $A$ occurs and 0 otherwise.
Substituting equations (4.52) and (4.53) into (4.51), hence

\[
\frac{\partial Q(\theta^k; Y_T, \theta^{k-1})}{\partial p_{ij}} = \frac{1}{p_{ij}} \sum_{t=1}^{T} Pr[S_t = j, S_{t-1} = i|Y_T; \theta^{k-1}] f(Y_T; \theta^{k-1})
\]  

(4.54)

Given the constraint (4.3), applying the Lagranian

\[
Q(\theta^k; Y_T, \theta^{k-1}) - \lambda_j \left( \sum_{S_t=0}^{1} p_{ij} - 1 \right)
\]

Then taking the first-order condition with respect to \( p_{ij} \)

\[
\frac{\partial Q(\theta^k; Y_T, \theta^{k-1})}{\partial p_{ij}} p_{ij} = \lambda_j \text{ for } j = 0, 1
\]

Substituting this into (4.54)

\[
\sum_{t=1}^{T} Pr[S_t = j, S_{t-1} = i|Y_T; \theta^{k-1}] = \frac{p_{ij} \lambda_j}{f(Y_T; \theta^{k-1})}
\]

(4.55)

Summing both sides of the above equation for \( j = 0, 1 \)

\[
\sum_{t=1}^{T} \sum_{S_t=0}^{1} Pr[S_t = j, S_{t-1} = i|Y_T; \theta^{k-1}] = \sum_{S_t=0}^{1} \frac{p_{ij} \lambda_j}{f(Y_T; \theta^{k-1})}
\]

(4.56)

Simplifying this equation using (4.3) and (4.40)

\[
\sum_{t=1}^{T} Pr[S_{t-1} = i|Y_T; \theta^{k-1}] = \frac{\lambda_j}{f(Y_T; \theta^{k-1})}
\]

(4.57)

Substituting equation (4.57) into (4.55) yields

\[
p_{ij}^k = \frac{\sum_{t=1}^{T} Pr[S_t = j, S_{t-1} = i|Y_T; \theta^{k-1}]}{\sum_{t=1}^{T} Pr[S_{t-1} = i|Y_T; \theta^{k-1}]}
\]

(4.58)
4.2.2 The TVTP model

Now, according to Hamilton’s (1989) paper for the fixed transition probability model the EM algorithm is adopted for estimating the unknown parameters of the log-likelihood function. The basic procedures are briefly stated as follows:

1 Start with the initial values $\theta^{(0)}$.

2 Obtain the smoothed state probabilities

$Pr[S_t|Y_T, Z_{T-1}; \theta^{(l-1)}] \quad \forall t$

$Pr[S_t, S_{t-1}, \cdots, S_{t-r}|Y_T, Z_{T-1}; \theta^{(l-1)}] \quad \forall t$

...to construct the expectation of the log-likelihood function $E \ln f(Y_T|Y_A, Z_{T-1}; \theta^{(l-1)})$.

3 Obtain updated parameter estimates $\theta^t = \arg \max E \ln f(Y_T|Y_A, Z_{T-1}; \theta^{(l-1)})$.

4 Repeat the iterations for $t = 2, \cdots, T$ until the estimation converges.

The expectation step

To calculate the smoothed state probabilities, conditioned on the parameter estimates from previous iteration, $\theta^{l-1}$, we first of all start with the calculation of the filtered probabilities.

The filtered probability Given $\theta^{l-1}$, the complete observations of $y$ and $z$ through date $t$, the algorithm for obtaining the filtered state probabilities for the $l$th iteration is as follows

1 Calculate the joint conditional probability distribution of $(S_t, S_{t-1}, \cdots, S_{t-r})$ given the available information at time $t - 1$.

$Pr[S_t, S_{t-1}, \cdots, S_{t-r}|Y_{t-1}, Z_{t-1}; \theta^{l-1}] = Pr[S_t|S_{t-1}, Z_{t-1}] \times Pr[S_{t-1}, \cdots, S_{t-r-1}|Y_{t-1}, Z_{t-2}; \theta^{l-1}]$
Methodology

where the first term in the righthand side of the equation is the transition probability given by (4.22) and the second term of that is the filtered joint probability which is obtained from the previous iteration.

2 Calculate the joint conditional density of $y_t$ and $S_t, S_{t-1}, \ldots, S_{t-r}$ conditional upon $Y_{t-1}$ and $Z_{t-1}$ as soon as $y_t$ is observed

$$f(y_t, S_t, S_{t-1}, \ldots, S_{t-r}|Y_{t-1}, Z_{t-1}; \theta^{t-1})$$

$$= f(y_t|S_t, S_{t-1}, \ldots, S_{t-r}, Y_{t-1}; \theta^{t-1})$$

$$\times Pr[S_t, S_{t-1}, \ldots, S_{t-r}|Y_{t-1}, Z_{t-1}; \theta^{t-1}]$$

where the conditional density function $f$ is given by eq(4.28), and the second term in the righthand side of the equation is given by Step 1.

3 Obtain the marginal conditional density of $y_t$

$$f(y_t|Y_{t-1}, Z_{t-1}; \theta^{t-1}) = \sum_{S_t=0}^{1} \cdots \sum_{S_{t-r}=0}^{1} f(y_t, S_t, S_{t-1}, \ldots, S_{t-r}|Y_{t-1}, Z_{t-1}; \theta^{t-1})$$

4 Then, calculating the updated joint state probability distribution at time $t$, this gives the filtered joint state probability of $(S_t, S_{t-1}, \ldots, S_{t-r})$ which is the $r+1$ most recent values of $S$ given all observations on $y$ through time $t$

$$Pr[S_t, S_{t-1}, \ldots, S_{t-r}|y_t, Y_{t-1}, Z_{t-1}; \theta^{t-1}]$$

$$= \frac{f(y_t, S_t, S_{t-1}, \ldots, S_{t-r}|Y_{t-1}, Z_{t-1}; \theta^{t-1})}{f(y_t|Y_{t-1}, Z_{t-1}; \theta^{t-1})}$$

where the numerator is given by Step 2 and the dominator is given by Step 3.

5 Furthermore, the filtered marginal state probability is obtained from summing the probability values of $(S_t, S_{t-1}, \ldots, S_{t-r})$ that are corresponding to all the
possible valuations of \((S_{t-1}, \ldots, S_{t-r})\)

\[
Pr[S_t|Y_t, Z_{t-1}; \theta^{-1}] = \sum_{S_{t-1}=0}^{1} \cdots \sum_{S_{t-r}=0}^{1} Pr[S_{t}, S_{t-1}, \ldots, S_{t-r}|Y_t, Z_{t-1}; \theta^{-1}]
\]

where \(Y_t = (y_t, y_{t-1}, \ldots, y_{r})\).

The above steps are iterated from \(t = 2\) through \(T\). Additionally, these filtered state probabilities are used as inputs of calculating the filtered probabilities for the next time period.

The smoothed probability Recall that the smoothed probabilities infer the values of the unobserved state variable \(S_t\) using all the information in the sample, \(Y_T\) and \(Z_{T-1}\). The derivation of the smoothed probabilities is obtained by the following steps.

1 Run the filtered joint state probabilities for \(t = 2, 3, \ldots, T\) and save the results of \(Pr[S_t, S_{t-1}, \ldots, S_{t-r}|Y_t, Z_{t-1}; \theta^{-1}]\) and \(f(y_t|Y_{t-1}, Z_{t-1}; \theta^{-1})\)

2 Compute the joint state probability of \((S_r, \ldots, S_{t-r}, S_t, \ldots, S_{t-r})\) conditional on \(Y_t\) and \(Z_{t-1}\), for \(\tau = t + 1, t + 2, \ldots, T\)

\[
Pr[S_r, \ldots, S_{t-r}, S_t, \ldots, S_{t-r}|Y_T, Z_{T-1}; \theta^{-1}]
\]

\[
= \frac{f(y_T, S_r, \ldots, S_{t-r}, S_t, \ldots, S_{t-r}|Y_{t-1}, Z_{t-1}; \theta^{-1})}{f(y_T|Y_{t-1}, Z_{t-1}; \theta^{-1})}
\]

\[
= \frac{1}{f(y_T|Y_{t-1}, Z_{t-1}; \theta^{-1})} \times f(y_T|S_r, \ldots, S_{t-r}, Y_{t-1}; \theta^{-1})
\]

\[
\times Pr[S_r, \ldots, S_{t-r}, S_t, \ldots, S_{t-r}|Y_{t-1}, Z_{t-1}; \theta^{-1}]
\]

\[
= \frac{1}{f(y_T|Y_{t-1}, Z_{t-1}; \theta^{-1})} \times f(y_T|S_r, \ldots, S_{t-r}, Y_{t-1}; \theta^{-1})
\]

\[
\times Pr[S_r|S_{t-1}, Z_{t-1}; \theta^{-1}]
\]

\[
\times Pr[S_{t-1}, \ldots, S_{t-r-1}, S_t, \ldots, S_{t-r}|Y_{t-1}, Z_{t-2}; \theta^{-1}]
\]
where $Y_T = (y_T, y_{T-1}, \cdots, y_{-r})$ and $Z_{T-1} = (z_{T-1}, z_{T-2}, \cdots)$. In addition, the first term of the final output is the result saved by Step 1, the second and the third terms of that are already given by equations (4.28) and (4.22), and the last term is obtained from the previous computation of this step. Notice that when $\tau = t + 1$, the last term becomes $Pr[S_t, S_{t-1}, \cdots, S_{t-r} | Y_t, Z_{t-1}; \theta^{l-1}]$ which is given by Step 4 of the filtered probability.

For each $\tau$ value and for each possible sequence of $(S_t, \cdots, S_{t-r})$, this step is repeatedly computed upon to $\tau = T$.

3 Once $\tau = T$ is reached, the smoothed joint state probability at time $t$ under the chosen sequence of $(S_t, \cdots, S_{t-r})$ is obtained from

$$Pr[S_t, \cdots, S_{t-r} | Y_T, Z_{T-1}; \theta^{l-1}] = \sum_{S_T=0}^{1} \cdots \sum_{S_{T-r}=0}^{1} Pr[S_T, \cdots, S_{T-r}, S_t, \cdots, S_{t-r} | Y_T, Z_{T-1}; \theta^{l-1}]$$

4 Thus, the smoothed marginal state probability is calculated as

$$Pr[S_t | Y_T, Z_{T-1}; \theta^{l-1}] = \sum_{S_{t-1}=0}^{1} \cdots \sum_{S_{t-r}=0}^{1} Pr[S_t, \cdots, S_{t-r} | Y_T, Z_{T-1}; \theta^{l-1}]$$

These smoothed state probabilities are used as inputs for the computation of the maximisation step, which we will demonstrate in the next section.

The maximisation step

Given the log-likelihood function (4.29), the maximum likelihood estimates are parameterised by $\theta$ and are regarding to a distribution conditioned on $\theta^{l-1}$ as the states are not realised

$$Q(\theta^l, Y_T, Z_{T-1}; \theta^{l-1}) = \int_{\theta_T} \left[ \log f(Y_T, \tilde{S}_T | Z_{T-1}; \theta^l) \right] f(Y_T, \tilde{S}_T | Z_{T-1}; \theta^{l-1}) \, d\theta_T$$

(4.59)
where \( f \) refers to the sum of all possible values of the states for the whole sample, and \( \mathcal{S}_T = (S_T, S_{T-1}, \cdots, S_1) \).

For a particular value of \((S_t, \cdots, S_{t-r})\), the logarithm of (4.28) is given as

\[
\log f(y_t|S_t, \cdots, S_{t-r}, Y_{t-1}) = -\frac{1}{2} \log(2\pi) - \frac{1}{2} \log(\sigma^2) - \frac{\{y_t - \mu(S_t) - \phi(L)[y_t - \mu(S_t)]\}^2}{2\sigma^2}
\]  

(4.60)

Therefore, the first order conditions of (4.59) with respect to \( \mu \), \( \phi \) and \( \sigma^2 \) are obtained as follows, \( i = 0, 1 \)

\[
\begin{align*}
\frac{\partial Q(\theta^i; Y_T, Z_{T-1}, \theta^{i-1})}{\partial \mu} &= \int_{\mathcal{S}_T} \frac{\partial \log \{f(Y_T|Y_{T-1}, \tilde{S}_T; \theta^i)Pr[\tilde{S}_T|Z_{T-1}; \theta^i]\}}{\partial \mu} \\
&\times f(Y_T, \tilde{S}_T|Z_{T-1}; \theta^{i-1}) \\
&= \int_{\mathcal{S}_T} \frac{\partial \log \{f(Y_T|Y_{T-1}, \tilde{S}_T; \theta^i)\}}{\partial \mu} \times f(Y_T, \tilde{S}_T|Z_{T-1}; \theta^{i-1}) \\
&= \int_{\mathcal{S}_T} \sum_{t=1}^{T} \frac{\partial \log f(y_t|Y_{t-1}, S_t, \cdots, S_{t-r})}{\partial \mu} \times f(Y_T, \tilde{S}_T|Z_{T-1}; \theta^{i-1}) \\
&= 0
\end{align*}
\]

Follow the law of conditional probability \(^6\), dividing both sides of the above equation by \( f(Y_T|Z_{T-1}; \theta^{i-1}) \), it becomes

\[
\int_{\mathcal{S}_T} \sum_{t=1}^{T} \frac{\partial \log f(y_t|Y_{t-1}, S_t, \cdots, S_{t-r})}{\partial \mu} \times Pr[\tilde{S}_T|Y_T, Z_{T-1}; \theta^{i-1}) \\
= \sum_{t=1}^{T} \sum_{S_t=0}^{1} \cdots \sum_{S_{t-r}=0}^{1} \frac{\partial \log f(y_t|Y_{t-1}, S_t, \cdots, S_{t-r})}{\partial \mu} \times Pr[S_t, \cdots, S_{t-r}|Y_T, Z_{T-1}; \theta^{i-1}] \\
= 0
\]

\(^6\)This law states that the probability of \( A \) given \( B \) is the ratio of a joint probability of \( A \) and \( B \) to a marginal probability of \( B \), mathematically, \( P(A|B) = \frac{P(A \text{and} B)}{P(B)} \).
Hence, for a specified value of \((S_t, \ldots, S_{t-r})\), we have

\[
\frac{\partial Q(\theta^t; Y_T, Z_{T-1}, \theta^{t-1})}{\partial \mu} = \sum_{t=1}^{T} \sum_{S_t=0}^{1} \cdots \sum_{S_{t-r}=0}^{1} \frac{[(1 - \phi(L))(y_t - \mu(S_t))]}{\sigma^2} \times Pr[S_t, \ldots, S_{t-r}|Y_T, Z_{T-1}; \theta^{t-1}] = 0
\]

So

\[
\mu_t^i = \frac{\sum_{t=1}^{T} [y_t - \phi(L)(y_t - \mu(S_t))] \cdot Pr[S_t, \ldots, S_{t-r}|Y_T, Z_{T-1}; \theta^{t-1}]}{\sum_{t=1}^{T} Pr[S_t, \ldots, S_{t-r}|Y_T, Z_{T-1}; \theta^{t-1}]} \tag{4.61}
\]

Likewise,

\[
\frac{\partial Q(\theta^t; Y_T, Z_{T-1}, \theta^{t-1})}{\partial \phi}
= \sum_{t=1}^{T} \sum_{S_t=0}^{1} \cdots \sum_{S_{t-r}=0}^{1} \frac{[(1 - \phi(L))(y_t - \mu(S_t))]}{\sigma^2} \cdot (y_t - \mu(S_t)) \times Pr[S_t, \ldots, S_{t-r}|Y_T, Z_{T-1}; \theta^{t-1}]
= 0
\]

\[
\phi_k^i = \frac{\sum_{t=1}^{T} (y_{t-k} - \mu(S_{t-k}))(y_t - \mu(S_t)) \cdot Pr[S_t, \ldots, S_{t-r}|Y_T, Z_{T-1}; \theta^{t-1}]}{\sum_{t=1}^{T} (y_{t-k} - \mu(S_{t-k}))^2 Pr[S_t, \ldots, S_{t-r}|Y_T, Z_{T-1}; \theta^{t-1}]} \tag{4.62}
\]

where \(k = 1, 2, \ldots, r\).
And

\[
\frac{\partial Q(\theta; Y_T, Z_{T-1}, \theta^{-1})}{\partial \sigma^2} = \sum_{t=1}^{T} \sum_{s_{t-1}=0}^{1} \sum_{s_{t-r}=0}^{1} \left\{ -\frac{1}{2\sigma^2} + \frac{[(1 - \phi(L))(y_t - \mu(S_t))]^2}{2\sigma^4} \right\} \\
\times Pr[S_t, \cdots, S_{t-r} | Y_T, Z_{T-1}; \theta^{-1}] \\
= 0
\]

\[
\sigma^2 \beta_{ij}^t = \frac{\sum_{t=1}^{T} [(1 - \phi(L))(y_t - \mu(S_t))]^2 Pr[S_t, \cdots, S_{t-r} | Y_T, Z_{T-1}; \theta^{-1}]}{\sum_{t=1}^{T} Pr[S_t, \cdots, S_{t-r} | Y_T, Z_{T-1}; \theta^{-1}]} \tag{4.63}
\]

The details of the derivation of \( \beta \) are presented in the paper of Diebold et al. (1994), hence, the final results are demonstrated in here which are:

\[
\beta_{0j}^t = \left\{ \sum_{t=2}^{T} z_{t-1} Pr[S_{t-1} = 0 | Y_T, Z_{T-1}; \theta^{-1}] \frac{\partial p_{00,t}(\beta_{0j})}{\partial \beta_{0j}} \right\}^{-1} \\
\times \sum_{t=2}^{T} z_{t-1} \left\{ Pr[S_t = 0, S_{t-1} = 0 | Y_T, Z_{T-1}; \theta^{-1}] - Pr[S_{t-1} = 0 | Y_T, Z_{T-1}; \theta^{-1}] \right\} Pr_{00,t}(\beta_{0j}^{-1}) - \frac{\partial p_{00,t}(\beta_{0j})}{\partial \beta_{0j}} \beta_{0j}^{-1} \right\}
\tag{4.64}
\]

\[
\beta_{1j}^t = \left\{ \sum_{t=2}^{T} z_{t-1} Pr[S_{t-1} = 1 | Y_T, Z_{T-1}; \theta^{-1}] \frac{\partial p_{11,t}(\beta_{1j})}{\partial \beta_{1j}} \right\}^{-1} \\
\times \sum_{t=2}^{T} z_{t-1} \left\{ Pr[S_t = 1, S_{t-1} = 1 | Y_T, Z_{T-1}; \theta^{-1}] - Pr[S_{t-1} = 1 | Y_T, Z_{T-1}; \theta^{-1}] \right\} Pr_{11,t}(\beta_{1j}^{-1}) - \frac{\partial p_{11,t}(\beta_{1j})}{\partial \beta_{1j}} \beta_{1j}^{-1} \right\}
\tag{4.65}
\]

In summary, in this section, I have discussed how to use the EM algorithm
together with the filtered and smoothed probabilities to obtain the maximum likelihood estimates of the model’s parameters. From the above procedures, it can be seen that every EM iteration goes through the filtered and smoothed probabilities and is followed by an updated of the first order conditions and the parameter estimates until the iteration converges to a fixed point that coincides with the optimum values of the likelihood function.

4.3 Bayesian inference and Gibbs-sampling

In the Bayesian analysis, the unknown parameters of the model are treated as random variables and take the form of probability statement. These probability distributions outline the information status about the model’s parameters. Bayesian estimation incorporates a analyst’s knowledge about the possible values of the parameters before observing the data which is represented by a prior distribution, with the information contained in the data once it has been observed. The final outcome of the probability distribution of these unknowns is called a posterior distribution.

Often, Bayesian estimation involves the derivation of the marginal posterior distributions of single parameters from integration of a joint posterior distribution of the model’s all unknown parameters. Sometimes, these calculations are difficult to solve. Therefore, the Gibbs-sampling approach is adopted to resolve these difficulties.

The general idea of the Gibbs-sampling method is described in short. Given a set of all \( k \) unknown parameters of the model \( \Theta \), let \( \theta_i \) denote an element of the set \( \Theta \) and \( \theta_{-i} \) be the set without \( \theta_i \), i.e. \( \theta_{-i} = (\theta_1, \theta_2, \cdots, \theta_{i-1}, \theta_{i+1}, \cdots, \theta_k) \). Hence, the Gibbs-sampling technique is to obtain the full conditional posterior distribution \( p(\theta_i|\theta_{-i}, Y) \) without deriving the joint or marginal posterior distribution, where the elements of \( \theta_{-i} \) are substituted with the most updated values and \( Y = (y_1, y_2, \cdots, y_T) \). In brief, the steps of the Gibbs-sampling are:

1. Given a random starting values of \( (\theta_1^0, \theta_2^0, \cdots, \theta_k^0) \).
2 Draw $\theta_1^1$ from $p(\theta_1^1|\theta_2^0, \ldots, \theta_k^0, Y)$.

3 Then draw $\theta_2^1$ from $p(\theta_2^1|\theta_1^1, \theta_3^0, \ldots, \theta_k^0, Y)$.

4 And so on.

k Lastly draw $\theta_k^1$ from $p(\theta_k^1|\theta_1^1, \theta_2^1, \ldots, \theta_{k-1}^1, Y)$ to finish one iteration.

The $k$ steps are repeated $J$ times until the values converge to their stationary distributions. Meanwhile, in order to reduce the impact of the arbitrary initial values, the first $L$ iterations are discarded.

Now, the Bayesian and the Gibbs-sampling techniques are used to derive the variables of interest in the model described in Section 4.1.2, $\Theta = (\mu, \phi, \sigma^2, \beta, \{(S_t, D_t)\}_{t=1}^{T})$, where $\mu = (\mu_0, \mu_1)$, $\phi = (\phi_1, \ldots, \phi_p)$ and $\beta = (\beta_1, \ldots, \beta_4)$.

### 4.3.1 Prior distributions

The prior knowledge about the parameters $\Theta$ are represented by a natural conjugate prior. The advantage of natural conjugate prior is that when it is merged with the likelihood function, the posterior distribution has the same form as the prior distribution.

The prior joint distribution of $\Theta^0$ is given as

$$p(\mu, \phi, \sigma^2, \beta, (S_0, D_0)) = p(\mu)p(\phi)p(\sigma^2)p(\beta)Pr(S_0, D_0)$$

where

$$\mu \sim N(m_0, M_0)$$

$$\phi \sim N(a_0, A_0)$$

$$p(\sigma^2) \propto \frac{1}{\sigma^2}$$

$$\beta \sim N(b_0, B_0)$$
and \( Pr(S_0, D_0) \) represents a prior probability value of the Markov process \((S_t, D_t)\) taking account of the every possibility of each element.

### 4.3.2 Conditional distributions and the Gibbs sampling

Given the prior values for \( \Theta^0 \), values of \( \Theta^i, i \geq 1 \), are generated by using the multi-move Gibbs sampler, which is promoted by Carter and Kohn (1994).

**Step 1 Generation of \( \{S^*_t\}_{t=1}^T \)**

The process of generating \( S^*_t, t = 1, 2, \cdots, T \), from the following joint conditional distribution

\[
p(S^*_1, \cdots, S^*_T | \mu, \phi, \sigma^2, \beta, Y_T)
\]

where \( Y_T = (y_1, \cdots, y_T) \).

Suppressing the conditioning on the model’s parameters from the full conditional distribution, consider the following statement

\[
Pr(S^*_1, \cdots, S^*_T | Y_T) = Pr(S^*_1 | Y_T) Pr(S^*_2 | S^*_1, Y_T) \cdots Pr(S^*_T | S^*_T-1, Y_T)
\]

\[
= Pr(S^*_1 | Y_T) Pr(S^*_2 | S^*_1, Y_T) \cdots Pr(S^*_T | S^*_T-1, Y_T)
\]

\[
= Pr(S^*_1 | Y_T) Pr(S^*_2 | S^*_1, Y_{T-1}) \cdots Pr(S^*_T | S^*_T-1, Y_{T-2}) \cdots Pr(S^*_1 | S^*_2, Y_1)
\]

\[
= Pr(S^*_1 | Y_T) \prod_{i=1}^{T-1} Pr(S^*_i | S^*_{i+1}, Y_i)
\]

where \( Y_t = (y_1, \cdots, y_t) \).

Equation (4.66) from line 4 to line 5 reveals the Markov property of \( S^*_t \) that, for instance, given the condition on \( S^*_T-1 \) and \( Y_{T-2} \), \( S^*_T \) and \( Y_T \) have no information about \( S^*_T-2 \) beyond that included in \( S^*_T-1 \) and \( Y_{T-2} \). Thus the subsequent stages are adopted:
Stage 1 Use Hamilton’s (1989) basic filter to obtain \( Pr(S_t^*|Y_t), t = 1, \cdots, T. \)

1. Employ the input as given by the output from the last iteration \( Pr[S_{t-1}, \cdots, S_{t-p-1}, D_{t-1}|y_{t-1}, \cdots, y_1] \) to obtain

\[
Pr[S_t, S_{t-1}, \cdots, S_{t-p}, D_{t-1} = d|y_{t-1}, \cdots, y_1] = Pr[S_t|S_{t-1}, D_{t-1}]
\times Pr[S_{t-1}, \cdots, S_{t-p}, D_{t-1}|y_{t-1}, \cdots, y_1]
\]

where the first term from the second line is the transition probability.

2. Use the outcome obtained above to calculate the joint conditional distribution once \( y_t \) is observed

\[
f(y_t, S_t, S_{t-1}, \cdots, S_{t-p}, D_{t-1}|y_{t-1}, \cdots, y_1)
= f(y_t|S_t, S_{t-1}, \cdots, S_{t-p}, y_{t-1}, \cdots, y_1)
\times Pr[S_t, S_{t-1}, \cdots, S_{t-p}, D_{t-1}|y_{t-1}, \cdots, y_1]
\]

where the first term on the right side is the state-dependent likelihood of \( y_t \) and is stated as

\[
\frac{1}{\sigma \sqrt{2\pi}} \exp\left\{ -\frac{1}{2\sigma^2} [y_t - \mu_0 - \mu_1 S_t - \sum_{i=1}^{p} \phi_i(y_{t-i} - \mu_0 - \mu_1 S_{t-i})]^2 \right\}
\]

3. Calculate the conditional likelihood of \( y_t \) by integrating out \( S_t, \cdots, S_{t-p-1} \) and \( D_{t-1} \), using Equation (4.68)

\[
f(y_t|y_{t-1}, \cdots, y_1)
= \sum_{S_t=0}^{1} \sum_{S_{t-p}=0}^{1} \sum_{D_{t-1}=0}^{1} f(y_t, S_t, \cdots, S_{t-p}, D_{t-1}|y_{t-1}, \cdots, y_1)
\]

(4.69)
Methodology

4. Hence the joint conditional distribution of \( S_t, \ldots, S_{t-p}, D_t \mid y_t, \ldots, y_1 \) on the updated observed data is

\[
Pr[S_t, \ldots, S_{t-p}, D_t \mid y_t, \ldots, y_1] = \frac{p(y_t, S_t, \ldots, S_{t-p}, D_t \mid y_{t-1}, \ldots, y_1)}{f(y_t \mid y_{t-1}, \ldots, y_1)}
\]

(4.70)

where the numerator is given by Equation (4.68) and the denominator is obtained from Equation (4.69).

5. Finally, the computation of \( Pr[S_t, \ldots, S_{t-p}, D_t \mid y_t, \ldots, y_1] \), or \( Pr[S_t^* \mid Y_t] \) is obtained as:

For \( 1 < d \leq \tau \),

\[
Pr[S_t^* \mid Y_t] = \begin{cases} 
Pr[S_t, \ldots, S_{t-p}, D_t = d + 1 \mid y_t, \ldots, y_1] & \text{for } S_t = S_{t-1} \\
0 & \text{for } S_t \neq S_{t-1}
\end{cases}
\]

For \( d = 1 \),

\[
Pr[S_t^* \mid Y_t] = \begin{cases} 
Pr[S_t, \ldots, S_{t-p}, D_t = 1 \mid y_t, \ldots, y_1] & \text{for } S_t \neq S_{t-1} \\
0 & \text{for } S_t = S_{t-1}
\end{cases}
\]

Run the equation as the input for the next iteration and continue until \( t = T \), and this provides \( Pr(S_t^* \mid Y_T) \).

Stage 2 To exploit the result of \( S_t^* \) conditioned on \( S_{t+1}^* \) and \( Y_t \), considering the
identity
\[
Pr(S_t^*|S_{t+1}^*, Y_t)
= \frac{Pr(S_t^*, S_{t+1}^*|Y_t)}{Pr[S_{t+1}^*|Y_t]}
= \frac{Pr(S_{t+1}^*|S_t^*, Y_t)Pr[S_t^*|Y_t]}{Pr[S_{t+1}^*|Y_t]}
= \frac{Pr[S_{t+1}^*|S_t^*]Pr[S_t^*|Y_t]}{Pr[S_{t+1}^*|Y_t]}
\]
\[
\alpha Pr[S_{t+1}^*|S_t^*]Pr[S_t^*|Y_t]
\]
where the first term is the transition probability and the second term is given by Stage 1.

Now, generating \( S_t^* \) from a uniform distribution based on the following conditional probability function

\[
Pr[S_t^* = i|S_{t+1}^*, Y_t]
= \frac{Pr[S_{t+1}^*|S_t^* = i]Pr[S_t^* = i|Y_t]}{\sum_{i=0}^{1} Pr[S_{t+1}^*|S_t^* = i]Pr[S_t^* = i|Y_t]}
\]  
(4.72)

If a random generated value is less than or equal to the calculated value of Equation (4.72), then it is set \( S_t^* = i \), otherwise \( S_t^* = j \), \( i \neq j \) and \( i, j = 0, 1 \).

Once a sequence of \( \{S_t^*\}_{t=1}^T \) is generated, \( \{S_t\}_{t=1}^T \) and \( \{D_t\}_{t=1}^T \) are obtained subsequently.

**Step 2 Generation of \( \phi \) and \( \sigma^2 \)**

Define \( y_t^* = y_t - \mu_0 - \mu_1 S_t \), conditioned on \( \{S_t\}_{t=1}^T \) and \( \mu \), rewriting Equation (4.11) as a linear autoregression model

\[
y_t^* = \phi_1 y_{t-1}^* + \phi_2 y_{t-2}^* + \cdots + \phi_p y_{t-p}^* + e_t \quad t = 1 + r, \cdots, T
\]  
(4.73)

Denote the lefthand side variables of Equation (4.73) as \( Y^* = (y_t^*, \cdots, y_T^*)' \) and the righthand side variables as \( x_t = (y_{t-1}^*, \cdots, y_{t-p}^*)' \) which is the \( t \)th column of the matrix \( X \). Given the prior distribution, the posterior distribution of \((\phi, \sigma^2)\)
is the normal-inverse Wishart distribution by suppressing the conditioning on the parameters

\[ p(\phi, \sigma^2|Y, X) = p(\phi|\sigma^2, Y, X)p(\sigma^2|Y, X) \]
\[ p(\phi|\sigma^2, Y, X) \sim N(a_1, A_1) \]
\[ p(\sigma^2|Y, X) \sim IW_k(V, n - m) \]

where

\[ A_1 = (A_0^{-1} + \sigma^{-2}X'X)^{-1} \]
\[ a_1 = A_1(A_0^{-1}a_0 + \sigma^{-2}X'Y) \]
\[ V = Y'Y' - Y'X'(XX')^{-1}X'Y' \]

**Step 3 Generation of \( \mu \)**

Rewrite Equation (4.11) as

\[ \phi(L)y_t = \mu_0\phi(L) + \mu_1\phi(L)S_t + e_t \quad (4.74) \]

where \( \phi(L) = 1 - \phi_1L - \cdots - \phi_pL^p \).

Define the lefthand side variables of Equation (4.74) as \( \tilde{Y} \) and the righthand side variables as \( \tilde{X} \). Given the prior distribution of \( \mu \) and known autoregression coefficients \( \phi \) and variance \( \sigma^2 \), the posterior distribution is

\[ \mu \sim N(m_1, M_1) \]

where

\[ M_1 = (M_0^{-1} + \sigma^{-2}\tilde{X}'\tilde{X})^{-1} \]
\[ m_1 = M_1(M_0^{-1}m_0 + \sigma^{-2}\tilde{X}'\tilde{Y}) \]
Step 4 Generation of $\beta$

The generation of $\beta$ follows Albert and Chib's (1993) paper that the data augmentation approach is employed to obtain the posterior distribution of the parameters of a probit model through a normal linear model.

Given a previous value of $\beta$ from last Gibbs sampler iteration, the posterior distribution of the latent variable $z_t$, according to Equations (4.17) and (4.18), is simulated from the truncated standard normal distributions

$$z_t|S_t = 0, \bar{z}_t, \beta \sim N(\bar{x}_t^T\beta, 1)I_{(-\infty, 0)}$$

$$z_t|S_t = 1, \bar{z}_t, \beta \sim N(\bar{x}_t^T\beta, 1)I_{(0, \infty)}$$

where

$$\beta = (\beta_1, \beta_2, \beta_3, \beta_4)'$$

$$\bar{x}_t = (S_{t-1}, S_{t-1}D_{t-1}, (1 - S_{t-1}), (1 - S_{t-1})D_{t-1})'$$

and $I_($) is an indicator function used to represent truncation.

Now, conditional on $z_t$, Equation (4.16) becomes a normal linear regression model with unit variance. Define $\tilde{X} = (\bar{x}_1, \cdots, \bar{x}_T)'$ and $Z = (z_1, \cdots, z_T)'$. Then the posterior distribution of $\beta$ is

$$\beta \sim N(b_1, B_1)$$

where

$$B_1 = (B_0^{-1} + \tilde{X}'\tilde{X})^{-1}$$

$$b_1 = B_1(B_0^{-1}b_0 + \tilde{X}'Z)$$

Steps 1-4 run repeatedly until the Gibbs sampler converges.
4.4 The determination of the number of regimes and lags

One of the most important decisions that a researcher has to make concerns the choice of the number of regimes. The problem is that this hypothesis test cannot be performed on the basis of the likelihood ratio test under the regular conditions, given that some parameters are not known when the true progress is governed by \( M \) states which are estimated under an \((M-1)\)-state MS model, and the information matrix is singular which is against one of the regularity conditions of having an asymptotic \( \chi^2 \) distribution for the likelihood ratio test. Fortunately, there are other tests or modifications on the standard likelihood ratio test available to avoid the problem. In this subsection, some of these tests are discussed.

Hamilton (1996) proposes a Lagrange multiplier test of the null that the \((M-1)\)-state MS model against the alternative that there is an additional shift in the mean of the progress. The test statistics are constructed by the derivative of the maximum likelihood estimation with respect to the parameter vector. In short, the test is described as follows.

Consider the MS model (4.41) that is used to demonstrate the maximisation step of the FTP model in Section 4.2.1. In a more general case where there are \( M \) regimes, the observed variable \( y_t \) conditional on an observed vector \( \Psi_t \), which includes a number of lags on \( y \) and a vector of observed exogenous variables \( \omega_t \), and an unobserved state variable \( S_t \) has normal distribution with mean \( x_t' \beta_{S_t} \) and variance \( \sigma_{S_t}^2 \), i.e.

\[
y_t | \Psi_t, S_t; \theta \sim N(x_t' \beta_{S_t}, \sigma_{S_t}^2)
\]

where \( \Psi_t \equiv (\omega_t, \omega_{t-1}, \ldots, \omega_1, y_{t-1}, y_{t-2}, \ldots, y_1, y_{-1}, \ldots, y_{-r}) \), and \( \theta = (\beta_1, \ldots, \beta_M, \sigma_1^2, \ldots, \sigma_M^2, P) \) is a vector of the maximum likelihood estimators, and \( x_t = (\omega_t, y_{t-1}, y_{t-2}, \ldots, y_{t-r}) \).
The null hypothesis in this case is

\[ H_0 : \delta = 0 \]

and the alternative is

\[ H_A : (y_t|\Psi_t, S_t; \theta^*) \sim N[(x_t'\beta_{S_t} + z_t\delta), \sigma^2_{S_t}] \]

where \( \theta^* = (\theta, \delta) \) and \( z_t \) is an \((l \times 1)\) vector of variables which is omitted from the mean of the process.

Additionally, the density function of \( y_t \) is given as

\[
f(y_t|x_t, S_t; \theta) = \frac{1}{\sqrt{2\pi}\sigma_{S_t}} \exp\left[-\frac{(y_t - x_t'\beta_{S_t} - z_t\delta)^2}{2\sigma^2_{S_t}}\right]
\]

Subsequently, the Lagrange multiplier test is

\[
\left[ \sqrt{T} \sum_{t=1}^{T} h_t(\theta) \right]' \left\{ \frac{1}{T} \sum_{t=1}^{T} [h_t(\theta)[h_t(\theta)']^{-1} [\sqrt{T} \sum_{t=1}^{T} h_t(\theta)] \right\}
\]

which is an asymptotic \( \chi^2 \) distribution with \( l \) degrees of freedom. Here,

\[
h_t(\theta) = \frac{\partial \log f(y_t|\Psi_t; \theta)}{\partial \delta}
\]

\[
= \sum_{j=1}^{M} \frac{\partial \log f(y_t|x_t, S_t; \theta)}{\partial \delta} Pr[S_t = j|\Gamma_t; \theta]
\]

\[
+ \sum_{\tau=1}^{T-1} \sum_{j=1}^{M} \frac{\partial \log f(y_t|x_t, S_t; \theta)}{\partial \delta} \times (Pr[S_t = j|\Gamma_t; \theta] - Pr[S_t = j|\Gamma_{t-1}; \theta])
\]

\[
= \sum_{j=1}^{M} \frac{(y_t - x_t'\beta_j)z_t}{\sigma^2_j} Pr[S_t = j|\Gamma_t; \theta]
\]

\[
+ \sum_{\tau+1}^{T-1} \sum_{j=1}^{M} \frac{(y_t - x_t'\beta_j)z_t}{\sigma^2_j} \times (Pr[S_t = j|\Gamma_t; \theta] - Pr[S_t = j|\Gamma_{t-1}; \theta])
\]

\[(4.77)\]
for $t = 1, 2, \cdots, T$. Note that $\Gamma_t = (y_t, y_{t-1}, \cdots, y_1, \omega_t, \cdots, \omega_1)$ and the term $Pr[S_t|\Gamma_t] - Pr[S_t|\Gamma_{t-1}]$ is a natural byproduct when the smoothed probability of an observation is from a particular regime.

Meanwhile, Hamilton conducts Monte Carlo analysis and finds the performance of the Lagrange multiplier test for the number of states is comparatively well. He also suggests that the performance of the test in small samples can be further improved by adopting an $F$ distribution. First, the term $(T - m + m_0)/(Tm_0)$ is multiplied by (4.76), and the test statistics is compared with an $F(m_0, T - m + m_0)$ distribution, where $m$ is the total number of parameters and $m_0$ is the number of restrictions.

Hansen (1992) constructs a bound of the asymptotic distribution of the likelihood ratio test for nonlinear models that standard conditions are not satisfied. The main idea is to decompose the likelihood ratio surface into a limit function and a random empirical process. Given the maximised estimation of the limit function, the asymptotic distribution of the empirical process can be derived from the data. Therefore, this permits to set up a boundary and uses this bound to test the null hypothesis.

Suppose the log-likelihood of a model is defined as

$$L_n(\beta, \gamma, \theta) = \sum_{i=1}^n l_i(\beta, \gamma, \theta)$$

where $\beta$ and $\gamma$ are nuisance parameters. In the MS model, like $y_t = \mu + \mu_d S_t + u_t$, $\phi(L)u_t = c_t$, $\theta = \phi$, $\gamma = p_{11}, p_{22}$ and $\beta = \mu_d$.

The hypothesis describes as follows

$$H_0 : \beta = 0 \quad H_1 : \beta \neq 0$$

Under the hypothesis, it is assumed that $\theta$ is fully identified, but $\gamma$ is not recognized.

In order to eliminate $\theta$, defining $\alpha = (\beta, \gamma)$, so $\theta$ can be represented as the
maximum-likelihood estimates in terms of $\alpha$

$$\hat{\theta}(\alpha) = \max L_n(\alpha, \theta)$$

Thus the concentrated likelihood function is given as

$$\hat{L}_n(\alpha) = L_n(\alpha, \hat{\theta}(\alpha)) = \sum_{i=1}^{n} l_i(\alpha, \hat{\theta}(\alpha))$$

and for a large sample

$$L_n(\alpha) = L_n(\alpha, \theta(\alpha)) = \sum_{i=1}^{n} l_i(\alpha, \theta(\alpha))$$

where $\theta(\alpha) = \arg\max \lim_{n \to \infty} \frac{1}{n} E L_n(\alpha, \theta)$ which is the pseudo-true value.

The likelihood ratio (LR) function is written as

$$LR_n(\alpha) = \hat{L}_n(\alpha) - \hat{L}_n(0, \gamma) = \sum_{i=1}^{n} [l_i(\alpha, \hat{\theta}(\alpha)) - l_i(0, \gamma, \hat{\theta}(0, \gamma))]$$

Analogously, in the large sample case

$$LR_n(\alpha) = L_n(\alpha) - L_n(0, \gamma) = \sum_{i=1}^{n} [l_i(\alpha, \theta(\alpha)) - l_i(0, \gamma, \theta(0, \gamma))]$$

Meanwhile, the LR surface is constituted of the limit function and the random empirical process, mathematically

$$LR_n = R_n(\alpha) + \hat{Q}_n(\alpha)$$
$$LR_n = R_n(\alpha) + Q_n(\alpha)$$

where $R_n(\alpha) = E(LR_n(\alpha))$ which can be viewed as the mean, $\hat{Q}_n(\alpha) = \sum_{i=1}^{n} q_i(\alpha, \hat{\theta}(\alpha))$ and $Q_n(\alpha) = \sum_{i=1}^{n} q_i(\alpha, \theta(\alpha))$ which represent the deviation from the mean. The above equations suggest that the reason of the likelihood function that is maxi-
mized at $\alpha$ other than $\alpha_0$ is random fluctuation of the functions $Q_n(\alpha)$ and $\hat{Q}_n(\alpha)$.

To derive the asymptotic distribution of standardized LR statistics, the sample variance function is constructed like this

$$V_n(\alpha, \hat{\theta}(\alpha)) = \sum_{i=1}^{n} q_i(\alpha, \hat{\theta}(\alpha))^2$$

where

$$q_i(\alpha, \hat{\theta}(\alpha)) = l_i(\alpha, \hat{\theta}(\alpha)) - l_i(0, \gamma, \hat{\theta}(0, \gamma)) - \frac{1}{n} \hat{L}R_n(\alpha)^2$$

Identify the standardized likelihood ratio process and statistic as

$$\hat{L}R_n^*(\alpha) = \hat{L}R_n(\alpha)/\sqrt{V_n(\alpha)^{1/2}}$$

$$\hat{L}R_n^* = \sup \hat{L}R_n^*(\alpha)$$

Define the centered random process

$$\hat{Q}_n^*(\alpha) = \hat{Q}_n(\alpha)/\sqrt{V_n(\alpha)^{1/2}}$$

$$Q_n^*(\alpha) = Q_n(\alpha)/\sqrt{V_n(\alpha)^{1/2}}$$

and $Q_n^*(\alpha)$ follows an empirical process law which converges weakly to $Q^*(\alpha) (Q_n^*(\alpha) \Rightarrow Q^*(\alpha))$, given that $Q^*(\alpha) = Q(\alpha)/\sqrt{V(\alpha)^{1/2}}$ is a normal process with covariance function

$$K^*(\alpha_1, \alpha_2) = K(\alpha_1, \alpha_2)/\sqrt{V(\alpha_1)^{1/2}V(\alpha_2)^{1/2}}$$

Rewrite equation (4.78) as an asymptotic approximation

$$\frac{1}{\sqrt{n}} \hat{L}R_n(\alpha) = \frac{1}{\sqrt{n}} R_n(\alpha) + \frac{1}{\sqrt{n}} \hat{Q}_n(\alpha)$$

(4.80)

Given $L_n(\alpha) - \hat{L}_n(\alpha) = o_p(1)$ which holds $\hat{L}_n(\alpha)$ is consistent for $L_n(\alpha)$ at rate 1 uniformly in $\alpha$, and $R_n(\alpha) = R_n(\beta, \gamma) \leq 0$ under the null hypothesis together with

$$\frac{1}{\sqrt{n}} Q_n(\alpha) = \frac{1}{\sqrt{n}} \sum q_i(\alpha) \Rightarrow Q(\alpha),$$

we derive a bound for the concentrated likelihood
process

\[ \frac{1}{\sqrt{n}} \hat{L}R_n(\alpha) \leq \frac{1}{\sqrt{n}} Q_n(\alpha) = \frac{1}{\sqrt{n}} Q_n(\alpha) + a_p(1) \Rightarrow Q(\alpha) \]

Therefore, the bound for the distribution of the standardized LR statistic is

\[ P\{ \hat{L}R_n^* \geq x \} \leq P\{ \sup Q^*(\alpha) \geq x \} \rightarrow P\{ \sup Q^* \geq x \} \]

where \( \sup Q^* \equiv \sup Q^*(\alpha) \).

Moreover, to construct the asymptotic distribution of the random variable \( \sup Q^* \), an easiest way is to produce a random sample set of \( \{u_i\}_1^n \), variables which is distributed as \( N(0,1) \) and then calculate

\[ \hat{L}R^*(\alpha) = \frac{\sum_{i=1}^n q_i(\alpha, \hat{\alpha}(\alpha)) u_i}{V_n(\alpha)^{\frac{1}{2}}} \]

with the covariance function \( \hat{K}_n^* \) defined as

\[ \hat{K}_n^*(\alpha_1, \alpha_2) = \frac{\sum_{i=1}^n q_i(\alpha_1, \hat{\alpha}(\alpha_1)) q_i(\alpha_2, \hat{\alpha}(\alpha_2))}{V_n(\alpha_1)^{\frac{1}{2}} V_n(\alpha_2)^{\frac{1}{2}}} \]

The test is found no distortion in size and its effective power is also good under Monte-Carlo experiments. However, the computation of this test is too onerous and only produces p-values which are an upper bound of the true p-values.

Psaradakis and Spagnolo (2003) discuss two methods for choosing the number of Markov regimes, one is based on complexity-penalised likelihood criteria, the other is based on the equivalent ARMA representation. The former evaluates directly the MS(M)-AR(r) model and determines the number of states using criteria like Akaike information criterion (AIC), Bayesian information criterion (BIC) and Hannan-Quinn criterion (HQ). In mathematic, for the MS(K)-AR(r) model, \( M \) is calculated as

\[ \hat{M} = \arg \max_{1 \leq k \leq K^*} \{ \ln L(\hat{\theta}; y_1, \cdots, y_T) - C_T \dim(\theta_k) \} \quad (4.81) \]
where \( L(\hat{\theta}_k; y_1, \ldots, y_T) \) is the likelihood function, \( k^* \) is the maximum number of states, \( \hat{\theta}_k \) is a vector of the maximum likelihood estimators, \( \theta_k \) represents a vector of parameters, \( \dim(\theta_k) = k(k+r+1) \), and \( C_T \) is a constant term which is obtained by using the AIC \((C_T = 1)\), the BIC \((C_T = \frac{1}{2} \ln T)\) and the HQ \((C_T = c \ln \ln T, c > 1)\) individually.

The latter follows the paper which is proposed by Zhang and Sting (2001). It shows that the auto-covariance structure of a weakly stationary process which is characterised as the MS model can be interpreted as ARMA\((p,q)\) model with \( p \leq Mr^2 \) and \( q \geq Mr^2 - 1 \) in the case of autoregressive switching models or \( p,q \leq k - 1 \) in the case of mean-variance switching models. Hence, the state dimension is determined as \( k \geq \max\{p/r^2, (q + 1)/r^2\} \) or \( k \geq \max\{p + 1, q + 1\} \). However, this gives only a lower bound of the number of regimes. Moreover, the identification of the ARMA\((p,q)\) model is verified by the three-pattern method (TPM).

According to the Monte Carlo analysis, two major conclusions are drawn. First, when there is lack of persistence in the Markov chain, or the sample size and the differences between parameter values in different regimes are small, all selection methods have trouble of selecting the right state dimension. At the same time, these methods perform also badly when the autoregressive coefficients are state-independent. Fortunately, these problems get better as sample size increases and the variations in values of parameter increase in magnitude. Second, among the selection procedures, the TPM outperforms others after all. The BIC and HQ tend to underestimate the number of regimes. Although the AIC performs better than the BIC and HQ, it does not meet the conditions of producing consistent estimation for \( M \), since its penalty factor does not deviate from infinity with \( T \) i.e. \( \lim T \to \infty, \ C_T/\ln \ln T = 0 \).

Furthermore, they (2006) further concern determination of the state dimension and autoregressive order of the MS model jointly. They propose a simple criterion function form based on the likelihood function and information criterion

\[
\delta(M, r) = -\ln \underline{L}_n(\hat{\theta}_{M,r}) + C_{n,M,r} \tag{4.82}
\]
where $M = 1, 2 \cdots M, r = 0, 1 \cdots r$ and $n$ is the sample size.

Similar conclusions are obtained as suggested by the Monte Carlo simulation results. When the sample size is not too small, the chance of obtaining the right model rises with increases in the difference of the parameter and the transition probability ($p_{ur}$) values. In addition, AIC is the best criterion of identifying the correct specification, followed closely by SIC and HQ.

Next, we are going to discuss the choice of lags. Kapetanios (2001) considers the choice of lags using information criteria in the MS model when the state dimension is fixed and known. The basic idea is that the smallest value of the loss function that assigns to the model is the most preferable. In the paper, five information criteria are considered: AIC, SIC, HQ, generalised information criterion (GIC) and informational complexity criterion (ICOMP). The lag order is determined by the loss function of the form $-l(\hat{\theta}) + C_{T,k}$, where $l(\cdot)$ is the log-likelihood function, $C_{T,k}$ is the penalty term, i.e. information criteria. According to the Monte Carlo simulations, the HQ is the best choice of selecting lags, and the SIC is the second best. While, the AIC, GIC and ICOMP tend to overestimate the true lag.

4.5 Applications of the MS model in the literature

4.5.1 The MS model with time-invariant transition probabilities

Since Hamilton introduced the FTP model in 1989, it has been used in the writings of many scholars working on several areas. For example, see Cecchetti et al. (1990) and Henry and Scruggs (2007) (stock returns), Frömmel (2004) (interest rate), and Hooi et al. (2008) (monetary policy). In this subsection, I confine myself to reviewing applications of the MS approach in the analysis of business cycles.

Goodwin (1993) performs a number of specification and forecasting tests to ex-
amine the fitness of the Hamilton MS model for 8 developed market economies. The test results suggest that the Hamilton model only slightly improves the fitness to the data over a linear model, as suggested by the Hansen LR test (1992) and Nyblom stability test (1989) where the null hypothesis of the AR(4) model cannot be rejected for all countries in the sample. Other tests suggest that the Hamilton model is still able to explain the data – to some extent. Moreover, the paper commends the ability of the Hamilton model to date turning points which are close to the results using other methods without requiring any prior information. Lastly, a test on the asymmetry of business cycles has been conducted, and the result supports the hypothesis of asymmetries.

Kanfmann (1997) introduces a dynamic MS factor model where the common factor follows a MS process. The estimation is based on the Bayesian Gibbs-Sampling approach. The model is used to estimate GDP, consumption and investment for the same countries as in Goodwin’s paper, plus Austria. The results obtained from the dynamic MS factor model are different from those in Goodwin. The results for all countries are in favour of the alternative hypothesis that business cycles have two distinctive regime means. The transition probabilities that measure the dates of recessions are close to the reference cycles for most of countries, except Great Britain. The paper also highlights that the adoption of a common MS factor model speeds up the recognition of a downturn. Furthermore, the paper points out that the reason of the MS specifications (the dynamic MS factor and the univariate MS models) are not rejected, is solely due to which estimation method is employed.

Kim and Nelson (1999) investigate the stabilization of the postwar US economy and the date of the possible structure break, which is based on the MS model in Hamilton (1989), by assuming the regime-dependent means and the variance are subject to a one-time unknown structural break. The results suggest the US economy has become more stable in the postwar period as a decline in the volatility of output growth and a reducing gap between the mean growth rates. In addition, the models estimate the date of the structural break to be 1984:1.
A MS vector equilibrium correction model is adopted by Krolzig and Sensier (1999) to analyse the linkage of business cycle fluctuations and the structural changes in UK industries. They use firstly the univariate MS-AR model to model the industrial production index (IP) for six major sectors separately, and find the proof of a common movement covered by industry-specific shocks. However, the MS-AR models fail to detect other recession according to the reference dating of business cycles. While the MS vector equilibrium correction model is able to identify all the reference recessions which are captured by a widespread cycle across the manufacturing sectors and uncover the regime shifts affect the structure of industry and business cycles simultaneously.

Kontolemis (2001) employs the univariate and the simple vector MS models to identify turning points of the US business cycle using four coincident series. It is found that each series displays different cycles at different periods given the estimation results of the univariate MS model. It is difficult to capture common turning points across all the series as some series present their own individual cycles. Meanwhile, a number of false cycles have been picked up whereas those important ones fail to be pointed out. On the other hand, business cycle turning points as produced by the vector MS model are very close to the NBER reference cycle. What is more, the paper also suggests that the vector MS model has better forecast ability in comparison with the univariate MS model since it contains richer useful information.

Breuing and Stegman (2003) apply alternative methods to investigate the robustness of the MS model for the Singaporean business cycle. They employ both formal and informal procedures to carry out tests. The formal method is to construct the sample and the pseudo population characteristics of the data and compare them. This test is used to examine the mean, the variance and the probabilities of regimes. In addition, the informal method is to plot the conditional mean density of the pseudo population contrasts to the actual data to reveal the goodness-to-fit. The outcomes of these two methods both suggest that the MS model outperforms
the linear model in capturing the features of the data.

Anas et al. (2004) extend the standard MS-VAR model which is suggested by Krolzig (1997a) as a method of analysing the common business cycle and the progression of regimes to a multiple MS-VAR model, which allows a specification Markov chain to determine the regime switching in each equation of the VAR system. This multiple MS-VAR model permits us to reveal explicitly the connection among the phases in different countries or sectors within an economy. Furthermore, they also propose a Granger causality test to identify the relationship between leading and lagging series. This gives the revelation of the inter-relationship among series. They apply the model to investigate the relationships of business cycles between the Euro zone and the US, as well as between the Euro zone industrial production (IP) and the standardised industrial component of the European Sentiment index (ESI). It is found that the economic conditions in the US affect the conditions in the Euro zone and the ESI moves together with the IP and even moves ahead sometimes. Additionally, the test of non causality is rejected in both ways in both cases.

Li et al. (2005) study the performance of the MS model on business cycles of 6 economies. They divide these 6 economies into 3 groups: industrialised economies (IEs), newly industrialised economies (NIEs) and developing economics (DEs). The study shows that the conventional two-regime MS model describes the IEs and DEs business cycle considerably well. However, it is unable to represent the regime shifts for the NIEs. This is because that these economies experience a once-for-all structural change in the stages of economic development during the sample period. Therefore, the paper implements two-period MS models by integrating the two-regime MS model and single structural-shift. These models separate the stochastic process into two stages, high and medium-growth stages. The advantages of the two-period MS models are, firstly, there are less parameters to estimate; secondly, business cycles of the NIEs are well explained.

Camacho (2005) develops a MS common stochastic trends model from a MS vector error correction model to investigate the relationships between short-run ad-
justment of output, consumption and investment and their long-run equilibriums. The author uncovers that, first, all three economic variables exhibit two distinct and statistically significant business cycle phases, and the NBER business cycle dates affect the dynamics of these variables. Second, the business cycle turning points and durations estimated by the model are very close to the official dating, in addition to the discovery of the first recession in the 21st century which has not been published officially at that time. Furthermore, the in-sample prediction ability of this nonlinear model outperforms the linear model. Third, the model also supports the findings of King et al. (1991) that shocks to the common trend have an effect on the short-run variation of the variables. Finally, large negative recessionary shocks can result in permanent falls in the long-run trend level.

The estimation of the Euro-area business cycle using the Industrial Production Index (IP) in the univariate MS model is useful for identifying the business cycle phases in in-sample analysis. However, Bengoechea et al. (2006) show that the out-of-sample and the real-time forecasts of the univariate MS model generate lagged prediction because of the delayed publication of the IP series. Hence, they consider the multivariate MS model by integrating IP and the European Commission Industrial Confidence Indicator (IC) which is updated, and extending hidden Markov processes to a mixture of completely independent and fully dependent Markov processes. Under this multivariate framework, the model produces growth rate cycle dating rather than business cycle dating. Moreover, time delay in both the out-of-sample and real-time forecasts is corrected.

Dueker and Sola (2008) expand the features of multivariate MS models (for example, MS vector autoregressions, dynamic MS factor models, etc) by giving different weights on cross-sectional units when calculating the regime probabilities of common business cycles. By modelling the European business cycle which is obtained by using a MS vector autoregression of the GDP series from 9 countries, the weighted regime probability MS model detects an additional recession that is ignored by the usual equal-weighted model.
Chen (2009) uses the MS-VAR model to examine the transmission effects of business cycle fluctuations in the US and Japan on the Taiwanese business cycle. He incorporates a regime-dependent impulse function into the MS-VAR model in order to disclose how Taiwan’s output reacts to a shock which results in a structural change from outside of the economy. The empirical results suggest that the response of the Taiwanese business cycle to fluctuations of business cycles in the US and Japan is not symmetric. In detail, the Taiwanese business cycle is significantly affected by the shocks in the business cycle of the US and Japan in the high-growth regime. On the contrary, it is not influenced by either of them in the low-growth regime. In addition, it finds that the transmission of business cycle fluctuations are from the US and Japan to Taiwan, not the other way round. In the meantime, fluctuations of the Japanese business cycle have less influential power on business cycles of Taiwan than the US business cycle fluctuations.

4.5.2 The MS model with time-varying transition probabilities

There is a non-negligible and growing number of literature which employ the DDMS and the TVTP specifications for the modelling of the business cycle.

Filardo (1994) uses Hamilton’s (1989) constant transition probability model with monthly IP data. In the paper, he finds that the Hamilton’s model fails to identify the features of monthly business cycles. Therefore, he extends the FTP model to allow the transition probabilities (as well as expected durations) to vary across time. By incorporating information that indicates future economic movements, he produces much better estimations of the model and the high correlation between the inferred phases of the economy and the NBER’s chronology. Further, he also shows that the dynamic of business cycles arises from the variation in the transition probabilities rather than a shift in the means. Filardo and Gordon (1998) apply the TVTP model to estimate the unobservable states and the expected phase durations of business cycles by employing Bayesian methods and the Gibbs sampler. They
document that the expected durations of the phase (expansions and recessions) achieve the highest point at the beginning of the new phase and fall substantially near the end of that phase.

Moreover, Layton (1998) uses the Economic Cycle Research Institute (ECRI) coincident index as a dependent variable rather than using GDP or IP in the estimation of the TVTP model. One of the conclusions of the paper is that the use of the coincident index produces much closer identification of dating US business cycles to the NBER dating as a result of its comprehensive and broader embodiment of economic activity. Besides, the leading indicators have statistically and significantly influence on the probabilities of regime shifts as well as on the prediction of movements of business cycles.

Following Filardo and Gordon's (1998) paper, Simpson et al. (2001) employ the TVTP model with both logit and exponential transition probability functions to investigate the UK business cycle. The empirical results suggest that the TVTP model in terms of movements in leading indicator variables identifies business cycle regimes and regime asymmetries more successful in both in-sample estimation and out-of-sample forecasting, compared to the linear models of the leading indicators and the FTP model. Furthermore, the results also suggest that the application of the exponential transition function is preferred to the logit function.

Furthermore, Layton and Katsuura (2001a) compare the abilities of matching and forecasting US business cycles in three different nonlinear specifications: the probit specification, the logit specification and the MS specification. Unsurprisingly, the MS specification performs better than the other specifications. In addition, the TVTP model performs slightly better than the FTP model.

In the meantime, they (2001b) use the regime probabilities that are obtained from the TVTP model to construct a new system of signalling business cycle turning points. The basic stages are, first of all, finding a local minimum value of the appropriate transition probability; second, given the first condition is satisfied, it must also satisfy both the conditions relate to the overall long-run mean and the
ratio of the present transition probability to the most recent local minimum value. According to the empirical study on the US, Japan and Australia, it is found that the signalling system is responsive to the duration of phases, although its overall performance is plausibly well.

What is more, Moolman (2004) and De Medeiros and Sobral (2007) apply the TVTP model with the logit transition function to the South African and the Brazilian business cycle, respectively. Both papers find that the TVTP model characterises the business cycle in terms of two distinctive phases, the turning points, and the duration of the regimes. Further, the inclusion of the leading indicators is important to the business cycle analysis and prediction.

Durland and McCurdy (1994) employ the other extended MS model to test the efficiency of dating US business cycles through comparing the linear AR model and the FTP model. Unlike the TVTP model which uses the leading indicator variable as conditional information to infer the transition probabilities in Filardo’s (1994) and Filardo and Gordon’s (1998) papers, they allow the transition probabilities to depend on the duration of the state. In their findings, they find support of nonlinearity of the time series and of asymmetries of different regimes. They also find strong evidence of duration dependence when the economy is in a recession but weaker dependency in expansions. Moreover, it is suggested that this duration-dependent transition Markov switching model outperforms the linear AR model and the FTP model (in terms of capturing the characteristics of business cycles).

By means of Bayesian estimation and the Gibbs sampling methodology, Kim and Nelson (1998) adopt the dynamic factor model with regime-switching to assess the two important features of business cycles: co-movements of economic variables and nonlinearity of business cycles. They argue that the employment of the multivariate common factor approach produces the closer time path of recessions with the NBER reference cycle, than the univariate model. Regarding nonlinearity, turning points obtained by the estimated model are sharper and reveal rather different growth patterns of business cycles, compared to the findings in the previous studies. Mean-
while, they also test duration dependence in business cycles under the multivariate context. The results confirm the findings in Durland and McCurdy (1994).

Additionally, Layton and Smith (2007) imply directly the NBER business cycle chronology as conditional information in the determination of the transition probabilities, together with the leading indicators to investigate duration dependence. By incorporating these two additional information variables into the state-switching probability function, in addition to allow the variation of the model’s parameters in different regimes, the empirical results suggest that there is strong duration dependence in recessions. In contrast to the result that is found by Durland and McCurdy (1994), they find some support in favour of duration dependence in expansions. Besides, information that is contained in the leading indicators certainly helped the prediction of regime-switching probabilities. This is true for both expansionary and contraction phases.

Kim and Yoo (1995) extend the univariate conventional TVTP model to the univariate unobserved component model with time-varying transition probabilities, and further transform to the multivariate MS factor model. The paper finds that the performance of the multivariate FTP model improves significantly. Additionally, it is found that the assumption of duration independence is rejected. What is more, the calculation of the time-varying expected durations based on the linear regression forecast may produce unclear signals about business cycle phases.

### 4.6 Concluding remarks

In this methodology chapter I have presented and discussed alternative specifications and estimation methods of the Markov switching model. This model is popular in the business cycle literature for a number of reasons: among others, it captures successfully asymmetries in the business cycle; it identifies turning points more accurately; it allows estimation with two, three or even more regimes; it allows the variance of the errors to be regime-dependent (if this is desired); it can be used in a uni- or multi-variate setting; it can feature time-varying transition probabilities.
Given these desirable characteristics the MS model is used in the applied work presented in the next two chapters.

Three different versions of the MS model have been discussed: the FTP, the DDMS and the TVTP models. First, the basic specifications and the general approach for estimating these versions are laid out, including the EM algorithm, the Bayesian approach and the Gibbs sampling. Then, the applied business cycle literature that has adopted this methodology is reviewed. Most of the papers examined conclude that the MS model is generally successful and useful in modelling business cycles.

Moreover, the literature on the determination of the number of regimes has been surveyed. Unfortunately, there is still no easy and reliable statistical method to provide an accurate determination of the number of regimes. The choice widely remains at the discretion of the researcher, even though, of course, there are always some helpful priors that facilitate the decision.

Looking ahead, Chapter 5 models the East and Southeast Asian business cycles in a fixed transition probability framework. Questions related to the persistence and duration of each growth state, the strength of expansions and the severity of downturns, their volatility across regimes, as well as the cross-country correlations are being addressed and answered.
The discussion in previous chapter has established that Markov switching (MS) models possess certain properties that make them suitable for modelling the business cycle. In this chapter, I use MS specifications to fit GDP data of selected countries and districts in East and Southeast Asia. The purpose of the MS model is to 'identify' the business cycle, i.e. to assign observations into different growth regimes endogenously. A decision needs to be made as to how many regimes are assumed – usually two or three in the business cycle literature. This econometric work also allows me to estimate each regime's persistence and duration.

The features of business cycles in each country and district are examined separately by applying a variety of fixed transition probability (FTP) specifications. In other words, an assumption is made that the probability of switching from one regime to another is constant over time. This implies that there can be no 'exogenous' time series that can actually affect this probability. In the next chapter, this assumption is relaxed but as it will become clear this has a cost in terms of increased
computational difficulty.

Moreover, as we have seen in Chapter 3, there is a trend that Asian countries and districts is becoming increasingly integrated with each other. This motivates an investigation into the degree of business cycle synchronisation between the economies in the sample by adopting a Markov-switching vector autoregressive (MS-VAR) framework. In other words, the analysis progresses from a univariate setting to a multivariate one.

The structure of this chapter is as follows. First, the dataset is discussed and descriptive statistics and unit root test results are provided. Then, the conventional homoscedastic Markov switching model (the Hamilton model) is fitted separately on each economy's data. The assumption of constant variance of the errors is then relaxed and alternative specifications with switching intercepts are estimated and reported. Finally, the chosen economies are separated in two groups based on their income and switching vector autoregressions that allow the study of contemporaneous correlations across regimes are performed. The last section concludes.

5.1 Empirical study

The identification of the expansionary and the recessionary states has always been one of the primary interests of empirical business cycle research. Since the publication of Hamilton's (1989) model of the US business cycle, the use of Markov-switching autoregressive model (MS-AR) for analysing output fluctuations has become increasingly popular.

In this section, I use the univariate MS model (i.e. $MS(M)$-AR$(r)$, where $M$ stands for the number of regimes and $r$ is the order of the autoregression) for the seasonally adjusted quarterly real GDP data for the selected East and Southeast Asian countries and districts: China (Mainland), Hong Kong, Indonesia, Japan, Korea, Malaysia, Philippines, Singapore, Taiwan and Thailand from 1970 to 2006. The purpose of this study is to examine the characteristics of the individual business cycle and provide an assessment of the model's ability to fit these particular data.
5.1.1 Data description


It may be useful here, and prior to any analysis with our chosen methodology, to present a simple approach to classical business cycle dating which serves as the referential dating first, with the purpose of comparing with the turning points obtained from the estimated MS models. A business cycle dating procedure was first introduced by Burns and Mitchell (1946) and was further refined by Bry and Boschan (1971). This algorithm is used by the the National Bureau of Economic Research (NBER) in dating the reference business cycle turning points. Since there is no official published business cycle chronology for comparison, here I present a simple mechanical rule, discussed in Brichenhall et al. (2000). The rule identifies a peak (or a trough) at time $t$ if the GDP value is strictly greater (or less) than the values of the next two quarters, i.e. $t + 1$ and $t + 2$; at the same time it should also be at least as large (or small) as the values within a year in the past and in the future. Table 5.1 and 5.2 show the results of the turning points as well as the duration of the phase of each country and district by applying this rule. Note that the Chinese business cycle turning points do not present in the table because the Chinese business cycle has not experienced any recession during the sample period (1995:1-2006:4).

I now turn to the analysis of the data. To begin with, the time series of each economy is tested for the presence of unit roots using the augmented Dickey-Fuller
Table 5.1: Classical turning points

<table>
<thead>
<tr>
<th></th>
<th>Hong Kong Duration (Quarters)</th>
<th>Indonesia Duration (Quarters)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Peak/Trough</td>
<td>Peak/Trough</td>
</tr>
<tr>
<td>1983:1</td>
<td>Trough</td>
<td>4</td>
</tr>
<tr>
<td>1994:1</td>
<td>Peak</td>
<td>44</td>
</tr>
<tr>
<td>1995:3</td>
<td>Trough</td>
<td>6</td>
</tr>
<tr>
<td>1997:2</td>
<td>Peak</td>
<td>7</td>
</tr>
<tr>
<td>1999:1</td>
<td>Trough</td>
<td>7</td>
</tr>
<tr>
<td>2001:1</td>
<td>Peak</td>
<td>8</td>
</tr>
<tr>
<td>2001:3</td>
<td>Trough</td>
<td>2</td>
</tr>
</tbody>
</table>

<table>
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<th></th>
<th>Japan Duration (Quarters)</th>
<th>Korea Duration (Quarters)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Peak/Trough</td>
<td>Peak/Trough</td>
</tr>
<tr>
<td>1973:4</td>
<td>Peak</td>
<td>12</td>
</tr>
<tr>
<td>1975:1</td>
<td>Trough</td>
<td>5</td>
</tr>
<tr>
<td>1979:2</td>
<td>Peak</td>
<td>29</td>
</tr>
<tr>
<td>1980:2</td>
<td>Trough</td>
<td>4</td>
</tr>
<tr>
<td>1993:1</td>
<td>Peak</td>
<td>51</td>
</tr>
<tr>
<td>1993:3</td>
<td>Trough</td>
<td>2</td>
</tr>
<tr>
<td>1997:1</td>
<td>Peak</td>
<td>14</td>
</tr>
<tr>
<td>1999:3</td>
<td>Trough</td>
<td>10</td>
</tr>
<tr>
<td>2001:1</td>
<td>Peak</td>
<td>6</td>
</tr>
<tr>
<td>2001:4</td>
<td>Trough</td>
<td>3</td>
</tr>
<tr>
<td>2004:1</td>
<td>Peak</td>
<td>13</td>
</tr>
</tbody>
</table>

### Table 5.2: Classical turning points (Cont.)

<table>
<thead>
<tr>
<th>Malaysia</th>
<th>Duration (Quarters)</th>
<th>Philippines</th>
<th>Duration (Quarters)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak/Trough</td>
<td>1997:4</td>
<td>Peak</td>
<td>1983:3</td>
</tr>
<tr>
<td>Peak/Trough</td>
<td>1998:4</td>
<td>Trough</td>
<td>1985:3</td>
</tr>
<tr>
<td>Peak/Trough</td>
<td>2000:4</td>
<td>Peak</td>
<td>1990:3</td>
</tr>
<tr>
<td>Peak/Trough</td>
<td>2001:4</td>
<td>Trough</td>
<td>1991:1</td>
</tr>
<tr>
<td>Peak/Trough</td>
<td>1997:4</td>
<td>Peak</td>
<td>1997:4</td>
</tr>
<tr>
<td>Singapore</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak/Trough</td>
<td>1974:2</td>
<td>Peak</td>
<td>2000:3</td>
</tr>
<tr>
<td>Peak/Trough</td>
<td>1975:2</td>
<td>Trough</td>
<td>2001:3</td>
</tr>
<tr>
<td>Peak/Trough</td>
<td>1981:2</td>
<td>Peak</td>
<td>2004:2</td>
</tr>
<tr>
<td>Peak/Trough</td>
<td>1982:4</td>
<td>Trough</td>
<td>2004:2</td>
</tr>
<tr>
<td>Peak/Trough</td>
<td>1984:2</td>
<td>Peak</td>
<td>2004:2</td>
</tr>
<tr>
<td>Peak/Trough</td>
<td>1985:4</td>
<td>Trough</td>
<td>2004:2</td>
</tr>
<tr>
<td>Peak/Trough</td>
<td>1996:1</td>
<td>Peak</td>
<td>2004:2</td>
</tr>
<tr>
<td>Peak/Trough</td>
<td>1998:3</td>
<td>Trough</td>
<td>2004:2</td>
</tr>
<tr>
<td>Peak/Trough</td>
<td>2000:4</td>
<td>Peak</td>
<td>2004:2</td>
</tr>
<tr>
<td>Peak/Trough</td>
<td>2001:3</td>
<td>Trough</td>
<td>2004:2</td>
</tr>
<tr>
<td>Thailand</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak/Trough</td>
<td>1996:3</td>
<td>Peak</td>
<td>2004:2</td>
</tr>
<tr>
<td>Peak/Trough</td>
<td>1998:3</td>
<td>Trough</td>
<td>2004:2</td>
</tr>
</tbody>
</table>

(ADF) test. The ADF test estimates

\[ \Delta y_t = \beta_1 + \beta_2 t + \delta y_{t-1} + \sum_{i=1}^{n} \psi_i \Delta y_{t-i} + u_t \]

where \( t \) is the trend variable, \( u_t \) is a pure white noise error term and \( \Delta y_{t-1} = y_{t-1} - y_{t-2}, \Delta y_{t-2} = y_{t-2} - y_{t-3}, \) etc. The null hypothesis is \( \delta = 0 \), i.e. there is a unit root in \( y_t \). The test statistics show that for all countries and districts the null hypothesis cannot be rejected at 5% significance level, except Indonesia for which the null is rejected at the 1% significance level. Thus, all series are found to be integrated of order 1. However, the ADF test is not powerful enough to test unit roots. Hence I conduct a more powerful unit root test – the KPSS test which is introduced by Kwiatkowski et al. (1992). The test estimates the following regression

\[ y_t = \alpha t + d \sum_{i=1}^{t} u_i + \varepsilon_t \quad t = 1, \ldots, T \]

where \( \sum u_i \) is a random walk component and \( \varepsilon_t \) is a noise component, both of them have zero-mean and covariance stationary; moreover, \( d \in \{0,1\} \). In contrast to the ADF test, the null hypothesis of the KPSS test is that the series is stationary \( (d = 0) \), therefore the alternative hypothesis is that the series has a unit root \( (d \neq 0) \). The statistic uses the one-sided Lagrange Multiplier (LM) statistic which is given as

\[ LM = T^{-2} \sum_{t=1}^{T} S_t^2 / \hat{\sigma}^2 \]

where \( S_t = \sum_{i=1}^{t} e_i, t = 1, 2, \ldots, T, e_t \) is the residual from the regression of \( y \) (that is \( e_t = y_t - \hat{y}_t \)), and \( \hat{\sigma}_e^2 \) is the estimator of the error variance of \( e_t \), i.e. \( \hat{\sigma}_e^2 = T^{-1} \sum_{t=1}^{T} e_t^2 \).

The null hypothesis of \( I(0) \) against the alternatives of \( I(1) \) is rejected for large values of the LM statistic. The test suggests that the test results for all countries and

\(^{1}\)DeJong et al. (1992) find that the ADF test is difficult to distinguish between an integrated process and roots of a process with near unity, and Diebold and Rudebusch (1991) also find that the ADF test has low power under fractionally-integrated alternatives.
districts are statistically significant at the 5% level. Despite that China, Malaysia, Taiwan and Thailand are insignificant at the 1% level, all series are non-stationary at the 5% significance level. As a result, I take first difference of logarithms (times 100) and obtain the quarterly growth rates, and the series are stationary now as shown in Figure 5.1.

Again, these differentiated series are tested for unit roots. Both the ADF and the KPSS tests confirm the stationary of all series at the 5% significance level, apart from the KPSS tests for Japan and Philippines which are accepted at the 1% level of significance.

Table 5.3 summarises the major descriptive statistics of each economy including the average quarterly growth rates, the standard deviation of growth rates, and the sum of squared deviation. It shows that China has the highest average growth rate per quarter (1.58%), and Japan has the lowest mean growth rate per quarter (0.25%) in the sample. Besides, Philippines also has a relative low average growth rate around 0.31% per quarter. It is not a surprise that Japan grows at a low rate since its economic development stage is at an advanced level. Regarding to limited observations and the extreme values in recessions, it has better to look at the median as it provides a better measure of central location than the mean about the normal growth level. Even so, China has still the highest mean growth rate (1.22% per quarter), and Japan has the lowest mean growth rate (0.21% per quarter). Moreover, China displays a comparative high degree of volatility given the standard deviation value of 1.96 among all other countries and districts. Furthermore, Indonesia, South Korea, Malaysia and Singapore also appear to have relative high fluctuations.

The rest of this section first applies the Hamilton (homoscedastic) model for individual economies; this is going to be the ‘benchmark’ model. Then it investigates a variety of alternative specifications to improve the fit of the model.
Figure 5.1: The actual quarterly real GDP growth rates

Notes: It should be aware of the growth rate for Singapore is calculated using industrial production index.
Table 5.3: Descriptive statistics of quarterly real GDP growth rates

<table>
<thead>
<tr>
<th></th>
<th>China</th>
<th>Hong Kong</th>
<th>Indonesia</th>
<th>Japan</th>
<th>South Korea</th>
<th>Malaysia</th>
<th>Philippines</th>
<th>Singapore</th>
<th>Taiwan</th>
<th>Thailand</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean</strong></td>
<td>1.58</td>
<td>0.45</td>
<td>0.64</td>
<td>0.25</td>
<td>0.89</td>
<td>0.72</td>
<td>0.31</td>
<td>0.86</td>
<td>0.39</td>
<td>0.63</td>
</tr>
<tr>
<td><strong>Median</strong></td>
<td>1.22</td>
<td>0.47</td>
<td>0.71</td>
<td>0.21</td>
<td>0.81</td>
<td>0.72</td>
<td>0.35</td>
<td>0.98</td>
<td>0.4</td>
<td>0.64</td>
</tr>
<tr>
<td><strong>Maximum</strong></td>
<td>8.6</td>
<td>2.86</td>
<td>5.2</td>
<td>1.77</td>
<td>4.03</td>
<td>2.63</td>
<td>3.29</td>
<td>6.6</td>
<td>2.71</td>
<td>2.54</td>
</tr>
<tr>
<td><strong>Minimum</strong></td>
<td>-1.01</td>
<td>-1.8</td>
<td>-4.96</td>
<td>-2.93</td>
<td>-3.79</td>
<td>-2.19</td>
<td>-3.39</td>
<td>-4.64</td>
<td>-2.74</td>
<td>-0.74</td>
</tr>
<tr>
<td><strong>Std. Dev.</strong></td>
<td>1.96</td>
<td>0.89</td>
<td>1.23</td>
<td>0.55</td>
<td>1.1</td>
<td>1.09</td>
<td>0.95</td>
<td>1.48</td>
<td>0.95</td>
<td>0.6</td>
</tr>
<tr>
<td><strong>Sum</strong></td>
<td>74.46</td>
<td>46.33</td>
<td>43.04</td>
<td>37.21</td>
<td>131.16</td>
<td>45.51</td>
<td>32.28</td>
<td>135.93</td>
<td>21.51</td>
<td>64.64</td>
</tr>
<tr>
<td><strong>Sum Sq. Dev.</strong></td>
<td>176.31</td>
<td>81.11</td>
<td>100.14</td>
<td>44.74</td>
<td>175.14</td>
<td>73.07</td>
<td>91.49</td>
<td>321.12</td>
<td>48.36</td>
<td>36.29</td>
</tr>
<tr>
<td><strong>Observations</strong></td>
<td>47</td>
<td>104</td>
<td>67</td>
<td>147</td>
<td>147</td>
<td>63</td>
<td>103</td>
<td>147</td>
<td>55</td>
<td>103</td>
</tr>
</tbody>
</table>
5.1.2 Model selection

As an empirical study, a central problem is how to select the "right" empirical model. Generally, there are two common approaches: general-to-specific (gets) and specific-to-general (spec). As the term suggests, the former starts with the most general model that characterises all the possible features of the data, then simplifies the model as much as possible through statistical tests and proper methods, until a congruent and parsimonious model is derived. Whereas, the latter is quite the opposite, which begins with the simplest model but includes the core variables, more relevant variables are added if they are necessary and useful to adjust inconsistencies between the model and the data.

Each modelling has its own advantages. In the gets approach, Gilbert (1986) states that, first of all, the option of including a particular coefficient is considered as adequacy rather than validity. Second, gets modelling is less vulnerable to the issue where different conclusions are drawn on the same subject due to start from different hypotheses, even he starting point is the same. Third, the estimation general model does not have misspecification as a result of omitted variables. Fourth, gets modelling is openly to the discovery of the final specification as long as it is congruent with data. Finally, gets modelling is more efficient in finding the final representation.

Lütkepohl (2007) points out that the gets approach is mainly used in modelling single time series equation. For multivariate time series, the spec methodology is more feasible. Instead of comprising all the interested variables and parameters at the beginning, only including the most important ones owing to a degree-of-freedom problem. Moreover, Herwartz (2010) shows that the spec strategy is preffered in small samples regarding ex-ante forecast performance. Furthermore, spec modelling has lower search cost.

Having discussed the merits of each strategy, with no intension of judging or even criticizing any of empirical modelling, as there is no uniform method in econometrics, but the following empirical study uses the spec methodology. The reason is that
following the previous studies on the topic of the MS model, the MS model with two regime-dependent means and four lags seems to be able to describes business cycles reasonably well. Therefore, I will start with the MSM(2)-AR(4) model shortly.

To select the best model for each economy, a specification strategy for single equation Markov-switching models is conducted. The analysis mainly focuses on the statistical significance of the estimated parameters, and the ability of the model to characterise the time paths of expansions (which are further separated into moderate growth and high growth periods) and recessions. The general steps are:

1. Estimate the Markov-switching mean or intercept model under the same number of regimes and obtaining SIC and HQ for each AR order \(r\); then, selecting \(r\) that minimizes the loss function (4.81) in Section 4.4.

2. All models are tested for linearity by taking the LR test of a linear model (based on Granger and Teräsvirta (1993), Chapter 6) as the null against an unrestricted MS-AR model. If the null hypothesis is rejected, then the time series is modelled by the class of the MS models which are nonlinear. Otherwise, it suggests that the time series is simply described by linear regression models.

3. Test for regime-dependent heteroskedasticity \(\sigma_1^2 \neq \sigma_2^2\) or \(\sigma_1^2 \neq \sigma_2^2 \neq \sigma_3^2\) under the condition of the number of regimes remains unaltered. The allowance of time-variant variances is to capture the differences in volatility between expansions and contractions. This test is performed under the likelihood ratio (LR) test. A necessary condition for the validity of the standard results is that the number of regimes \(M\) is unchanged under the hypothesis. Under this condition, t-tests concerning the significance of parameters can be performed as in linear models.
The LR test is constructed as follows

\[ H_0 : \theta = 0 \]
\[ H_1 : \theta \neq 0 \]

The test statistic is

\[ LR = 2 \left[ \ln L_{UR}(\tilde{\theta}) - \ln L_R(\tilde{\theta}) \right] \]

where \( \tilde{\theta} \) can be any estimator in the regression model, \( \ln L_{UR} \) denotes the unrestricted log-likelihood function, and \( \ln L_R \) represents the restricted log-likelihood function. Under the null, the test statistic LR follows an asymptotic chi-square \((\chi^2)\) distribution with degree of freedom \((df)\) equal to the number of restrictions imposed by the null hypothesis.

4. Examine the transition probabilities of the historical time paths for recessions.

5. A double check of the model specification using the formal statistical test is performed. The selection of the univariate regime-dependent mean MS specification is based on the complexity-penalized likelihood criterion function \((4.82)\) introduced in Section 4.4. However, the regime-dependent intercept and the multivariate MS models are not applied to this rule.

5.1.3 The MS-AR models for individual countries and districts

The Hamilton's MSM(2)-AR(4) model

I estimate the business cycle of each economy (except China\(^2\)) by using the Hamilton model (1989), which is fitted to the quarterly percentage changes. By doing so, I

\(^2\)The reason for the absence of a result for China is that some transition probabilities are close to the border and numerical stability is endangered.
attempt to investigate the features of individual economy's business cycles through the country-specific analysis. The models are estimated by maximum likelihood, which has been carried out using the EM algorithm (discussed in Chapter 4). The estimation results are summarised in Table 5.4.

The first two rows of the estimates indicate the conditional means of the quarterly growth rate of real GDP $\mu(S_t)$ in the two states. The next four rows are the estimates of the autoregressive coefficients. Rows 7 and 8 give the transition probabilities of the process staying in the expansive state or the contractionary state. The following two rows are the proportion of time in either regime 1 or regime 2 (i.e. the unconditional probabilities), and the next two rows show the expected duration of the $i$th state. Lastly, the rest of the rows are the standard errors, the log-likelihood values, the model selection criteria (the AIC, HQ and SIC), the likelihood ratio test statistic and the significance level of the linearity test.

The information observed from the country-specific analysis shows evidence to support the assumption of two distinct growth rate states in Hong Kong, South Korea, Malaysia, Singapore and Thailand. The estimates of the state-dependent means, $\mu_1$ and $\mu_2$, of these economies are statistically significant. The picture for
the other economies is more unclear. Moreover, the magnitudes of conditional means for most of countries and districts are economically different, where the mean growth rate in regime 1 is positive and the mean growth rate in regime 2 is negative. The results suggest that the state-dependent mean growth rates of quarterly contraction (expansion) for Hong Kong, Japan, South Korea, Malaysia, Singapore and Thailand are -0.99% (0.65%), -0.23% (0.29%), -1.46% (1.05%), -1.17% (1.03%), -0.82% (1.34%) and -1.36% (0.57%), respectively. On the other hand, the conditional means for Indonesia, Philippines and Taiwan in state 2 are positive. This can be interpreted as in Indonesia, Philippines and Taiwan, the mean growth rates in the low-growth regime are 0.52%, 0.28% and 0.03%, individually.

An important feature of business cycles is the asymmetric movements of expansions and recessions. One great advantage of using the MS model is that it can generate asymmetry of regimes. In general, the duration of an expansion differs from the duration of a contraction, as well as the unconditional probabilities. For example, the duration of an expansion is 19.46 quarters in Hong Kong, whereas the duration of a recession is 3.3 quarters. Seen in another way, Hong Kong spends 86% of time in an expansionary state. However, countries like Indonesia and Philippines have fairly similar durations of expansions and contractions.

The other important and the most innovative characteristic of the Hamilton model is the ability of dating business cycle turning points endogenously. The Hamilton model uses the filtered and smoothed probabilities to construct the historical time paths for corresponding growth states. In Hamilton's (1989) paper, he proposes a decision rule to date periods whether the economy is more likely in an expansion or a recession. This decision rule is based on the smoothed probability such that

\[ S_t = \begin{cases} 
1 & \text{if } Pr[S_t = 1|Y_T] > 0.5 \\
2 & \text{otherwise} 
\end{cases} \]

As before, an expansion is assigned to 1 and a recession is assigned to 2. The decision rule says that the economy is in an expansion if the smoothed probability
is greater than 0.5, or it is in a recession if the smoothed probability is less than 0.5. In addition, it requires that the minimum duration of the recessionary state lasts at least 6 months or 2 quarters.

The filtered and smoothed probabilities of recessions for each country and district are visualised in Figure 5.2. The graphs show that the time paths of the filtered and smoothed probabilities are generally consistent in dating recessions. Following the decision rule as described earlier on

- The Hong Kong's business cycle is characterised by three strong recessions marked by the Hamilton model in 1982-83, the double dip recession in 1984-1986, the financial crisis from 1997 until the early of 1999 and 2002:3-2003:3 through the sample period.

- The results on Indonesia may surprise at a first glance, as regime 2 seems to be in constant growth. However, given the estimation result, it is understandable that it represents the low growth regime rather than the recession. It still captures a major recession in 1998-1999.

- The Japanese economy is illustrated by high fluctuations between 1970 and 2006, but there is only one major recession in 1973 that has been detected.

- The estimation results for Korea show the filtered probabilities capture merely the recession in 1974-1975 whereas the smoothed probabilities capture a series of recessions in the 1970s, the short period of recession in the second half of 1980, the recession in 1998.


- The Philippine economy shows the same feature of nonstop growth in regime 2 as Indonesia. One main recession of the Philippine business cycle is shown to have taken place in 1984. Unexpectedly, it does not signal the 1997 financial crisis.
Figure 5.2: Hamilton's MSM(2)-AR(4) model
• There are several recessions spotted by the Hamilton model for the estimation of the Singaporean economy. The graph shows that the downturns from 1974 to the first half of 1975, the double-dip recession between 1981 and 1986, the recession in 1991-92, and the other double-dip recession in 1996-1999 and three continuing recessions since 2001 until 2004.

• The Hamilton estimation for the Taiwanese economy shows an unstable picture. However, since the conditional mean for regime 2 is positive, it is reasonable to interpret that the Taiwanese economy grows in the low-growth regime. Moreover, the economy of Taiwan experiences a continuous sequence of contractions from 1999 to 2006.

• Finally, the model picks up a double-dip recession for the Thai economy in 1996:3-1999.

In summary, it has been shown that the MSM(2)-AR(4) model proposed by Hamilton is only able to capture some features of the individual business cycle in the dataset. Nevertheless, there is a need to explore alternative specifications, as the results are not satisfactory in most cases (e.g. missing known recessions). The next section examines various forms of the MS-AR model, and selects the ‘best’ one for modelling the business cycle in each economy in the sample.

The MS-AR model

In the last section, it was argued that the specification of the MSM(2)-AR(4) model in Hamilton’s (1989) paper was not able to fully capture the characteristics of most of individual countries’ and districts’ business cycles. Hence, I will consider more general Markov-switching models in this section. Initially, the assumption of a two-regime MS model is maintained and an alternative specification where the intercept term is subject to regime shifts is considered. Moreover, the assumption of a homoskedastic variance is relaxed. In a further step, the MS-AR model with three regimes is employed, where regime 1 stands for high growth periods, regime 2 de-
notes normal or moderate growth periods, and regime 3 corresponds to recessions or low growth periods. The estimation results are shown in Table 5.5, Table 5.6 and Appendix A (alternative specifications of the MS-AR model).

**China.** According to the loss function, a second autoregressive order$^3$ is chosen among the two-regime models with regime switching means. Thus, I estimate the MSM(2)-AR(2) model first. The result shows that both regime-dependent means are statistically significant, but the signs in both regimes are positive. It can be explained that average growth in the low growth state is around 1.12% per quarter, and is 8.2% per quarter in the rapid growth state. The transition probability of the high growth state is 0.33 and that of the low growth state is 0.98. Expected duration of regimes are 1.49 quarters for high speed expansions and 41.52 quarters for low speed expansions. Meanwhile, the unconditional probabilities of the MSM(2)-AR(2) show the Chinese economic fluctuations spend most of time in the low growth regime. This is evidence suggesting that the three-regime Markov-switching model may be more appropriate. Under the three regimes, AR(1) is chosen.

Clearly, the MSM(3)-AR(1) model improves the fitness of the data much better. The regime-varying means and the autoregressive coefficient are statistically significant. The estimated quarterly mean growth rate in the high growth phase is around 7.32%, and that in the moderate phase is about 0.9%, and 2.27% in the low growth phase. All regimes are statistically significant, and the differences of their magnitudes are considerable. Expected duration of high growth is 1.51 quarters, that of normal growth is 8.46 quarters, and that of low growth is 1.59 quarters. In addition, LR linearity test rejects the null hypothesis of linearity.

Dating of time paths of recessions are based on the filtered and smoothed probabilities as illustrated in Figure 5.3b. The MSM(3)-AR(1) model picks up single strong low growth in 1996:2-1997:2 and in 2004. It is worth to note that the Chi-

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$^3$The maximum order of the MSM model can be estimated for China is 2. This is because during the estimation of MS-AR beyond order 2, some transition probabilities reach the limits, and this endangers numerical stability.
Table 5.5: Estimation results: The MS-AR models

<table>
<thead>
<tr>
<th>Parameter</th>
<th>China (MSM(3)-AR(1))</th>
<th>Hong Kong (MSMH(3)-AR(4))</th>
<th>Indonesia (MSIH(3)-AR(4))</th>
<th>Japan (MSMH(3)-AR(3))</th>
<th>Korea (MSIH(3)-AR(4))</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\mu_1$</td>
<td>7.32 (0.62)</td>
<td>1.84 (0.07)</td>
<td>0.73 (0.32)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\mu_2$</td>
<td>0.9 (0.22)</td>
<td>0.36 (0.11)</td>
<td>0.19 (0.07)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\mu_3$</td>
<td>2.27 (0.46)</td>
<td>-0.64 (0.24)</td>
<td>-0.37 (0.41)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$v_1$</td>
<td></td>
<td>1.11 (0.22)</td>
<td></td>
<td></td>
<td>0.83 (0.36)</td>
</tr>
<tr>
<td>$v_2$</td>
<td></td>
<td>0.32 (0.12)</td>
<td></td>
<td></td>
<td>0.51 (0.13)</td>
</tr>
<tr>
<td>$v_3$</td>
<td></td>
<td>-0.69 (1.62)</td>
<td></td>
<td></td>
<td>-0.43 (1.23)</td>
</tr>
<tr>
<td>$\phi_1$</td>
<td>-0.45 (0.09)</td>
<td>0.11 (0.08)</td>
<td>0.04 (0.06)</td>
<td></td>
<td>0.22 (0.14)</td>
</tr>
<tr>
<td>$\phi_2$</td>
<td></td>
<td>0.28 (0.07)</td>
<td>0.08 (0.06)</td>
<td></td>
<td>0.15 (0.06)</td>
</tr>
<tr>
<td>$\phi_3$</td>
<td></td>
<td>-0.07 (0.08)</td>
<td>0.3 (0.07)</td>
<td></td>
<td>0.08 (0.06)</td>
</tr>
<tr>
<td>$\phi_4$</td>
<td></td>
<td>-0.04 (0.07)</td>
<td>-0.06 (0.07)</td>
<td></td>
<td>-0.06 (0.06)</td>
</tr>
<tr>
<td>$p_{11}$</td>
<td>0.33 (0.07)</td>
<td>0.72 (0.03)</td>
<td>0.87 (0.03)</td>
<td></td>
<td>0.97 (0.03)</td>
</tr>
<tr>
<td>$p_{22}$</td>
<td>0.88 (0.17)</td>
<td>0.96 (0.17)</td>
<td>0.98 (0.17)</td>
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<td>0.98 (0.17)</td>
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<tr>
<td>$\xi_1$</td>
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<td>0.17 (0.16)</td>
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<td>$\xi_2$</td>
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<td>0.72 (0.16)</td>
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<td>0.84 (0.16)</td>
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<td>0.06 (0.16)</td>
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<tr>
<td>$(1 - p_{11})^{-1}$</td>
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<td>8.88 (0.07)</td>
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Table 5.6: Estimation results: The MS-AR models (Cont.)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Malaysia MSM(3)-AR(4)</th>
<th>Philippines MSMH(2)-AR(4)</th>
<th>Singapore MSI(3)-AR(4)</th>
<th>Taiwan MSM(3)-AR(4)</th>
<th>Thailand MSM(3)-AR(4)</th>
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<td>0.88</td>
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<td>3.8</td>
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<td>2.57</td>
<td>3.79</td>
<td>2.12</td>
<td>3.14</td>
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<tr>
<td>[HQ]</td>
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<td>2.81</td>
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<td>15.38</td>
<td>42.57</td>
<td>25.37</td>
<td>21.22</td>
<td>24.86</td>
</tr>
</tbody>
</table>

nese business cycle may not experience any recession, but it cannot rule out the possibility of having low growth, even though the classical business cycle does not show.

Although the complexity-penalized likelihood criterion suggest that the MSM(2)-AR(2) model is preferred than the MSM(3)-AR(1) model (74.93 vs 77.69), all three regime-dependent means in the latter model are statistical significant. This may be due to the small sample size.

It is reasonable to assume that the average growth rates move smoothly towards a new level after transforming from one state to another. In this circumstance, the MSI-AR specification is employed. As dictated by the information criteria, the first-order autoregressive process is represented. The results that are estimated by the MSI(3)-AR(1) model are somehow different from those of the MSM(3)-AR(1) model. As a comparison with the MSM(3)-AR(1) model, the growth rate in the high growth regime is 8.37%, 1.06% in the moderate growth regime, and 1.93% in the low growth regime. The probabilities of staying in all the three regimes are greater than those estimated in the MSM(3)-AR(1) (0.41 vs. 0.33 in high growth, 0.94 vs. 0.88 in normal growth and 0.86 vs. 0.37 in low growth). Correspondingly, the expected duration of all the regimes are longer as estimated by the MSI(3)-AR(1) model which are 1.71 quarters for high expansion, 17.09 quarters for moderate expansion and 6.99 quarters for low expansion. In addition, the filtered and smoothed probabilities of detecting low growth in 1996:4-1998, 2003-2004 and 2005:1-2006. In brief, either the MSM(3)-AR(1) or the MSI(3)-AR(1) model can be considered as the best choice of analyzing the Chinese business cycle given that the differences between the two models are minor.

Hong Kong. The best choice of the order of lags for Hong Kong is four in the case of the mean-dependent MS model with two regimes. The estimation results of the Hamilton model for Hong Kong seem to explain the data well, as given in Table 5.4. The mean growth rate in the expansion and the recession regimes are 0.65% and -0.99% respectively, which are both statistically significant. The duration of
Figure 5.3: The MS-AR model for the Chinese business cycle
expansions lasts on 19.46 quarter, whereas that of recessions lasts only 3.3 quarters. This fits the realisation that expansions are longer than recessions, and recessions have short durations. It is also revealed from the transition probabilities as the transition probability of staying in regime 1 is greater than that of staying in regime 2. However, this model fails to reject the null hypothesis of linearity.

I relax the assumption that the white noise process $e_t$ is homoskedastic, instead allowing for regime-dependent heteroskedasticity of $e_t$. The null hypothesis is $\sigma^2_{S_{t=i}} = \sigma^2_{S_{t=j}}$, for $i, j = 1, \cdots, M$. The LR test yields $LR = 2(\ln L_{UR} - \ln L_R) = 14.8$ and follows the $\chi^2$ distribution with degree of freedom equal to 1, which gives the critical value equals 3.84. Hence, the null hypothesis is rejected at 5% significance level, and I accept that the variance is regime-dependent, i.e. $\sigma^2_{S_{t=i}} \neq \sigma^2_{S_{t=j}}$, at least one $i \neq j$.

The conclusion draws from the estimated MSMH(2)-AR(4) model is dramatically different from the homoskedastic MSM(2)-AR(4) model. It shows the mean quarterly growth rate in the low growth state is 0.39%, whereas in the MSM(2)-AR(4) model is -0.99%. Moreover, the mean growth is not statistically significant in the high growth regime. The duration of high growth lowers dramatically to 9.17 quarters, whereas the duration of low growth increases to 17.55 quarters. The standard error of high growth (1.21) is higher than that of low growth (0.46). The filtered and smoothed probabilities graph that the Hong Kong’s economy has stayed in the low growth regime since the late 1980s as shown in Figure 5.4a. In addition, the regime-dependent variance MS model rejects the null in favour of the alternative hypothesis that the series is nonlinearity.

Therefore I consider the three regimes model and AR(4) is selected. I estimated the MSM(3)-AR(4) and the MSMH(3)-AR(4) specifications. It is found evidence of heteroskedasticity in variances since the estimated LR test statistic gives 6.44 is greater than the critical value 5.99 at the significance level of 5%. The MSMH(3)-AR(4) model indicates that the quarterly mean growth rates of regimes are -0.64% in recessions, 0.36% in normal growth, and 1.64% in rapid growth, all three regimes
Figure 5.4: The MS-AR model for the Hong Kong's business cycle
differ statistically significant and economically.

Recessions in Hong Kong have an expected duration of 3.36 quarters, and that of high expansion is 3.59 quarters. Whereas normal growth lasts on 23.68 quarters and it shows greater persistence, the transition probability of a normal growth period followed by another quarter of normal growth periods is 0.96. In addition, periods of rapid growth are slightly more volatile than periods of other two growth phases as suggested by the standard errors. The estimated probabilities of recessions using the MSMH(3)-AR(4) model show a very similar picture as the MSM(2)-AR(4) model, as given in Figure 5.4b. However, it does not detect the recessions in 1995 and 2001 which are spotted by the classical points.

Moreover, among all the MSM specifications, the criterion function suggests that the MSMSH(3)-AR(4) model is the best, given the minimum value of 109.71.

I also estimate the MSI specification, the autoregressive order of four is chosen once again. Testing the heteroskedasticity of variances at 5% significance level, it is expected that the variances are found to be regime-dependent. Furthermore, the results are so different from the corresponding MSM-AR models. In the MSI(2)-AR(4) model, the growth rate in regime 1 is 1.63% and 0.19% in regime 2. The duration of regime 2 is longer than that of regime 1 (20 vs. 2.39 quarters). The transition probability of regime 2 is 0.95, which is larger than that of regime 1 as it gives 0.58. This is the exactly opposite story of the corresponding MSM specification.

Then the MSI specification with 3 regimes has been conducted. Once more, there is evidence of heteroskedasticity and the lag of 3 is selected. In the MSIH(3)-AR(3), the growth rates are 0.85% in high growth, 0.15% in normal growth, and -1.42% in low growth. All of them are statistically significant. High and low growth last shorter durations with 4.08 and 1.3 quarters individually, whereas normal growth lasts on 25.87 quarters. Moreover, the transition probabilities of remaining in the same regime are 0.75 for high growth, 0.96 for normal growth and 0.23 for low growth. The outcome of the MSIH(3)-AR(3) model in the estimated turning points of recessions, as visualised in Figure 5.4c, is less fluctuated and short-lived than the
analogous MSMH model. It dates five major recessions in the first half of 1982, 1984:2-1985:3, the second half of 1987, 1997:3-1998:1, and the first half of 2003. To sum up, the MSMH(3)-AR(4) model is chosen as the best fit for Hong Kong, in line with the reference business cycle dating.

**Indonesia.** The linearity test in the Hamilton model indicates that there is no need to fit a nonlinear model to the data. However, the lag 4 is not the choice as shown by the loss function. Hence, the autoregression of order 2 appears to be the most satisfactory, in which case the linearity assumption is rejected. The estimation of the MSM(2)-AR(2) model indicates a negative mean growth rate of -2.74% per quarter in regime 2, a positive mean growth rate of 0.81% in regime 1, and they are statistically significant. The expected duration of the contraction state and that of the expansion state are 2.15 and 60.14 quarters, respectively. There is only one strong recession in 1998 marked by the MSM(2)-AR(2) model in Figure 5.5a.

Testing the assumption of regime-dependent variances, the estimated LR statistics is 42.26, hence the null of homoskedasticity is rejected. Once more, under the condition of regime-dependent variances, the picture of the Indonesia business cycle is characterised differently. First of all, the order of three is chosen. Second, the estimated mean growth rates of two regimes are both positive at 0.91% (regime 1) and 4.25% (regime 2) correspondingly. This is odd that the average growth of high growth is far less than that of low growth. Third, the estimated duration of low growth is 1.1 quarter, and the duration of high growth is about 11.69 quarters. The transition probabilities give the same story that the probability of staying in low growth is far too low, in contrast to highly persistent probability in regime 1. Additionally, the model depicts four strong but short-lived fluctuations in the second half of 1996, the first half of 1998, 1999:4-2000:1, and the second half of 2001 in Figure 5.5b.

Given the practical doubts, three regimes is considered. Evidence of heteroskedas-
ticity is found. The autoregressive order of zero is selected\(^4\). The high growth, the normal growth and the low growth regimes expand at 1.35%, 0.49% and 0.3% per quarter in the MSMH(3)-AR(0) model. However, the last two regimes are statistically insignificant. The duration of three regimes is 2.65 (high growth), 6.65 (normal growth) and 1.54 (low growth) quarters individually. After all, the MSMH(2)-AR(3) is the most appropriate model among the MSM specifications, as selected by the criterion function.

Since the mean adjusted form of the Markov-switching model implies that a permanent regime shift in the mean \((\mu(S_t))\) results an immediate one-time-jump in the process mean into a new level. It may consider that the adjustment of the expected growth rate approaches smoothly to its new level after a change in regime. In this situation, the MSI-AR model may be used.

Among the two regimes of MS intercept models, the lag of order four is selected. In the MSI(2)-AR(4) model, the growth rates in regime 1 and regime 2 are indifferently in magnitudes and statistically insignificant (0.61% in regime 1 and 0.31% in regime 2). Meanwhile, the duration of high growth decreases dramatically to 3.73 quarters. Moreover, the linearity test of the model is failed to reject the null. Therefore, the LR test of detecting regime-dependent variances is carried out and is found to support the alternative hypothesis (i.e. \(\sigma^2_{S_i \neq j} \neq \sigma^2_{S_i \neq j}\), for \(i \neq j\)). The same as before, lag 4 is picked. Surprisingly, unlike the homoskedastic MSI model, the MSIH(2)-AR(4) model estimates the quarterly growth rates in two regimes (0.44% for expansions and -0.22% for recessions) change in opposite directions as a comparison with the MSI(2)-AR(4) model, although the recession regime is statistically insignificant. The expected duration of a recession is still around 1 quarter, but that of an expansion is 10.3 quarters. Coincidentally, the unconditional probability of expansions is 0.91, while that of contractions is 0.09. The probability of staying in expansions is highly consistent around 0.9 and that of staying in recessions is extremely low around 0.02 which proves the low persistence of regime 2.

\(^4\)When the order of lags is zero, the MSM specification is equivalent to the MSI specification.
Figure 5.5: The MS-AR model for the Indonesian business cycle
standard error is five times volatile in recessions than in expansions (3.22 vs. 0.62). Furthermore, the model is able to reject the null of linearity. The probabilities of the MSIH(2)-AR(4) model spot the same recessions during the sample period as the MSMH(2)-AR(4) model, except the recession in 1996.

In the case of three regimes, the MSIH(3)-AR(4) model is preferred. The high and normal expansion regimes have positive and significant growth rates about 1.11% and 0.32% respectively, however, the recession regime is insignificant even though it is negative at -0.69%. The transition probabilities and the unconditional probabilities indicate the normal expansion regime is more persistent than other two regimes, while the expected duration of the normal expansion lasts on 8.88 quarters and that of the high expansion and the recession last on 2.48 and 1.03 quarters. The state of recessions displays a relative high degree of volatility with the standard error equals 3.4. The filtered and smoothed probabilities of the MSIH(3)-AR(4) model illustrate the same recessions as the MSIH(2)-AR(4) model. Overall, the best fitness of the MS specification for business cycles of Indonesia is inconclusive. In relation to classical turning points, the MS models capture an additional recession in 1999:4-2000:1.

Japan. As suggested by the loss function, the Hamilton model is opted. The discussion of the model results has already represented in the early section, thus it will not repeat in detail here. Only one point needs to be clarified. The linearity test in the Hamilton model suggests that a linear model describes the data more adequately, but there is a doubt on the presence of heteroskedasticity, which means the invalidity of the test. So, I carry out the heteroskedastic test. The LR statistic obtains 34.6 which rejects strongly the hypothesis of regime-invariance. Again, the lag four is chosen. The MSMH(2)-AR(4) model estimates the growth rate in the expansion regime is 0.23% per quarter and in the recession regime is -0.1% per quarter. However, the significance level of the recession regime is far above 5%. The expected duration of the expansionary regime is 76.9 quarters with high persistent transition probability of 0.99, and that of the ressionary regime is 9.56 quarters with
comparable high persistent transition probability of 0.9. As expected, the regime of expansion shows less fluctuation than the regime of recession as revealed by the regime-dependent standard errors (0.36 vs. 1.04). The MSMH(2)-AR(4) model in Figure 5.6a visualises a long-lasting recession in 1972-1976 which includes the first oil price shock and the bubble economy in 1989.

A consideration of the Markov-switching mean specification with three regimes is conducted. Hence, I estimate the 3-regime Markov-switching model with the lag of order 2. In the MSM(3)-AR(2) model, the quarterly mean growth rates are 1.24% for high growth, 0.4% for moderate growth, and 0.02% for low growth. This time estimated mean growth rates of the high and moderate phases are statistically significant, but the low growth phase remains insignificant. The results also show that the Japanese business cycle has an extremely high persistency in the low expansion phase with the transition probability of 0.98. Moreover, the state of normal growth is also highly persistent (0.97). This can also be revealed from the expected duration of the regime, which lasts on 48.66 quarters in low expansion and 28.99 quarters in moderate growth. The expected duration and the transition probability of high expansion are considerably lower than other two states, given the values of 4.71 quarters and 0.79. Moreover, the outcome of the MSM(3)-AR(2) model is graphed in Figure 5.6b. It can be seen that the model detects strong low growth in the 1970s including the first oil-price shock from 1973-1976 and unrest low growth since the 1990s.

Given the confirmation of regime-dependent variances, the MSMH(3)-AR(3) model is suggested. Meanwhile, it is also the best model according to the criterion function which gives 86.24. The noticeable differences between the homoskedastic and heteroskedastic model are the opposite signs in regime 3 (0.02% vs. -0.37%) and the duration of regime 3 and regime 2 (48.66 vs. 4.62 quarters and 28.99 vs. 63.59 quarters). The volatility of the contraction regime is severer than other two regimes as suggested by the standard errors. Furthermore, the filtered and smoothed probabilities of the MSMH(3)-AR(3) only detect the period of the downturn in the early
Figure 5.6: The MS-AR model for the Japanese business cycle
of the 1970s which is the first oil price shock (1973-1975) and the bubble economy in 1988-1990.

Then the model of MSI(2)-AR(4) is calculated and gives different regime identification compared to the MSM specification. The estimation results of this model give positive quarterly growth rates of 0.19% in regime 1 and 0.07% in regime 2, which are both statistical insignificant as it is further proved by the failure of passing the linearity test. Consequently, the desire of testing the assumption of homoskedasticity is required, and the test provides the proof of regime-dependence. The two regime growth rates are still positive, where high expansion is slightly lower than low expansion (0.11% vs. 0.21%), besides, the low expansionary regime is statistical insignificant. Both the estimated expected duration of high and low expansion increase considerably to 55.25 and 9.41 quarters, in relation to the MSI(2)-AR(4) model. So are the transition probabilities of remaining in the same regime. The transition probability of staying in the low growth phase (0.89) is less than that of staying in the expansion phase (0.98). The MSIH(2)-AR(4) model shows the similar picture of dating economic downturns as the MSMH(2)-AR(4) model, as illustrated in Figure 5.6d.

Applying three regimes to the MSI specification. Testing for regime-dependent heteroskedasticity gives $LR = 11.12$ for the hypothesis MSI(3)-AR(3)$^5$: $\sigma^2_{S_t=1} = \sigma^2_{S_t=2} = \sigma^2_{S_t=3}$, versus MSIH(3)-AR(3): $\sigma^2_{S_t=1} \neq \sigma^2_{S_t=2} \neq \sigma^2_{S_t=3}$. With $\chi^2_{0.05}(2) = 5.99$, the null hypothesis of a regime-invariant variance is rejected. In the MSIH(3)-AR(4) model as it is chosen, two expansion regimes are statistically significant, where in normal growth is 0.1% and in high growth is 0.51%. The contraction regime is -0.94% and statistical insignificant. The unconditional probability of a contracted growth is about 0.03 and with a duration of 1.01 quarters, the unconditional probability of a normal growth is 0.83 and with a duration of 66.81 quarters, and the unconditional probability of a rapid growth is 0.15 and the duration of 3.82 quarters. The persistency of moderate growth and high growth is higher than that of contracted

$^5$The MSI(3)-AR(4) model is unable to calculate, given the same problem as I estimate the MSM specification for China.
growth (0.99, 0.74 and 0.01, respectively). The MSIH(3)-AR(4) model captures the comparable fluctuated movements of business cycles with the MSMH(3)-AR(3) model in Japan as Figure 5.6e clarifies. Briefly, although the MSMH(3)-AR(3) and the MSIH(3)-AR(4) models are more or less comparable, the more parsimonious MSMH(3)-AR(3) model is chosen as the best fit of describing the macroeconomic fluctuations of the Japanese economy.

Moreover, all the estimated univariate MS models apart from the MSM(3)-AR(2) model identify two major recessions during the sample period, compared to the turning points in Table 5.1.

South Korea. The appropriate lag order in the two-regime MS model is four, which is the same as in Hamilton’s model. Thus, the discussion of the estimation results of the model will not represent here again. Alternatively, the test of heteroskedasticity is performed and is found to support the alternative hypothesis. The MSMH(2)-AR(4) model estimates the positive average quarterly growth rates in high growth (0.78%) and low growth (1.32%) in contrast to the negative average growth rate in regime 2 in the Hamilton model. The expected duration of regime 1 rises slightly from 17.02 quarters (the Hamilton model) to 17.14 quarters (the MSMH(2)-AR(4) model) and that of regime 2 rises dramatically from 1.78 quarters to 7.53 quarters. In the meantime, the economy is more fluctuated in regime 2 than in regime 1 as said by the standard errors (1.69 versus 0.48). Figure 5.7a visualises prolonging fluctuations during the 1970s and the early of the 1980s, slow growth in 1987-1989, 1997-1998 and 2001-2002.

Adopting three regimes and testing heteroskedasticity of variances, the MSMH(3)-AR(4) model is preferred and is also suggested by the complexity-penalized likelihood criterion. The estimated quarterly average growth rates are 2.25% in high expansion, 0.78% in moderate expansion and -0.46% in the contraction which is though statistically insignificant. It is not surprise to see that with the expected duration of lasting on 13 quarters in normal expansion, the transition probability of staying in the same regime is 0.92 which is as twice as higher than other two regimes
(0.34 in high growth and 0.45 in the recession). At the same time, the volatility of the recession regime is more unstable than other two expansion regimes. In Figure 5.7b, the filtered and smoothed probabilities capture the first and the second oil price shocks (1973-1975 and 1979:4-1980), the recession in 1987 and the Asian financial crisis in 1997.

As always, I consider a smooth adjustment in mean growth rather than an immediate jump into the new level, corresponding to a regime shift. The MSI(2)-AR(4) model shows that quarterly growth in regime 2 changes immediately to 0.39% and in regime 1 to 0.68%, but regime 2 is not statistically significant. The most obvious change is the almost equalised transition probabilities as well as the expected duration of the two regimes (0.72 against 0.73, and 3.56 against 3.73 quarters). Due to the regime classification calculated by the MSI(2)-AR(4) model, it is not amazed to see the Korean economy swings in the low growth regime over time. After all, the model fails to pass the linearity test.

Having tested for the heteroskedasticity, I find the null hypothesis is rejected given the LR test statistic equals 53.44, in other words, $\sigma_1^2 \neq \sigma_2^2$. Therefore, I estimate the MSIH(2)-AR(4) model. The growth rates of regimes are 0.46% quarterly for high expansion, 0.62% per quarter for low expansion which are both statistically significant. The duration of time in high expansion lasts on 21.36 quarters which is longer than the estimated result in the MSI(2)-AR(4) model, and the duration of low growth lasts on 9.09 quarters which is also longer than the estimate in the previous model (3.73 quarters). In addition, the volatility in the low growth regime (1.65) is more fluctuated than in the high expansion regime (0.51). It is noticeable that the transition probability of entering and staying in the high growth regime increases substantially from 0.72 (in the MSI(2)-AR(4) model) to 0.95. For the meantime, the persistency of staying in the low growth regime also rises to 0.89.

The results for the Korean business cycle analysis using the MSIH(2)-AR(4) model is graphed in Figure 5.7c, which is similar to the description of the MSMH(2)-AR(4) model. It can be seen clearly that the major difference from the model
Figure 5.7: The MS-AR model for the Korean business cycle

Along with the three-regime forms, the heteroskedastic model with 4 lags is selected. Although the estimated rates of three regimes growth have expected signs which are 0.83% in high expansion, 0.51% in moderate expansion and -0.43% in the recession, the contraction regime is not statistically significant from zero. High and normal expansion have the long-term expected duration of 36.85 and 44.43 quarters individually, whereas the expected duration of contractions persists just 2.03 quarters. The most noteworthy discrepancy is that the model detects only two short time recessions in 1980-1981 and the financial crisis of 1997. Moreover, the recession regime is the most volatile regime (2.58), and is followed by the high growth regime (1.39). To conclude, even though the MSIH(3)-AR(4) model fits the reference business cycle dating best, given the suspicion of the importance of regime 3, the model that can be used to best describe business cycles of the Korea economy is indecisive.

Malaysia. Model selection procedures suggest the Hamilton model. As a matter of fact, the regime-variant variances model MSMH(2)-AR(4) is rejected. The results of the heteroskedasticity of the MSM(2)-AR(4) model lead to indifference regime classification. The difference in the regime standard errors has no effect on the regime detection that is determined by shifts in mean due to different movements of the business cycle. The Hamilton model seems to capture the characteristics of the Malaysian business cycle rather well. Two regime-dependent means are both statistically significant and economically magnitudes. The expected duration of expansions and recessions are 24.81 and 3.62 quarters, provided that the transition probability of staying in the expansionary regime (0.96) is higher than that of staying in the recessionary regime (0.72) as anticipated.

Next, given the minimized criterion value of 74.84, in the MSM(3)-AR(4) model, all three regimes are still statistically significant and economically magnitudes, with
the values of 1.32% per quarter in the high expansionary regime, 1% per quarter in the normal expansionary regime and -1.15% quarterly in the contractive regime. The moderate expansionary state in Malaysia has an expected duration of 20.78 quarters, it shows strong persistent with the transition probability that the regime will be followed by another quarter of normal growth is 0.95. On the other hand, the duration of the high expansionary and the recessionary regimes only last on 3.03 and 3.86 quarters correspondingly but both of the persistency are great (about 0.67 and 0.74 individually). An overview of the results with the MSM(3)-AR(4) model is given in Figure 5.8a. The model reveals the financial crisis (1997:4-1998) and the recession in 2000:4-2001.

Alternatively, the MSI(2)-AR(4) model is estimated. The estimation outcomes change slightly. The model illustrates the shifts from regime 1 with a positive conditional growth rate $\mu_1 = 1.66$ to regime 2 with a negative growth rate $\mu_2 = -0.78$. Moreover, the duration of time in the expansionary state lasts fairly shorter (22.8 quarters) compared to the MSM(2)-AR(4) model. In contrast, the duration of the recessionary state is slightly longer to 3.76 quarters. Additionally, the MSI(2)-AR(4) model also detects the same recessions during the sample period as given in Figure 5.8b. Meanwhile, the heteroskedastic model with two-regime and four lags is also rejected by the LR test.

According to the results of the MSI(3)-AR(2) model, the growth rates of the smoothed regime shifts are 2.02% in high growth, 0.88% in moderate growth and -1.17% in the contractive regime which are not so different from the outcome of the analogous MSM specification. The most perceptible variation is the estimated expected duration of the high expansionary regime which is only 1.21 quarter, as well as the considerably shortened duration of the normal expansionary regime which is just 2.91 quarters. On the other hand, the expected duration of the recessionary regime has not altered much as it still lasts on 3.63 quarter. Moreover, the transition probability of persisting in regime 1 is very low at around 0.17, and that of remaining in regime 2 drops also moderately to 0.66.
Figure 5.8: The MS-AR model for the Malaysian business cycle
Overall, along with the performance of the above models, the MSM(3)-AR(4) model is considered as the best fit in the case of the Malaysian economy. Besides, all the inferred recessions obtained by the MS models are consistent with the classical turning points.

**Philippines.** In accordance with the model selection criteria, the order of two is chosen. In the MSM(2)-AR(2) model, the economy of Philippines exhibits considerably low growth rates in contractions with an estimated quarterly rate of \(-1.95\%\). However, the probability that a recession will be followed by another quarter of the recession is fairly moderate. Furthermore, the proportion of time in recessions is only 0.05, at the same, the recession only persists a very short period with the value of 1.67 quarters. On the other side, the expected duration of booms is 30.85 quarters, even if the average quarterly growth rate is 0.45%. The model sketches a double-dip recession in 1984-1985:3 and 1990:4-1991:1 in Figure 5.9a. It is unanticipated that the 1997 financial crisis fails to be picked up. Additionally, the null hypothesis of linearity is strongly rejected while it is accepted in the Hamilton model.

As usual, a LR test for regime-dependent heteroskedasticity is conducted and it is rejected the null of a regime-invariant variance. The model of regime-dependent variances tells a completely different story. First of all, the order of lag 4 is chosen. Second, both regime-dependent means have no long opposite signs given the quarterly rates of 0.4% in high growth and 0.18% in low growth, on top of the insignificance of low growth. Third, the length of the two regimes is altered simultaneously to 6.98 (high growth) and 3.47 (low growth) quarters. Fourth, correspondingly, the transition probabilities are also adjusted to great persistency in both regimes with the values of 0.86 in high expansion and 0.71 in low expansion. Moreover, the standard errors imply that the economy is more than 4 times fluctuated in low expansion than in high expansion (1.46 vs. 0.34). The probabilities of the recession state for the MSMH(2)-AR(4) model is sketched in Figure 5.9b. It perceives a number of strong low growth between 1984 and 1992, in 1996-1997:2, 2000 and 2002-2003. In comparison with the classical turning points, the homoskedastic model detects the
identical recessions, whereas, the heteroskedastic model captures more frequent low growth.

Then I applied the three-regime model with lag 4. However the t-test for the high expansionary state is statistically insignificant with quarterly growth of 0.11%. In contrast, the quarterly mean growth rates of moderate expansion and the recession are statistically significant and economically magnitudes with the values of 0.54% and -2.08%. Moreover, the transition probability of the recessionary state is comparatively low, and the unconditional probability is only 0.04 corresponding to the expected duration of 1.59 quarters. In addition, the transition probability of the moderate expansionary regime is relatively higher than that of high expansionary regime (0.96 versus 0.77). The two regimes have the expected duration of 4.28 (high growth) and 25.57 (normal growth) quarters. The implication of the MSM(3)-AR(4) model for the statistical characterisation of the Philippines business cycle illustrates the same time paths of recessions as the MSM(2)-AR(2) model.

Although the alternative hypothesis of heteroskedasticity is accepted, it is unreasonable that the high growth regime is negative, in addition to the statistic insignificance of the recessionary regime. Therefore, the heteroskedastic model of the three-regime specification is excluded from the discussion. Nevertheless, the criterion function based on the MSMH(2)-AR(4) model produces the smallest value of 106.73, compared to other MSM models.

Applying the smoothed adjustment of growth in regime shifts, the MSI(2)-AR(2) model presents small differences from the MSM(2)-AR(2) model. The growth rate of the contractive regime is slightly higher in absolute term as given by -2.25%. Furthermore, the expected duration of the expansionary regime has been shortened to 25.27 quarters. Moreover, the probabilities of recessions reveal an additional recession in the second half of 1986 in comparison to the MSM(2)-AR(4) model in Figure 5.9d. Similarly, the analogous model with the regime-dependent variances provides comparable story of the Philippine business cycle as the MSMH(2)-AR(4) model.
Figure 5.9: The MS-AR model for the Philippine business cycle
In the homoskedastic three-regime model, lag 2 is selected. The quarterly growth rates of three states are 0.99% in high growth, 0.37% in normal growth and -2.32% in recessions. All of them are statistically significant. The model estimates that the state of high growth has the expected duration of 2.43 quarter, which is nearly twofold of that in the recessionary state. Additionally, the expected duration of moderate growth lasts on 63.66 quarters. The transition probability of remaining in the recessionary state is considerably lower than other two regimes, which further confirms the above points. What is more, the recessionary probabilities capture the recessions in 1984, 1985:2-1985:4 and 1986:3-1986:4, whereas the recession in the late of the 1980s has been eliminated, as shown in Figure 5.9e. Once again, for the same reason, there will be no discussion about the heteroskedastic specification of the regime-dependent intercept with three regimes. Overall, the MSMH(2)-AR(4) model seems to be the best fitted regression model for business cycles of the Philippine economy.

Singapore. The Hamilton model suggests the conditional mean of the growth rates in the booming and the recessionary states have expected signs and are both statistically significant. The regime durations consist also to the conventional sketch of the longer length of booms, as the model gives 10.53 quarters in booms and 3.13 quarters in recessions. Then testing for heteroskedasticity, the LR test statistic gives 13.04 which suggests the rejection of the null. The MSMH(2)-AR(4) model estimates two positive conditional mean growth rates in both regimes with the values of 1.39% (high expansion) and 0.4% (low expansion), both states are statistically significant at 5%. The expected regime duration of high growth is 9.81 quarters which is lower than the duration of low growth as it is 13.53 quarters. In the meantime, the transition and unconditional probabilities are higher in the low growth state which are 0.93 and 0.58 respectively. Since the probabilities of regime 2 stands for low growth, it can be seen that the overall Singaporean economy is rather unstable in Figure 5.10a, this is proved by the estimated standard errors (0.73 in booms and 1.62 in contractions). As suggested by the transition probabilities, each time of the
occurrence of low growth persists a quite long time. Low growth takes place from 1974 to the first half of 1977, more than half decade during the 1980s, in 1991-1992 and since 1995 until the end of the sample period.

In relation to the outcome of the MSMH(2)-AR(4) model, the three regimes is performed. The MSM(3)-AR(4) model exhibits a high positive mean in regime 1 (about 2.2% quarterly), a considerable expanding speed rate in the normal growth state (around 1.2% per quarter) and a rational contractive rate of -0.6% in the recessionary state. Moreover, the duration of time in the high growth and the recession regimes are fairly close (3.55 and 3.96 quarters), for the meantime, the transition probabilities of these two regimes are similar too. The expected duration of moderate expansion lasts on 9.94 quarters with the transition probability of 0.9. The visualization of the MSM(3)-AR(4) model as shown in Figure 5.10b displays several strong recessions in 1974-1975:2, a double-dip recession in 1980-1985, 1991-1992:3, the other double-dip recession in 1995:2-1998 taking account of the Asian financial crisis, and 2000-2003:2.

A similar situation happens to the heterskedastic MSM(3)-AR(4) model, regarding to the MSMH(2)-AR(4) model. However, on the basis of the complexity-penalized likelihood criterion function, the MSMSH(3)-AR(4) model is chosen. All three regimes are positive, but regime 3 (recession) is statistically insignificant. The longer regime duration in regime 3 compares to other two regimes. Furthermore, the outcome of the MSMH(3)-AR(4) model graphs the almost identical description of macroeconomic fluctuations in low growth regime as the MSMH(2)-AR(4) model.

The MSI(2)-AR(4) model presents that the shifts from the boom regime with a positive growth rate $v_1 = 1.54$ to the recessionary regime with a negative growth rate $v_2 = -0.91$. The expected duration of time in the boom lasts even longer (12.44 quarters) in contrast to the Hamilton model. On the other hand, the duration of the recession is shorter to 2.94 quarters. The recessionary probabilities of the model (in Figure 5.10d) detect less and shorter duration of recession in 1974-1975:2, two double-dip recessions in 1981-1985 and 1996-1998, and three discontinuing strong
Figure 5.10: The MS-AR model for the Singapore business cycle

Given evidence of regime-dependent variances, the MSIH(2)-AR(4) model indicates two positive regime-dependent intercepts of growth rates (1.09% for high growth and 0.47% for low growth), where both regimes are statistically significant at the 5% level. The regime duration of the fast expansionary regime is moderately shorter than that of the slow expansionary regime (13.43 vs. 16.56 quarters). This is also the case for the transition probabilities of entering and staying in the same state for another quarter in both regimes. The episodes of the slow expansionary regime are characterised by a more than two-folder higher standard error of the innovation (1.7), in comparison with the fast expansionary state (0.78). The probabilities of regime 2 show a comparable picture as the MSMH(2)-AR(4) model except the disappearance of low growth in 1991-1992.

In accordance with the estimation results of the MSI(3)-AR(4) model, the high growth regime expands at 3.85% quarterly which is the fastest estimated growth rate so far among other estimated models. However, such the high speed expansion only lasts 1 quarter. The normal expansion state grows at the quarterly rate of 1.08% with the expected duration of 14.75 quarters. Moreover, the growth rate of the recessionary regime contracts at -0.93% per quarter with the short-lived expected duration of 2.45 quarters. Furthermore, the persistence of staying in high growth is extremely low as suggested by the transition probability $p_{11} = 0.004$, whereas moderate growth persists quite high with the value of $p_{22} = 0.93$. The filtered and smoothed probabilities of recessions visualise the recessions in 1974-1976:2, the double-dip recession in 1981-1985, 1999 and 2000:4-2003, which are highly compatible with the turning points identifies in Table 5.2. However, given the heteroskedasticity test statistic $LR = 5.2$, the null hypothesis is unable to be rejected. Hence, there will be no estimation of the three regime-dependent intercepts MS model with heteroskedastic variances.

To summarize, the MSI(3)-AR(4) model is found to be relatively preferred.
Taiwan. The employment of the loss function chooses the order of 4, but the Hamilton model fails to reject the null hypothesis of linearity. Therefore, testing for regime-varying variances, the LR test statistics of 22.06 rejects the null. The conditional regime means are both statistically significant with the average quarterly growth rates of 0.53% in high growth and 0.72% in low growth. Although the probability of one state followed by another quarter of the same state in both regimes are highly persistent (0.95 in high expansion and 0.8 in low expansion), however, the regime durations differ considerably as the high expansionary regime lasts on 18.5 quarters and the low expansionary regime persists 5.03 quarters. Meanwhile, the fluctuations of high growth are eight times volatile than low growth. Furthermore, the model is found to reject the LR linearity test. The filtered and smoothed probabilities identify the time paths of low growth in 1988-1989, 1995-1997 and 1999:3-2000:3. Nonetheless, the filtered probability also spots low growth in 1983:3-1984:2.

In contrast, the three regimes of the MS-AR model is considered and the loss function is in favor of the MSM(3)-AR(4) model. Unexpectedly, the LR test on homoskedasticity of the variance yields $LR = 2.44$ and it cannot reject the null hypothesis of homoskedasticity under the $\chi^2$ distribution with degree of freedom of 2. The inclusion of an additional growth state (i.e. moderate growth) improves certainly the analysis of the Taiwanese business cycle. The high-growth regime with an expected growth rate of 1.72% per quarter, the normal growth regime with an expected growth of 0.7% per quarter, and the low growth regime with an expected growth of 0.15% per quarter. The expected duration of regime 1 is 2.04 quarters, that of regime 2 is 23.01 quarters and that of regime 3 is 8.61 quarters. Analogously, the persistency of moderate and low growth is remarkably higher than high growth (0.96, 0.88 and 0.51 respectively). Figure 5.11b shows the low growth probability outcome of the MSM(3)-AR(4) model. Clearly, the model captures a series of continuous downturns since 1997:4, other than the only one recession in 2001 as revealed by the classical mechanical rule in Table 5.2.
Based on the criterion function, the MSMH(2)-AR(4) model gives smaller value of 73.67, but the MSM(3)-AR(4) model suggests three statistically significant regime-dependent means.

Alternatively, the MSI(2)-AR(4) model demonstrates that during the downturns the Taiwanese economy has a growth rate of 0.28% per quarter, while during periods of high expansion, it averages 0.45% per quarter. However, both of the regimes are statistically insignificant. This is also proofed by the failure of rejecting the linearity test. The regime durations of the two growth states nearly equalize, even though the regime of high expansion is slightly higher than the regime of low expansion (2.71 and 2.42 quarters). These are accompanied by the almost equivalence in the transition probabilities of the two regimes (0.63 in regime 1 and 0.59 in regime 2). Not surprisingly, with no distinction in regime switching, the probabilities of low growth show no clearly detection of downturns as illustrated in Figure 5.11c.

On the contrary, the heteroskedastic MSI(2)-AR(4) model declares nonlinearity. Like the analogous regime-dependent mean specification, the MSIH(2)-AR(4) model has a lower growth rate of 0.28% in high growth compared to 0.35% in low growth. Nevertheless, the expected duration of high growth is dramatically longer than that of low growth given the values of 22.69 and 5.63 quarters, although the transition probabilities of the two growth regimes show greater persistency (0.96 in regime 1 and 0.82 in regime 2). Moreover, the standard error of regime 1 is more volatile than that of regime 2. Unlike other models, the MSIH(2)-AR(4) model identifies three distinctive downturns in 1987:4-1990:1, 1995-1997 and 1999:2-2000:3.

The results are very interesting when I apply three regimes to the regime-dependent intercept specification. The MSI(3)-AR(4) model suggests the economy contracts at -0.06% in the regime of recessions, and grows at 1.25% in the high expansionary state and 0.59% in the normal expansionary state, but the recessionary regime is not statistically significant. The expected regime durations are consistent with traditional demonstration where normal growth is the longest length of 21.31 quarters, in respect of the length of 2.26 quarters in high growth and 3.65 quarters
Figure 5.11: The MS-AR model for the Taiwanese business cycle
in contractions. In Figure 5.11e the probabilities of recessions capture similar contrac
tions as the outcome of MSM(3)-AR(4) model but with more straightforward
identification of starting and ending points of each recession.

Testing for heteroskedasticity, the null is rejected at 5% significance level given
the LR test value of 6.32. In this case, all three regimes are statistically different
from zero. The economic growth rate shifts smoothly from the value of 1.77% in
regime 1 to 0.87% in regime 2 and further drops to 0.4% in regime 3. Whereas,
the expected duration of regime 3 increases substantially to 32.6 quarters, that of
regime 2 decreases gradually to 17.98 quarters and that of regime 1 rises extends to
4.64 quarters. In the meantime, all three regimes possess highly persistent transition
probabilities of remaining in the same regime for another quarter (0.78 in regime 1,
0.94 in regime 2 and 0.97 in regime 3). The most fluctuated regime is regime 3 with
the value of 0.62, the volatile of regime 1 and regime 2 are very close and relatively
stable. In Figure 5.11f, the time paths of the filtered and smoothed probabilities
plot nonstop low growth since 1997.

To sum up, the best model of characterizing the features of business cycles of
Taiwan is the MSM(3)-AR(4) model, according to the principle of parsimony and
the comparison of the overall performance of all estimated models.

Thailand. In the Hamilton model, the average quarterly growth rates of two
regime are 0.57% for the phase of the expansionary growth, and -1.36% for the phase
of the contractive growth. The expected duration of expansions is 22.1 quarters and
is associated with the unconditional probability of 0.88, on the other hand, the
expected duration of recessions is 2.93 quarters and is associated with the uncon-
tditional probability of 0.12. The transition probabilities of persisting in the same
regime for another quarter are 0.95 for expansions and 0.66 for contractions. The
heteroskedastic test is rejected the null, i.e. there is evidence of regime-dependent
heteroskedasticity in the white noise process. The average quarterly growth rate in
the high expansionary state does not change so much as it is still around 0.53%, but
the conditional mean growth rate in the low expansionary state changes not only the
sign but also the statistical significance since it grows only 0.01% per quarter. Not surprisingly, the expected regime duration of low expansion increases to 17.48 quarters. However, there is also an unanticipated increase in the regime duration of high expansion to 33.56 quarters. Moreover, both regimes have the comparable transition probabilities of persisting in the same regime for another quarter. Nonetheless, the regime of low growth is more fluctuated than the regime of high growth as its volatility is more than threefold greater. Furthermore, in Figure 5.12a the filtered and smoothed probabilities of the model also extend the period of low growth from 1994:2 to 1999 in comparison with the MSM(2)-AR(4) model.

I undertake the estimation of the MSM(3)-AR(4) model to investigate whether the inclusion of an additional regime will sketch more characteristics of the Thai business cycle. Clearly, I find that the MSM(3)-AR(4) model leads to some improvements of explaining the business cycle. This is also proved by the complexity-penalized likelihood criterion. Meanwhile, I also find no evidence of the existence of heteroskedasticity in this case. The conditional mean growth rate grows at the highest speed of 1.09% per quarter on average in the fast expansionary state with the short-lived expected duration of only 1.84 quarters. The average lowest quarterly growth speed is -1.29% in the recessionary state with the expected duration of 2.66 quarters. The normal expansionary regime expands at 0.47% quarterly on average and lasts on 10.21 quarters. The unconditional and transition probabilities of normal growth is the greatest among others (0.66 and 0.9 respectively). The high growth regime has reasonably greater unconditional probability but less persistency of remaining the same regime, which is completely the opposite case in the recessionary regime. The recessionary probabilities uncover three continuous depressions between 1997 and 1999:1 as described by Figure 5.12b, which are comparable with the classical business cycle dating.

Instead, the two regimes homoskedastic model with regime varying intercepts and the lag of 2 shows no remarkable dissimilarity from the Hamilton model. It is the same case for the MSIH(2)-AR(2) model in association with the analogous
Figure 5.12: The MS-AR model for the Thai business cycle
MSMH model. However, the estimation results are different in the three-regime model of the MSI specification. The MSI(3)-AR(4) model suggests the average expansionary rate of high growth is 0.41% quarterly which is smaller than that of moderate growth (0.91%), at the same time, it is also statistically insignificant. The mean growth rate of the recessionary state contracts at -1.55% per quarter. The most striking difference of the MSI(3)-AR(4) model from the above discussed models is the regime duration of the normal expansionary regime lasts on 21.84 quarters which is two times longer than the estimated analogous MSM model. Other two calculated regime durations are still pretty consistent with the result of the MSM(3)-AR(4) model. What is more, the transition probability of staying in the high expansionary regime for another period is exceptionally low, compared to the MSM(3)-AR(4) model (0.02 vs. 0.46). The contractive probabilities of the model in Figure 5.12e reveal three continuous depressions from 1996:2 to 1999:1.

In the presence of heteroskedasticity in variances, the MSIH(3)-AR(1) model is chosen on the basis of the loss function. This time the contractive state becomes statistically insignificant as it falls quarterly at -0.64% on average. The economy expands at the fastest speed of 2.37% per quarter in the regime of high growth and at the plausible quarterly rate of 0.6% in the regime of moderate growth. The most unexpected estimation result from this model is that the regime duration of an recession persists 10.61 quarters, and in the meantime, its persistency of remaining in the recession for another period is also considerably high given the transition probability \( p_{33} = 0.91 \). Whereas, the regime durations of high and normal expansion last reasonably on 1.44 and 18.83 quarters correspondingly. It is no questionable that the recessionary state is the most volatile state among others as revealed by the standard errors. In Figure 5.12f, the probabilities of contractions characterise one single non-stop recession in 1996-1999.

Consequently, under the parsimony principle, I conclude that the MSM(3)-AR(4) model is the most appropriate model.
Concluding remark

In summary, the Hamilton specification – the MSM(2)-AR(4) model is able to capture the main dynamic movements of individual country’s and region’s business cycle, but it does not satisfy in characterising some of country- or region-specific business cycles. The introduction of three regimes has certainly improved the analysis of business cycles in some countries and districts. The relaxation of the assumption of the homoskedastic errors allows the detection of asymmetries between expansionary and recessionary movements, besides, the different duration of each regime. In addition, compared the recession probabilities for these economies, all the economies (except Japan) picked up the 1997 financial crisis. Furthermore, some economies were synchronized in the downturns of 2001 and 2000. This reveals evidence of co-movements among the countries and districts; this might be due to the increasing globalisation of markets. Therefore, in the next section, I am going to investigate the common regime shifts among multiple economic time series.

5.1.4 Common regime shifts in multi-country growth models

The preceding analysis has shown that there may be a certain degree of common movements of business cycles in the region. In this section, I investigate this empirically and try to answer the following question: Is there a regional business cycle?

The empirical study of the business cycle usually concentrates on two issues: first, the common features of macroeconomic time series, and second the nature of regime-switching resulting from macroeconomic activities. The Markov-switching vector autoregressive (MS-VAR) model has been used before to analyse macroeconomic fluctuations associated with these issues. A major advantage of the MS-VAR model is that it allows a quantitative description of the co-movement of economic growth rates of interdependent economies.

In this section, I examine different forms of the MS-VAR model: I test the order
of the autoregression on the basis of the loss function; consider models with more
than two regimes and test heteroskedasticity in the variance-covariance.

The plan of this section is as follows. I divide these nine countries and districts
into two groups: developing and developed economies in order to investigate if the
correlation of the business cycle of these two groups behave differently. The division
of the groups is based on the IMF World Economic Outlook. Then, I estimate all
countries and districts together to investigate evidence of regional business cycles
which may be caused by common shocks. Hopefully, this will shed light on the issue
of establishing a currency union within the region, which is currently an active area
of research. Finally, I provide a summary of the results.

Developing economies

The underlying estimated system of quarterly real GDP growth rates in developing
economies is

\[ \Delta y_t = \left( \Delta y_t^{CHN} \Delta y_t^{IND} \Delta y_t^{MAL} \Delta y_t^{PHI} \Delta y_t^{THAI} \right)' \]

where \( \Delta y_t \) denotes the real GDP growth rate for China, Indonesia, Malaysia, Philippines and Thailand during the sample period from 1995:2-2006:4.

The loss function supports a fourth order autoregression in differences. Hence
I start with the estimation of the MSM(2)-VAR(4) model. First of all, I estimate
the system by assuming the variance-covariance matrix is regime-independent. The
estimation results are shown in Table 5.7.

The estimated mean growth rates are associated with high and low growth in
the specification. It shows clearly that average growth in the phase of high growth is
greater than the phase of low growth for most of countries, except Thailand. Hence
the effects of a regime shift are

\[ \hat{\mu}_1 - \hat{\mu}_2 = \left( 2.18 \ 0.65 \ 0.98 \ 0.11 \ -0.29 \right)' \]
Table 5.7: Estimation results: Developing economies

<table>
<thead>
<tr>
<th>Parameter</th>
<th>MSM(1)-VAR(4)</th>
<th>MS(1)-VAR(4)</th>
<th>MS(1)-VAR(2)</th>
<th>MS(1)-VAR(2)</th>
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<tr>
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<tr>
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<td>0.7</td>
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</tr>
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</table>

Figure 5.13: The MS-VAR model: Developing economies
Compared to the univariate MSM(2)-AR(4) model for each economy (except China), the values of the mean growth rates in Philippines increase, and the sign of the second regime changes to the opposite in Malaysia and Thailand.

However, those estimated mean growth rates are statistically insignificant. Although the model detects some evidence of asymmetries in the common business cycle, it is not very obvious. The transition probability estimations imply a relative higher persistency in regime 2 (0.69) than in regime 1 (0.44). In the meantime, the expected duration of low growth (3.02 quarters) lasts slightly longer than that of high growth (1.78 quarters). The filtered and smoothed probabilities for the time paths of recessions are shown in Figure 5.13a. It can be seen that the series that combines five countries is much more fluctuated than any individual country in the same period. The probabilities identify a number of slow expansions during the sample period, but such high frequent common regime shifts of joint estimated economic growth of the five countries in the low growth regime do not seem to prove the existence of common shocks. Most importantly, the MSM(2)-VAR(4) model fails to pass the linearity test after all.

In the MSI(2)-VAR(4) model, the outcomes show a completely different picture. First of all, The estimation results of regime dependent means change noticeably. Both regime-switching means for countries like China and Philippines are statistically different from zero. The average growth rate of Indonesia in regime 2 is negative and is about -0.65% per quarter compared to the positive mean growth rate 0.35% in the MSM(2)-VAR(4) model. In contrast to the univariate MSI(2)-AR(4) model for Indonesia, the MS-VAR estimation changes not only the sign in regime 2 but also the statistical significance of both regimes. This is opposite case for Malaysia. Meanwhile, the estimated quarterly mean growth rates of Thailand change unpredictably to both negative values of -0.59% in regime 1 and -0.84% in regime 2. Moreover, the regime dependent mean growth rate of China in low growth is higher than the rate in high growth (1.95% vs. 1.91%). Consequently, the change
in the mean growth rate which is caused by a regime shift is given by
\[
\bar{v}_1 - \bar{v}_2 = \begin{pmatrix}
-0.04 & 1.84 & 0.32 & 0.51 & 0.25
\end{pmatrix}
\]

Second, the expected duration of time in both expansionary regimes increase significantly to 14 (regime 2) and 6.91 (regime 1) quarters, and are accompanied by strong persistency that are indicated by the transition probabilities of 0.93 and 0.86 respectively. Third, the model is able to reject the null hypothesis of linearity. At last, the probabilities in the low growth or recessionary regime identify two downturns in 1997:3-1998:3 and 2000-2006:2, as visualised in Figure 5.13b.

In addition, there is evidence of regime dependent variances in the two-regime MSI-VAR specification, as the null of the homoskedastic variance-covariance matrix is strongly rejected. This is testified by the LR test as it gives \( LR = 70.78 \) and follows the asymptotic \( \chi^2 \) distribution with degree of freedom equal to \( (M-1)K(K+1)/2 = 15 \), and this yields the critical value of 25.

I estimate the MSIH(2)-VAR(2) model which allows the variance-covariance matrix to be regime-dependent \( \Sigma(S_t) \), as summarised in Table 5.7 and the low growth probabilities are shown in Figure 5.13c. By allowing the regime-dependent variance-covariance matrix, the model detects even more fluctuated time paths in the low expansionary state. They are associated with negative mean growth rate in Thailand (-0.01%) and rather slow growth in other countries where are 1.67% for China, 0.05% for Indonesia, 0.13% for Malaysia, and 0.62% for Philippines. The slump in the average growth rate in the MSIH(2)-VAR(2) model is given by
\[
\bar{v}_1 - \bar{v}_2 = \begin{pmatrix}
1.13 & 0.64 & 0.27 & 0.21 & -0.01
\end{pmatrix}
\]

The effect of a shift in regime for the Chinese business cycle with the annualised rate of 4.52%, shows its importance than the rest of the countries, where the fall in the mean growth rate is between -0.04% and 2.56% per annum. This is a proof of asymmetric business cycles in the national size.
In contrast to the MSI(2)-VAR(4) model, the regime durations of time in the two states are shorter (3.3 quarters in regime 1 and 6.82 quarters in regime 2) and these are accompanied by relative lower transition probabilities (0.7 and 0.85) as well.

At present, let us consider the contemporaneous correlations among the countries. The contemporaneous correlation illustrates the correlation of the regime variables of each component associated with different equations in a bivariate system that results from contemporaneous regime shifts. In this matrix, the lower triangular gives the contemporaneous correlations in regime 1 and the upper triangular gives those correlations in regime 2.

\[
\begin{bmatrix}
  CHN & -0.02 & 0.26 & 0.2 & 0.84 \\
  0.02 & IND & -0.03 & -0.23 & 0.16 \\
  0.38 & 0.36 & MAL & 0.8 & 0.06 \\
  -0.24 & 0.48 & 0.23 & PHI & 0.16 \\
  -0.53 & 0.16 & -0.38 & 0.49 & THAI
\end{bmatrix}
\]

The contemporaneous correlations of the system show how strong relationships are between countries in both regimes. This means that an economic shock occurs in one country will have spill-over effects on other countries' economies, regardless whether the shock is national or international. Such an effect can be either positive (which means business cycles between two economies are more synchronized) or negative (which indicates that business cycles of two economies are less synchronized with each other) to the affected economy. For instance, in regime 1, the impacts on the economy that are caused by shocks vary with countries. China is negatively correlated with foreign growth rates of Philippines and Thailand. On the contrary, Indonesia is positively correlated with growth rates of all other countries. Furthermore, Malaysia is only negatively correlated with Thailand in the state of expansion. The correlation between Philippines and Thailand is strongly positive in regime 1. As a result, it can be seen that the allowance of a regime-dependent variance shows
economic shocks affect the correlation of national economies in different states. Additionally, the economies are more related in regime 1 (high growth) rather than in regime 2 (low growth).

The significant differences in the two regimes of the MS(2)-VAR(4) models suggest that the two-regime classification cannot fully characterise the common business cycle. Since the assumption of two-regime is not able to well-defined the episodes of expansions as well as downturns, a three-regime model that depart positive high growth (regime 1) and low growth (regime 3) from moderate growth (regime 2) is undertaken.

Somewhat strangely, the estimation outcomes for the MSI(3)-VAR(2) model indicate the mean growth rates in normal expansion episodes are negative for Indonesia and Malaysia (-0.31% and -0.08% respectively) which are not supposed to be, whereas the rates are positive values of 0.53% and 0.02% in the low growth regime, on average.

Moreover, in comparison with the MSI(3)-AR(2) model for Malaysia and Philippines, the improvement in the estimation of Philippines seems to be at the cost of that of Malaysia.

The effect of a shift from regime 1 coincides with high growth to regime 2 corresponds to normal growth is

$$\tilde{v}_1 - \tilde{v}_2 = \begin{pmatrix} -1.05 & 1.37 & 1.26 & 0.82 & -0.35 \end{pmatrix}^\prime$$

And the slump in mean of growth rate from regime 2 to regime 3 is given as

$$\tilde{v}_2 - \tilde{v}_3 = \begin{pmatrix} 1.49 & -0.84 & -0.1 & 0.38 & 1.88 \end{pmatrix}^\prime$$

From the above, none of the regime-switching effect of these countries can be rationally explained since they are not in accordance with the expected results of the conventional theory, the only exception is Philippines where the economy in the high growth regime expands the fastest at the rate of 1.56% per quarter, and
expands at a lower rate of 0.74% per quarter in the normal growth regime and grows modestly at 0.36% quarterly in the low growth regime. Furthermore, at least one of the estimated regime-switching mean growth rates of all five countries is statistically indifferent from zero.

Even though, the MSI(3)-VAR(2) model does not seem to support the assumption of three distinctive regime dependent means of the joint stochastic process of five countries’ economic growth, other characteristics of common business cycles appear to be well-defined. The duration of the high growth regime is 3.29 quarters, that of the normal growth regime lasts on 33.89 quarters, and a clear indication of recessions or low growth with the duration of 7 quarters. Furthermore, the transition probability of staying in regime 2 is 0.97 which is the highest, the second highest transition probability of remaining in the same regime is regime 3 which is 0.86. Even if the transition probability of remaining in regime 1 is the lowest among others, it is still highly persistent around 0.7. The probabilities for the low growth or contraction regime detect only the financial crisis in 1997:1-1999:1 as illustrated in Figure 5.13d.

Overall, the application of the MS-VAR model does not seem to capture and explain the characteristics of common business cycles of joint developing economies well, even though the financial crisis in the late of the 1990s has been spotted throughout the estimated models.

Developed economies

In developed economies, I evaluate the following countries and districts in the system

\[ \Delta y_t = \begin{pmatrix} \Delta y_{t}^{HK} & \Delta y_{t}^{JAP} & \Delta y_{t}^{KOR} & \Delta y_{t}^{TW} \end{pmatrix} \]

again \( \Delta y_t \) represents the growth rate for Hong Kong, Japan, Korea and Taiwan during the sample period 1981:2-2006:4. Singapore is excluded from the estimation because of its economic growth is represented using IP instead of GDP.

The number of lags is four according to the model selection criteria. So I first
Table 5.8: Estimation results: Developed economies

<table>
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<tr>
<th>Parameter</th>
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<th>MSMH(2)-VAR(4)</th>
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</tr>
</thead>
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<td>8.04</td>
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Table 5.9: Estimation results: Developed economies (Cont.)

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<td>1.05 (0.25)</td>
</tr>
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<td>0.74 (0.19)</td>
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<td>0.74 (0.19)</td>
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<td>1.23 (0.32)</td>
</tr>
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<td>0.84 (0.16)</td>
<td>1.23 (0.32)</td>
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Figure 5.14: The MS-VAR model: Developed economies
estimate the MSM(2)-VAR(4) model. The estimation results for the mean growth rate show that only Japan exhibits contraction in the second regime, meanwhile, Japan experiences the lowest growth in the first regime. In relation to the MSM(2)-AR(4) model, the second regime mean growth rates are positive and statistically insignificant in Hong Kong and Korea. Except for Japan, the expansionary mean growth rates of all other economies decrease slightly. Moreover, the effect on the mean growth rate that results from a regime transition is obtained by

$$\tilde{\mu}_1 - \tilde{\mu}_2 = \begin{pmatrix} 0.05 & 0.38 & -0.42 & 0.26 \end{pmatrix}.$$ 

The probability that a high expansion (or a low expansion) will be followed by another quarter of the high expansion (low expansion) is high and persistent about 0.84 (0.63). The expected duration of time in the high expansionary state is longer than that of regime 2 (6.32 vs. 2.72 quarters). In Figure 5.14a the filtered and smoothed probabilities are highly volatile from 1982 to 2006. However, the MSM(2)-VAR(4) model cannot reject the null hypothesis of linearity.

Testing for heteroskedasticity, the LR test statistic gives $LR = 60.26$ which reject powerfully the null at the critical value of 18.31, in short, $\Sigma_{S_t=1} \neq \Sigma_{S_t=2}$. Therefore, I conduct the estimation of the MSMH(2)-VAR(4) model. By allowing the variances to be regime dependent, the economic states of all countries and districts are divided into either low or high growth. No matter in which regime, the average quarterly growth rate of the South Korean economy always expands the fastest among others (1.1% in regime 1 and 0.53% in regime 2). This is followed by the economy of Taiwan where it grows 0.95% in high growth and 0.42% in low growth. It is no doubt that Japan has the lowest expansion rates in both regimes since its economy is well developed. Additionally, this vector format of the MSMH autoregressive model tells more or less the same story as the corresponding univariate model.

The heteroskedastic model calculates the duration of high growth persists 8.04 quarters but is shorter than the duration of low growth as it lasts on 12.99 quarters. The estimated regime transition probabilities of staying in the same state for another
period are greatly persistent, especially, the probability of regime 2 is the greatest. Interestingly, the volatility of macroeconomic fluctuations is different among the economies along with the standard errors. The economy of Hong Kong is more fluctuated in the state of high growth, whereas the Korean economy is the contrary situation. For the meantime, Japan and Taiwan have the equivalent regime volatility. Although the probabilities of the MSMH(2)-VAR(4) model look like less fluctuated than the MSM(2)-VAR(4) model, in fact, it captures the comparable episodes of low growth during the sample period, with the exception of the occurrence of the downturn in 1988:2-1989 in place of 1986:2-1987:2 (Figure 5.14b).

Consider the contemporaneous correlations of the four variables, again, the contemporaneous correlations in the lower triangular matrix are obtained from regime 1 and the upper triangular matrix are gained from regime 2. Obviously, the correlations between developed economies are not tightened together in the recessionary (or low growth) state. This means that business cycles of developed economies are far less synchronized with each other. On the other hand, in the expansionary regime, the contemporaneous correlations are strong between some economies, in particular the strong positive relationship between Hong Kong and Taiwan, between Japan and South Korea, and between Korea and Taiwan, in addition to the negative correlation between Japan and Taiwan.

\[ \begin{bmatrix}
    HK & 0.15 & 0.4 & -0.01 \\
    0.06 & JAP & 0.01 & 0.09 \\
    0.04 & 0.58 & KOR & 0.15 \\
    0.71 & -0.33 & 0.21 & TW
\end{bmatrix} \]

Alternatively, considering the situation of the mean of the system approaches to the new level gradually after a shift in the regime. The outcomes for the MSI(2)-VAR(4) differ totally to the MSM(2)-VAR(4) model. All countries and districts are associated with negative mean growth rates in the second regime, except Korea which corresponds to the low growth rate. This is a completely different picture
in the country-specific analysis. In comparison with the MSM(2)-VAR(4) model, it produces almost equal regime durations (3.3 quarters for the expansionary (or high growth) state and 3.41 quarters for the recessionary (or low growth) state, as well as the probabilities of persisting in the identical regime (0.7 and 0.71). In addition, the probabilities in Figure 5.14c reflect even more instabilities than the two previous models.

Once again, the confirmation of heteroskedasticity permits us to compute the MSIH(2)-VAR(4) model. The outcome of the model is not so different from the MSI(2)-VAR(4) model. The most noticeable difference in the quarterly growth rates of the variables in the system is that Taiwan grows slowly at 0.31% instead of contracting at -0.08% in regime 2. At the same time, most of the estimated regime growth rates (in absolute term) change moderately. At least one of their statistical significance is indifferent from zero, excluding Taiwan. The regime durations and the transition probabilities \( p_{11} \) and \( p_{22} \) are still very close. I draw a similar conclusion about the economic relationships between the variables in the system in two regimes as the analogous regime dependent mean model in accordance with the contemporaneous correlations. Furthermore, the volatility of each economy in different regimes is also similar to the MSMH(2)-VAR(4) model. Comparable low growth or recessions are caught by the filtered and smoothed probabilities as those illustrated in the MSMH(2)-VAR(4) model (Figure 5.14d), apart from the fluctuations in the 1980s.

Recalling the three-regime model for developing economies, it may be the case in here as well. At first, I start with the calculation of the MSM(3)-VAR(4) model. Almost mean quarterly growth rates of regime 1 and 2 are statistically significant, but all of them are statistically indifferent from zero in regime 3. Even though, the results for the MSM(3)-VAR(4) model display an interesting outcome that the common business cycle is asymmetric in the phase of recessions. In the MSM(3)-AR(4), as opposed to small negative average growth rates in regime 3 in Hong Kong, Japan and Taiwan, which are -0.1%, -0.07% and -0.22% individually, Korea is in the
state of low expansion with a sluggish quarterly rate of 0.06%. The effects of shifting to another regime are obtained as

\[
\begin{align*}
\bar{\mu}_1 - \bar{\mu}_2 &= \begin{pmatrix} 0.82 & 0.24 & 0.12 & 0.44 \end{pmatrix}' \\
\bar{\mu}_2 - \bar{\mu}_3 &= \begin{pmatrix} 0.47 & 0.27 & 0.85 & 0.97 \end{pmatrix}' 
\end{align*}
\]

Perceptibly, the regime shifts give rise to the effects on the fall in means are nearly identical for Japan.

Moreover, the expected durations and the persisting transition probabilities of high growth and normal growth are fairly close (5.5 and 6.62 quarters, 0.82 and 0.85). According to the probabilities in regime 3 (contractions or low growth) in Figure 5.14e, the major recessions or low expansion occur mainly in the late of the 1990s and until the end of the sample period.

However the estimation results of the MSM(3)-VAR(4) model with heteroskedastic variances cannot be calculated, hence, I can only discard the estimation of the MSMH(3)-VAR(4) model. Instead, the MSI(3)-VAR(4) is carried out. Since I have found the verification of regime dependent variances, I go straightly to estimate the MSIH(3)-VAR(4) model. All three economies have negative quarterly growth rates in regime 3 apart from Korea which the loss in unfavourable economic growth is very small (about 0.11% per quarter). Noticeably, in the second regime, Japan has a negative growth rate of -0.02%, and in the third regime, it contracts at a deeper rate of -0.18%. Whereas, in the univariate analysis, it contracts only in regime 3. In addition, for all economies, the quarterly growth in regime 1 is larger than in regime 2, and further the growth rates in the latter is larger than in regime 3. It is also true in the univariate estimation. The effects of a shift in regime from regime 1 to regime 2 and that of from regime 2 to regime 3 are presented by

\[
\begin{align*}
\bar{\nu}_1 - \bar{\nu}_2 &= \begin{pmatrix} 0.53 & 0.06 & 0.24 & 0.5 \end{pmatrix}' \\
\bar{\nu}_2 - \bar{\nu}_3 &= \begin{pmatrix} 0.62 & 0.16 & 0.39 & 0.76 \end{pmatrix}' 
\end{align*}
\]
Interestingly, the effect of the regime shift from regime 2 to regime 3 is greater than that of moving from regime 1 to regime 2, which suggests again some asymmetries in the international business cycle.

The expected durations of regimes are 4.23 quarters for regime 1, 7.93 quarters for regime 2, and 2.5 quarters for regime 3, accompanied with transition probabilities of 0.76, 0.87 and 0.6 respectively, which are quite high and persistent.

The time paths of recessions for developed economies as demonstrated in Figure 5.14f detect the recessions (low growth) in 1985:2-1985:3, 1990:2-1990:3, two double-dip slow growth (recessions) from 1997:2 to 1999:3 as well as between 2000:3-2003:1, the contractions (low expansion) in 2004 and 2005:4-2006:2.

The contemporaneous correlations obtained from the MSIH(3)-VAR(4) model show that the contemporaneous correlations are highly related in regime 1 (the high expansionary regime) and regime 3 (the recessionary or low growth regime). Especially, the correlations of Hong Kong-Taiwan, Japan-Korea and Japan-Taiwan
Business Cycles with Fixed Transition Markov Switching Models

are relatively higher. Whereas they are less correlated in regime 2, except the relatively strong negative linkage between Hong Kong and Taiwan, and between Japan and Taiwan.

All markets

In the following paragraphs, I investigate common regime shifts in joint economic growth of all nine economies under consideration. More precisely, the following system of the quarterly real GDP growth rate is under estimating

$$\Delta y_t = (\Delta y_{t, CHN}^{CHN} \Delta y_{t, HK}^{HK} \Delta y_{t, IND}^{IND} \Delta y_{t, JAP}^{JAP} \Delta y_{t, KOR}^{KOR} \Delta y_{t, MAL}^{MAL} \Delta y_{t, PHI}^{PHI} \Delta y_{t, TW}^{TW} \Delta y_{t, THAI}^{THAI})$$

A number of specifications of the MS-VAR model are considered.

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Table 5.10: Estimation results: All markets

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</tr>
<tr>
<td>p11</td>
<td>0.1</td>
<td>0.62</td>
<td>0.55</td>
</tr>
<tr>
<td>p22</td>
<td>0.08</td>
<td>0.67</td>
<td>0.66</td>
</tr>
<tr>
<td>p33</td>
<td>0.68</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ξ1</td>
<td>0.01</td>
<td>0.64</td>
<td></td>
</tr>
<tr>
<td>ξ2</td>
<td>0.30</td>
<td>0.36</td>
<td>0.62</td>
</tr>
<tr>
<td>ξ3</td>
<td></td>
<td></td>
<td>0.28</td>
</tr>
<tr>
<td>(1 - p11)⁻¹</td>
<td>5</td>
<td>5.86</td>
<td>2.22</td>
</tr>
<tr>
<td>(1 - p22)⁻¹</td>
<td>3.17</td>
<td>3.07</td>
<td>6.99</td>
</tr>
<tr>
<td>(1 - p33)⁻¹</td>
<td></td>
<td></td>
<td>3.17</td>
</tr>
<tr>
<td>σ</td>
<td>CHN 1.03</td>
<td>0.95</td>
<td>1.6</td>
</tr>
</tbody>
</table>
Table 5.10: Estimation results: All markets

<table>
<thead>
<tr>
<th>Parameter</th>
<th>MSM(2)-VAR(3)</th>
<th>MSI(2)-VAR(3)</th>
<th>MSI(3)-VAR(1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HK</td>
<td>0.5</td>
<td>0.37</td>
<td>0.44</td>
</tr>
<tr>
<td>IND</td>
<td>0.58</td>
<td>0.55</td>
<td>0.93</td>
</tr>
<tr>
<td>JAP</td>
<td>0.18</td>
<td>0.16</td>
<td>0.27</td>
</tr>
<tr>
<td>KOR</td>
<td>0.33</td>
<td>0.39</td>
<td>0.61</td>
</tr>
<tr>
<td>MAL</td>
<td>0.42</td>
<td>0.31</td>
<td>0.61</td>
</tr>
<tr>
<td>PHI</td>
<td>0.43</td>
<td>0.39</td>
<td>0.5</td>
</tr>
<tr>
<td>TW</td>
<td>0.35</td>
<td>0.31</td>
<td>0.47</td>
</tr>
<tr>
<td>THAI</td>
<td>0.36</td>
<td>0.35</td>
<td>0.62</td>
</tr>
<tr>
<td>ln L</td>
<td>-191.01</td>
<td>-66.77</td>
<td>-375.35</td>
</tr>
<tr>
<td>AIC</td>
<td>22.68</td>
<td>17.94</td>
<td>23.23</td>
</tr>
<tr>
<td>SIC</td>
<td>35.17</td>
<td>30.43</td>
<td>29.55</td>
</tr>
<tr>
<td>HQ</td>
<td>37.31</td>
<td>22.58</td>
<td>25.6</td>
</tr>
<tr>
<td>LR linearity</td>
<td>-85.23</td>
<td>123.24</td>
<td>45.31</td>
</tr>
<tr>
<td>test</td>
<td>[1.00]</td>
<td>[0.00]</td>
<td>[0.01]</td>
</tr>
</tbody>
</table>


The test for the order of vector autoregression $r$ suggests that the order 3, so I start with Markovian mean-regime shifts between two regimes with the third-order vector autoregression. The results are given in Table 5.10. Strikingly, Hong Kong and Japan have contractions rather than slow growth in other economies in regime 2. The average growth rates in expansion periods are normally higher than in contraction periods, apart from Thailand. The drop in the estimated mean growth rates after a regime shift is given as

$$\tilde{\mu}_1 - \tilde{\mu}_2 = \begin{pmatrix} 1.04 & 0.68 & 0.51 & 0.45 & 0.32 & 0.8 & 0.35 & 0.52 & -0.09 \end{pmatrix}$$

The expected duration of an expansion is moderately longer than that of slow growth (or a recession) (5 vs. 3.17 quarters), followed by high and persistent transition probabilities in both regimes. Figure 5.15a captures a series of slow expansion dated by the MSM(2)-VAR(3) model in 1997:4-1999:1, 2000:2-2001, 2002:3-2003:2, 2004:2-2004:4 and 2005:4-2006:2. Nonetheless, this form is unsuccessful in the test of nonlinearity.

Instead, the system is estimated by the MSI(2)-VAR(3) specification for each of the component. The linearity test is passed no uncertainty at all under this specification. Based on the estimation results, the effect of a shift from regime 1 to
Figure 5.15: The MS-VAR model: All Markets
regime 2 is obtained by

\[
v_1 - v_2 = \begin{pmatrix} 1.24 & 1.41 & 0.34 & 0.13 & 0.33 & 0.95 & 0.34 & 0.97 & 0.02 \end{pmatrix}.
\]

The rates of growth in the expansionary regime are greater than during the contraction or low growth regime. Mostly, China mainland experiences the highest average growth in regime 1 (3.66% per quarter) and in regime 2 (2.42% per quarter), in contrast to other economies. On the other hand, it is implausible that Japan and Malaysia both have negative growth rates in the two regimes. The estimated transition probabilities imply a slightly higher persistency and longer duration in the first regime than in the second regime (0.82 vs. 0.67, and 5.56 vs. 3.07 quarters).

The contemporaneous correlations show significant relationships of economic shocks affecting national economics for the past 12 years.

\[
\begin{array}{c|c|c|c|c|c|c|c|c|c}
   & CHN & HK & IND & JAP & KOR & MAL & PHI & TW & THAI \\
CHN & 0.08 & -0.01 & 0.1 & 0.29 & 0.41 & -0.35 & -0.15 & 0.08 & 0.08 \\
HK & 0.22 & 0.42 & 0.24 & 0.27 & -0.26 & -0.11 & -0.04 & -0.27 & -0.03 \\
IND & -0.07 & -0.07 & -0.59 & 0.29 & -0.59 & -0.15 & -0.4 & 0.55 & 0.14 \\
JAP & -0.29 & 0.29 & 0.29 & 0.25 & 0.17 & 0.17 & 0.05 & 0.15 & 0.55 \\
KOR & 0.29 & 0.29 & 0.27 & 0.27 & -0.11 & -0.11 & -0.06 & 0.08 & 0.07 \\
MAL & -0.35 & -0.15 & -0.11 & 0.27 & 0.27 & 0.27 & 0.08 & 0.04 & 0.08 \\
PHI & -0.15 & 0.17 & -0.04 & 0.17 & 0.17 & 0.17 & 0.05 & 0.15 & 0.15 \\
TW & 0.08 & -0.04 & -0.04 & 0.08 & 0.08 & 0.08 & 0.06 & 0.07 & -0.53 \\
THAI & -0.27 & -0.03 & 0.14 & 0.55 & 0.15 & 0.15 & 0.04 & 0.07 & -0.53 \\
\end{array}
\]

As the contemporaneous correlation indicates, China mainland is negatively and highly correlated with Philippines, which may be corresponding to the low shares of trade and capital flows between two economies, as shown in Chapter 3. Whereas it is robustly and positively related to Malaysia, although, the shares of trade and capital flows between them are relatively compatible with China-Philippines. Surprisingly, the relationship between Hong Kong and the mainland China is mildly positive.
correlated, regardless their strong relationships of trade and capital flows. Simultaneously, Hong Kong is comparably and pessimistically correlated to Malaysia and Thailand, but is highly positive linked to Japan. Even though the shares of intra-regional trade and capital flows between the former pairs are stronger than those latter pair. Moreover, strong negatively correlations characterise the relations between Indonesia and Malaysia, which is contrasted to the expectation that they should be positively correlated given they are the major members of ASEAN. Though trade share and capital flows between Korea and Thailand are far less correlated, two of them are strongly and positively correlated, and almost equally and positively associated with China mainland, Hong Kong, Japan and Malaysia. Malaysia is positively correlated with the members of the ASEAN, excluding Indonesia.

The filtered and smoothed probabilities in the second regime are visualised in Figure 5.15b. The time paths of the MSI(2)-VAR(3) model are similar to those of the MSM(2)-VAR(3) model.

According to the previous analysis for the middle-income and high-income economies, the two-regime process underestimates the strength of expansions. Indeed, a three-regime estimation is under consideration. Not surprisingly, the MSI(3)-AR(1) model depicts that Hong Kong has the highest average quarterly growth rate in regime 1 (1.99%), whereas Japan has the lowest average quarterly growth rate in the high expansionary state (0.32%). China (mainland) and Korea have close mean growth rates in the first regime (1.33% and 1.31%, respectively). In the moderate growth regime, the mainland of China has the highest mean growth rate about 2.97% which even outweighs the expansionary rate in regime 1. In contrast, the rest of the economies have mean growth rates from 0.17% to 1.08%. Moreover, China (mainland), Indonesia, Philippine and Thailand experience slow growth rather than a contraction in regime 3. It means that the loss in economic growth of those economies is less hurting. The falls in the mean from regime 1 to regime 2 and from regime 2
to regime 3 are given as

\[
\tilde{v}_1 - \tilde{v}_2 = \begin{pmatrix}
-1.64 & 1.37 & 0.2 & 0.15 & 0.58 & 0.22 & 0.8 & -0.04 & 0.08
\end{pmatrix}^	op
\]

\[
\tilde{v}_2 - \tilde{v}_3 = \begin{pmatrix}
2.18 & 1.1 & 0.27 & 0.22 & 0.89 & 1.67 & 0.19 & 1.06 & 0.29
\end{pmatrix}^	op
\]

The expected durations of regimes are 2.23 quarters for rapid growth, 6.99 quarters for moderate growth and 3.17 quarters for contractions or slow growth. It is no doubt that the duration of expansions (total duration of rapid and normal expansion) exceeds the duration of recessions (or low growth). The transition probabilities indicate that the high growth phase is comparatively feeble in relation to others (0.55), while the phases of normal growth and recessions (or low growth) are quite persistent (0.86 and 0.68 individually).

The contraction (low growth) probabilities detect all the recessions as the previous models in shorter durations, except the one in 2004 , as shown in Figure 5.15c.

\[
\begin{bmatrix}
CHN \\
-0.07 & HK \\
0.07 & 0.34 & IND \\
0.21 & 0.03 & 0.24 & JAP \\
-0.22 & -0.01 & -0.19 & 0.23 & KOR \\
0.08 & -0.08 & 0.02 & 0.24 & 0.19 & MAL \\
-0.15 & -0.04 & 0.06 & -0.09 & 0.05 & 0.24 & PHI \\
-0.12 & 0.05 & -0.05 & 0.16 & -0.04 & 0.21 & 0.14 & TW \\
-0.04 & 0.14 & -0.004 & -0.04 & 0.3 & -0.09 & 0.08 & -0.42 & THAI
\end{bmatrix}
\]

There are some changes in the contemporaneous correlations under the estimation of the MSI(3)-VAR(1) model. Firstly, the correlations between the economies reduce remarkably (in absolute term). For instance, the link between China and
Malaysia falls astonishingly from 0.41 to 0.08, and Korea-Thailand drops moderately from 0.55 to 0.3. Secondly, the spill-over effects between the estimated variables caused by shocks which result in changes in the cross-correlations of output are altered, according to the contemporaneous correlations. For example, the most striking change is that the relationship between China (mainland) and Hong Kong becomes negative, which converses to the expectation. In addition the correlation between China (mainland) and Korea changes completely to the opposition.

Summary

Overall, these results tend to suggest that there is evidence of cross-country business cycle synchronisation among selected Asian economies. More specifically, when those economies are divided into groups, it is found that, with two regimes, the output growth correlations are highly synchronised in the phase of rapid expansion. With three regimes, the relationships between output growth of the economies are strongly correlated in the states of rapid expansion and recessions. Moreover, under the same condition, aggregate output is strongly and highly linked in developing economies. Whereas, in developed economies, the correlations between countries and districts are relatively weaker compared to developing economies. These two findings support the works of Imbs (2004) and Kalemili-Ozcan et al. (2001), as I discussed earlier. It should be noted that these two points of view have no contradiction since the latter is based on different mechanism. Moreover, for the whole group, the regional business cycle exhibits some asymmetries. But the results also suggest the correlations between the economies decrease considerably, in relation to the two subgroups.

5.2 Final remarks

This chapter applies the Markov-switching (MS) model where the conditional stochastic process is an autoregression and the regime generating process is a Markov chain
Business Cycles with Fixed Transition Markov Switching Models

and is time-invariant. In the empirical work, I explore the features of business cycles in Asian countries and districts by employing the MS model. The MS-AR model is used to model the business cycle of individual economies; and the MS-VAR model is used to extract the common features of multi-country business cycles.

First of all, the Hamilton specification is adopted to capture the main characteristics of the individual business cycle. It is found that the specification of the MSM(2)-AR(4) model cannot fully characterise the features of business cycles for most economies in the sample. Consequently, I investigate more generalised specifications of the MS-AR model, by relaxing the homoskedastic assumption of variances, by introducing a third regime, and by using the intercept form rather than the mean adjusted form.

According to the estimation results of the MS-AR model, the regime identifications distinguish between contractions (or low growth) and expansions (or high and normal expansions for the three-regime model). The introduction of an additional regime certainly improves the model fit in several instances. Most of the economies (apart from Singapore) have longer expected duration of expansions than that of contractions (low growth). In the case of the two-regime model, the persistence of both regimes is quite high, whereas, in the case of the three regimes model, the regime of normal expansion is generally more persistent than other two regimes. Different behaviour of durations and variances in different regimes suggest that there are asymmetries. However, it is also found that the MS-AR model with fixed transition probabilities is unable to fully define the characteristics of their business cycles for some economies, for instance, Indonesia.

Moreover, there is some evidence of co-movements among the economies. Therefore, a bivariate Markov-switching vector autoregressive model is estimated to investigate whether there are common regime shifts and common cycles for Asian countries and districts. These nine Asian economies are divided into two groups: the middle-income group and the high-income group. Each is investigated individually. After that, I also estimate all the economies altogether.
The estimation results suggest that there is evidence of the cross-country business cycle synchronisation, as revealed by the filtered and smoothed probabilities and the contemporaneous correlations between outputs. Expansions and recessions occur to a large extent simultaneously across countries and districts, mainly, the recessions (low expansion) in the late-1990s and between 2000 and 2006. On the other hand, the co-movement of the macroeconomic fluctuations does not exclude the possibility of asymmetries. In particular, the results suggest that output growth rates are more likely to be correlated in the phases of high expansion and contractions (in the three regime model). Furthermore, it is also found that developing economies are relatively more correlated than developed economies.

This chapter has provided an detailed description of the features of business cycles in the East and Southeast Asian region using a number of alternative MS specifications. The correlations between the region's business cycle across different growth regimes have also been explored. However, a possible criticism of these results may be that the fixed transition probability model may be too restrictive as it does not allow the transition probabilities to change over time. The next chapter addresses this potential criticism by evaluating the use of time-varying regime switching models.
CHAPTER 6

Estimating Business Cycles with Time Varying Markov Switching Models

6.1 Introduction

In previous chapters it was argued that Markov switching models possess desirable properties that make them ideal for business cycle estimations. These include the endogenous classification of observations into alternative states, the estimation of the probability of switching from one state to another and the estimation of the dynamics of the autoregressive process. In addition, these models can yield estimates of regime-dependent correlations of a number of series in a vector autoregressive setting. Chapter 5 provided an example of the application of fixed transition probability models using GDP data for the selected East and Southeast Asian economies.

An assumption that has been made up to this point is that the transition probabilities remain constant over time. This implies that these probabilities are not dependent on any exogenous variables. Clearly, this is a restrictive assumption, as ideally one would like to investigate the behaviour of the model by allowing other
variables to affect the transition probabilities. Filardo (1994) and Filardo and Gordon (1998), among others, used time varying transition probability (TVTP) models to estimate the US business cycle.¹

This chapter undertakes the same task for the sample Asian economies. Specifically, a coincident leading indicator (CLI) is introduced, which is assumed to affect the transition probability matrix. Such 'dynamic' models are interesting but, unfortunately, their estimation can be problematic due to over-parameterisation issues. Despite these potential problems, it is worth investigating and reporting the results. In addition, I explore specifications in which the transition probabilities depend on regime duration — see Pelagatti (2005).

### 6.2 Data description

In contrast to the previous chapter where quarterly GDP data were used, the dependent variable $y_t$ in this chapter is the monthly industrial production (IP) index. This is because the monthly frequency of the data may help ease the problem of 'not enough observations' that usually blockades data-intensive estimation procedures such as TVTP Markov switching models. Hence, the IP index is employed instead because it constitutes the most cyclical subset of the aggregate economy and is available on a monthly basis for most — but not all — selected economies. Data is available for China, Indonesia, Japan, Korea, Malaysia, Philippines, Taiwan and Thailand. In addition, the cyclical profile² of the IP index (as shown in Figure 6.2) and GDP (as shown in Figure 1.3) in these chosen economies seem to be reasonably related.

Data information about IP index of China (Mainland), Indonesia, Japan, Korea, Malaysia, Philippines, Taiwan and Thailand is illustrated in Table 6.1. Note that only the IP index of Philippines is on a quarterly basis³. All IP series are seasonally

---

¹The methodology is detailed in Section 4.2.2.
²The cyclical component is estimated by using the HP filter.
³Since the components of the CLI index of Philippines are only available in quarterly, for the
Figure 6.1: The deviations of IP
Figure 6.2: Cycles in IP

CHNIPCY

JAPIPCY

KORIPCY

MALIPCY

PHIPCY

TWIPCY

THABIPCY
adjusted. Particularly, the IP index of China is also normalised.

As before, all IP series are tested for unit roots using the ADF and the KPSS tests. It is found that IP series for all economies, except China, have unit roots. Consequently, the first difference of the log of seasonally adjusted IP index (times 100), i.e. the monthly IP growth rate, is employed as the explained variable in the analysis. Note that although the IP index of China is stationary, as to ensure the growth rates are stationary, it is also taken the logarithmic first difference.

The main descriptive statistics of monthly (quarterly) IP growth rates for each economy are summed up in Table 6.2. On the monthly basis, Korea has the highest mean growth rate of 0.39% per month, whereas China grows only 0.004% per month. In addition, Japan grows at a slow rate of 0.06% which is corresponding to slow quarterly GDP growth as I reviewed in the previous chapter. It tells the same story as it is described by the median. However, Korea is not the economy who has experienced the fastest monthly IP growth. Taiwan has attained the highest growth rate of 12.48 in a single month. On the other hand, Taiwan has also experienced the lowest fall in the monthly IP growth (-7.31%), compared to other economies (except Philippines). Furthermore, according to the standard deviation, Taiwan is the most volatile economy given the value of 2.16. Moreover, Malaysia and Thailand are also comparably fluctuated (1.36 and 1.4 respectively).

Since the IP series of Philippines is quarterly data, it grows at the average rate of 0.99% per quarter. Additionally, its economic growth is considerably volatile with the standard deviation value of 1.86.

The reason of choosing composite leading indicators (CLI) as the exogenous variable in the estimation of transition probabilities is, according to Filardo's (1994) paper, empirical estimation results of the CLI outperform other candidate variables considered in the paper, especially, its ability of dating business cycle turning points.

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4The original IP series for China has some missing values during the sample period, hence, I use the OECD data which is normalised. The normalisation is computed by subtracting the mean, then dividing by the mean of the absolute deviation from the series and finally adding 100.
Table 6.1: Data description: Industrial Production Index

<table>
<thead>
<tr>
<th>Country/District</th>
<th>Sample Period</th>
<th>Data Source</th>
<th>Base Year=100</th>
<th>Data Adjustment</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>1983:01-2006:12</td>
<td>Main Economic Indicator, OECD</td>
<td>-</td>
<td>Seasonally adjusted (SA), Normalized</td>
</tr>
<tr>
<td>Indonesia</td>
<td>1990:01-2006:12</td>
<td>Main Economic Indicator, OECD</td>
<td>2005</td>
<td>SA</td>
</tr>
<tr>
<td>Taiwan</td>
<td>1982:01-2006:12</td>
<td>Council for Economic Planning and Development</td>
<td>2001</td>
<td>SA</td>
</tr>
</tbody>
</table>
Figure 6.3: The actual monthly (quarterly) growth rates

Notes: Philippines growth rates are quarterly.
Table 6.2: Descriptive statistics of monthly (quarterly) IP growth rates

<table>
<thead>
<tr>
<th></th>
<th>China</th>
<th>Indonesia</th>
<th>Japan</th>
<th>South Korea</th>
<th>Malaysia</th>
<th>Philippines*</th>
<th>Taiwan</th>
<th>Thailand</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean</strong></td>
<td>0.004</td>
<td>0.14</td>
<td>0.06</td>
<td>0.39</td>
<td>0.19</td>
<td>0.99</td>
<td>0.21</td>
<td>0.24</td>
</tr>
<tr>
<td><strong>Median</strong></td>
<td>0.01</td>
<td>0.22</td>
<td>0.05</td>
<td>0.38</td>
<td>0.18</td>
<td>1.21</td>
<td>0.2</td>
<td>0.24</td>
</tr>
<tr>
<td><strong>Maximum</strong></td>
<td>0.24</td>
<td>2.55</td>
<td>1.8</td>
<td>6.11</td>
<td>4.87</td>
<td>4.89</td>
<td>12.48</td>
<td>4.29</td>
</tr>
<tr>
<td><strong>Minimum</strong></td>
<td>-0.27</td>
<td>-7.14</td>
<td>-1.75</td>
<td>-5.4</td>
<td>-3.94</td>
<td>-3.42</td>
<td>-7.31</td>
<td>-6.12</td>
</tr>
<tr>
<td><strong>Std. Dev.</strong></td>
<td>0.08</td>
<td>0.73</td>
<td>0.59</td>
<td>0.98</td>
<td>1.35</td>
<td>1.86</td>
<td>3.16</td>
<td>1.4</td>
</tr>
<tr>
<td><strong>Sum</strong></td>
<td>1.07</td>
<td>28.33</td>
<td>20.22</td>
<td>372.6</td>
<td>24.13</td>
<td>64.67</td>
<td>64.26</td>
<td>39.67</td>
</tr>
<tr>
<td><strong>Sum Sq. Dev.</strong></td>
<td>1.64</td>
<td>124.99</td>
<td>110.86</td>
<td>457.56</td>
<td>230.93</td>
<td>231.98</td>
<td>1388.05</td>
<td>326.62</td>
</tr>
<tr>
<td><strong>Observations</strong></td>
<td>287</td>
<td>203</td>
<td>323</td>
<td>443</td>
<td>125</td>
<td>65</td>
<td>209</td>
<td>167</td>
</tr>
</tbody>
</table>

*aData in quarterly.
Table 6.3: Data description: The index of composite leading indicators

<table>
<thead>
<tr>
<th>Country/District</th>
<th>Sample Period</th>
<th>Data Source</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>1983:01-2006:12</td>
<td>Main Economic Indicator, OECD</td>
<td>Normalized</td>
</tr>
<tr>
<td>Indonesia</td>
<td>1990:01-2006:12</td>
<td>Main Economic Indicator, OECD</td>
<td>Normalized</td>
</tr>
<tr>
<td>Japan</td>
<td>1980:01-2006:12</td>
<td>Economic and Social Research Institute, Cabinet Office</td>
<td>2005=100</td>
</tr>
<tr>
<td>Korea</td>
<td>1970:01-2006:12</td>
<td>Korean Statistical Information Service</td>
<td>2005=100</td>
</tr>
<tr>
<td>Taiwan</td>
<td>1982:01-2006:12</td>
<td>Council for Economic Planning and Development</td>
<td>2001=100</td>
</tr>
<tr>
<td>Thailand</td>
<td>1993:01-2006:12</td>
<td>Bank of Thailand</td>
<td>1995=100</td>
</tr>
</tbody>
</table>
Table 6.3 reports the sources of the index of the CLI for the 8 economies. Here, the CLIs of Malaysia and Philippines are constructed according to the procedure in Zhang and Zhuang (2002). The CLI is constructed using six economic and financial series for each of the two countries. The components of the CLI for Malaysia include stock price index both in local currency and in US dollar, exports in US dollar, money supply (M1), IP in Korea and US federal fund rate. The components for Philippines comprise stock price index in US dollar, exchange rate (peso per US dollar), discount rate, manufacturing employment, money supply (M1) and IP in Korea. The steps of constructing the CLI are as follows

1. Apply the exponential smoothing method to the series of exports, M1, IP in Korea and manufacturing employment, in order to remove the seasonal component.

2. Adopt the HP filter to extract the cyclical components of all series.

3. The cyclical components of all series are smoothed using a simple centred moving average with the moving average length of 7 months.

4. These seasonally adjusted, detrended and smoothed indicator series are standardised with a mean of 100 and a variance of 1.

5. Finally, the CLI index values are the average values of the sum of the standardised individual series.

6.3 TVTP estimations

This section presents the TVTP estimation results for Indonesia, Japan, Korea and Taiwan. The estimation sample varies from 1970:01 to 2006:12. The autoregressive process has been assumed to be the 4th order.

\footnote{Estimations for China and Thailand could not be carried out because of a non-invertible matrix. The Malaysian series are too short and estimation is not possible. Results for the Philippines (quarterly data) are non-sensical and are not reported.}
I follow Filardo (1994) quite closely and estimate a two-regime specification, where the transition probabilities are a function of the CLI described in the previous section. Results are reported in Table 6.4. The first observation is that the data can indeed be classified in two distinct phases: a contraction phase and an expansion phase. The means of the two regimes are statistically significant for Indonesia and Japan but not so for Taiwan. For Korea the contraction regime mean is insignificant, whereas the expansion regime mean is significant.

In relation to the results of the MSM(2)-AR(4) model in Chapter 5, firstly, Japan and Korea have always two distinct regimes, apart from the MSM(2)-AR(4) model for Japan where the recessionary regime is statically insignificant. Secondly, the estimated regime dependent means for the Indonesian business cycle not only changes the sign in the contraction phase but also the statistical significance in both phases in the TVTP model. Finally, the business cycle of Taiwan is only statistically insignificant in one regime in the Hamilton model, in addition to the identification of the low growth regime rather than the contraction regime in here.

The second observation is that $\beta_{ij}$ and $\beta_{ij}$ (see Equation (4.23)) have the opposite signs. However, most of these coefficients are not statistically significant and, as a result, we cannot safely evaluate the news content of the index variable. Have these coefficients been significant it is possible to infer that changes in the CLI will alter the probability that the state will be in the same state next period. This does not appear to be the case here.

A remaining question is to consider how the specification does in accounting for the contraction and expansionary phases. A caveat is that in contrast to the U.S., for example, which has an official classification of recessions made public by the NBER, the countries in question do not have this official information. This makes it difficult to judge this aspect of the model. Figure 6.3 shows that for Indonesia the probabilities that the economy is in a recessionary state increase in the second half of 1991, 1993-94 and 1999. Japan appears to enter high probability recession states quite frequently during the sample, especially in the last decade. Korea, in contrast
Table 6.4: Estimation results of the TVTP model

<table>
<thead>
<tr>
<th></th>
<th>Indonesia</th>
<th>Japan</th>
<th>Korea</th>
<th>Taiwan</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \mu_0 )</td>
<td>-2.58</td>
<td>-0.33</td>
<td>-0.13</td>
<td>-0.08</td>
</tr>
<tr>
<td></td>
<td>(0.66)</td>
<td>(0.11)</td>
<td>(0.46)</td>
<td>(0.48)</td>
</tr>
<tr>
<td>( \mu_1 )</td>
<td>0.53</td>
<td>0.48</td>
<td>1.36</td>
<td>2.09</td>
</tr>
<tr>
<td></td>
<td>(0.25)</td>
<td>(0.09)</td>
<td>(0.18)</td>
<td>(1.38)</td>
</tr>
<tr>
<td>( \phi_1 )</td>
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<td>-0.55</td>
<td>-0.28</td>
<td>-1.08</td>
</tr>
<tr>
<td></td>
<td>(0.09)</td>
<td>(0.07)</td>
<td>(0.07)</td>
<td>(0.11)</td>
</tr>
<tr>
<td>( \phi_2 )</td>
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<td>-0.09</td>
<td>0.15</td>
<td>-0.81</td>
</tr>
<tr>
<td></td>
<td>(0.12)</td>
<td>(0.08)</td>
<td>(0.08)</td>
<td>(0.19)</td>
</tr>
<tr>
<td>( \phi_3 )</td>
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<td>0.21</td>
<td>0.16</td>
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</tr>
<tr>
<td></td>
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<td>(0.07)</td>
<td>(0.08)</td>
<td>(0.18)</td>
</tr>
<tr>
<td>( \phi_4 )</td>
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<td>0.09</td>
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<td>(0.06)</td>
<td>(0.08)</td>
<td>(0.13)</td>
</tr>
<tr>
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</tr>
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<td>(200.03)</td>
<td>(2.82)</td>
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<td>(3.97)</td>
</tr>
<tr>
<td>( \beta_{01} )</td>
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<td>-5.11</td>
<td>-153.44</td>
<td>-1.46</td>
</tr>
<tr>
<td></td>
<td>(3.06e+10)</td>
<td>(2.51)</td>
<td>(0)</td>
<td>(2.85)</td>
</tr>
<tr>
<td>( \beta_{10} )</td>
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<td>1.05</td>
<td>-8.52</td>
</tr>
<tr>
<td></td>
<td>(9.37)</td>
<td>(0.73)</td>
<td>(1.57)</td>
<td>(6.49)</td>
</tr>
<tr>
<td>( \beta_{11} )</td>
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</tr>
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</tr>
<tr>
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<td>( LR )</td>
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<td>-486.27</td>
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</table>

Notes: Standard errors in parentheses.
Figure 6.4: TVTP probabilities of slow growth

Notes: Indonesia (top left), Japan (bottom left), Korea (top right), Taiwan (bottom right)
seems to have only one recessionary episode following the Asian crisis of 1997 and this is clearly depicted in the graph. Finally, Taiwan appears to have a 'variable' profile.

While these observations are not at odds with economic reality and the model seems to be doing reasonably well, it is difficult to gauge the value added of extending the framework of transition probabilities to a dynamic one and of incorporating the CLI. Therefore, it is fair to conclude that there does not seem to be a dramatic improvement in model performance after all, given the statistical insignificance of coefficient values on variables $z_t$ (i.e. $\beta_{01}$ and $\beta_{11}$), which indicates that there is no time variation in the transition probabilities.

### 6.4 Duration-dependent MSVAR

Pelagatti (2005) extended Durland and McCurdy's (1994) duration-dependence setting from a univariate to a multivariate one. The two-state Markov chain that governs the regime switching has transition probabilities that depend on the time that the chain has been in a given regime. Again, this is a deviation from the assumption of constant transition probabilities made in the previous chapter.

The DDMSVAR model presents similar difficulties with the TVTP in that there may be problems of over-parameterisation. Like with most VAR specifications there is a degree of discretion as to what variables should be included. And, as the estimation methodology is based on Gibbs sampling (see Section 4.3) estimation times can be lengthy.

In order to address these problems I have opted for simplicity. Hence, the model estimated here has two variables: the growth rate of IP and the change in the CLI. There are no lags and only current values of the variables enter the specification. The models are estimated with 100 iterations.\(^6\)

Results for equations (4.11) and (4.16) are reported in Table 6.5. Again, as in

---

\(^6\) Increasing the number of iterations smooths out the probabilities of recession and expansion but makes no significant difference to the estimated coefficients of the model.
Table 6.5: Estimation results of the DDMS model

<table>
<thead>
<tr>
<th></th>
<th>Indonesia</th>
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<th>Korea</th>
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<th>Philippines</th>
<th>Taiwan</th>
<th>Thailand</th>
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<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
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<td>0.0001</td>
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<td>0.02</td>
<td>0.001</td>
<td>0.005</td>
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<td>(0.004)</td>
<td>(0.006)</td>
<td>(0.01)</td>
<td>(0.005)</td>
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<tr>
<td>$CL\bar{I}$</td>
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<td>-0.002</td>
<td>-0.001</td>
<td>0.01</td>
<td>-0.002</td>
<td>0.002</td>
</tr>
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<td></td>
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<td>(0.001)</td>
<td>(0.003)</td>
<td>(0.0003)</td>
<td>(0.01)</td>
<td>(0.001)</td>
<td>(0.0007)</td>
</tr>
<tr>
<td>$\mu_1$</td>
<td>$IP$</td>
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<td></td>
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<td></td>
</tr>
<tr>
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<td>0.004</td>
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<td></td>
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<td>(0.007)</td>
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<td>$CL\bar{I}$</td>
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<td>0.01</td>
<td>-81.56</td>
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<td>(0.0003)</td>
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<td>(0.002)</td>
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<td>(1.55)</td>
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<td>$\beta_2$</td>
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<td></td>
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<td>(0.05)</td>
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<td>$\beta_3$</td>
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<td>-0.003</td>
</tr>
<tr>
<td></td>
<td>(0.36)</td>
<td>(0.03)</td>
<td>(0.15)</td>
<td>(0.17)</td>
<td>(0.21)</td>
<td>(0.03)</td>
<td>(0.01)</td>
</tr>
<tr>
<td>$\sigma$</td>
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<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>0.05</td>
<td>0.0002</td>
<td>0.0005</td>
<td>0.001</td>
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<td>0.002</td>
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<td></td>
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<td>(3.6e-005)</td>
<td>(0.0001)</td>
<td>(0.0004)</td>
<td>(0.0002)</td>
<td>(0.0001)</td>
</tr>
<tr>
<td>$CL\bar{I}$</td>
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<td></td>
<td>(5.4e-007)</td>
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<td>(8.1e-007)</td>
<td>(8.9e-006)</td>
<td>(7.8e-006)</td>
</tr>
</tbody>
</table>

Standard errors in parentheses.

the TVTP, the complexity of the model does not appear to deliver superior results to the simple FTP specification. The estimated coefficients of $\mu_0$ and $\mu_1$ for the IP series are statistically insignificant for most economies. If the estimated coefficients $\beta_2$ and $\beta_4$ from the probit regression (Equation 4.16) are indifferent from zero then there will be no duration dependence in either regime. In this case, they are mostly insignificant. If we assumed that the functional form of the estimated equation is correct then we would conclude that recessions and expansions do not appear to be duration-dependent.

Of course, there may be a criticism of the functional form chosen, for example the choice of variables and the number of lags. However, given that the sample dataset consists of several countries there are constraints on the availability of data. There were efforts to collect data to estimate a specification similar to Pelagatti (2005) for the U.S., which includes employment, manufacturing and trade sales and personal
income less transfer payments, but the limitations became apparent very early. I leave an exploration of alternative specifications for future research.

Despite the lack of encouraging results, the graphs 6.5 - 6.11 paint a slightly more positive picture about the usefulness of the DDMSVAR model. In most cases the contraction that followed the 1997 crisis is picked up as a substantial increase in the recession probability. As mentioned before, the lack of an NBER-type official classification prevents an adequate assessment of these results. The paths for the contraction and expansion probabilities are different across countries, as one would expect, but possibly excessively so. This highlights another limitation of applying a 'one size-fits-all' time series methodology to a group of countries. Unlike Chapter 5's FTP analysis, however, it is more difficult to have tailor-made models for each economy given the possibility of trying a number of variables as potential components of the VAR in the duration-dependence case.
Figure 6.6: Japan: DDMSVAR states for recession (top) and expansion (bottom)

States
\[ \text{Pr}(SS_{t}=05) \]

Figure 6.7: Korea: DDMSVAR states for recession (top) and expansion (bottom)

States
\[ \text{Pr}(SS_{t}=05) \]
Figure 6.8: Malaysia: DDMSVAR states for recession (top) and expansion (bottom)

Figure 6.9: Philippines: DDMSVAR states for recession (top) and expansion (bottom)
Figure 6.10: Taiwan: DDMSVAR states for recession (top) and expansion (bottom)

Figure 6.11: Thailand: DDMSVAR states for recession (top) and expansion (bottom)
6.5 Final remarks

A qualified conclusion is that the CLI-based dynamic Markov switching models do not appear to deliver a superior performance with respect to understanding better the East and Southeast Asian economies' business cycle. Of course, this may have to do with the choice of the CLI as the exogenous variable in the TVTP and the VAR component in the DDMSVAR. However, trying to assess the added value of different variables would be beyond the scope of this thesis, given the breadth of the sample. I leave this for future research.
Chapter 7

Conclusions

The study of business cycles is hardly new. They have long attracted the interest of economists and a lot of attention from policymakers and the public. Understanding the characteristics of business cycles is not only useful in terms of measuring the effects of various shocks impacting the economy, but also because it helps private agents to make informed economic decisions and policymakers to design better policies targeted at reducing economic instability.

The selected East and Southeast Asian countries and districts in this thesis are members of the Executives’ Meeting of East Asia-Pacific Central banks (EMEAP) (excluding Australia and New Zealand). They are also the components of the MSCI (Morgan Stanley Capital International) index of emerging markets in Asia (excluding India). The region generates great interest because it encompasses both developed economies and emerging ones. Moreover, impressive economic development and the increasing share of world output in emerging markets also draw a great deal of attention in documenting features of their business cycles. Furthermore, the severe regional crisis in 1997-1998 and its recovery back to robust growth rates may shed light on the most recent financial crisis of 2007 to the present.
Although the aim of the thesis is to model empirically the business cycle of the chosen East and Southeast Asian economies, it begins with a review of the fundamental structure of the real business cycle (RBC) model in Chapter 2. Through a careful presentation of the relevant micro-foundations, I restate the basic idea of RBC theory that views business cycles as processes of efficient adjustment to exogenous changes in the economic environment solely driven by productivity shocks. When productivity shocks alter the efficiency of capital and/or labour, this affects the decisions on the tradeoff of consumption and saving and that of labour and leisure. In sequence, this changes the consumption and production choices of households and firms, which eventually have an effect on output. In the same chapter I also review several major extensions and limitations of RBC theory. Finally, the chapter offers an empirical literature review on international business cycles, the role of various economic indicators in predicting business cycles and of different economic techniques used to identify business cycles.\textsuperscript{1}

Chapter 3 provides a macroeconomic overview of the sample economies. These economies are studied individually through an investigation of their economic policies and economic structure, their economic performance and expenditure components of GDP. Some of these economies are in different stages of economic development and the chapter highlights differences in economic conditions and factors. However, despite these differences, there are still certain similar macroeconomic features shared among them, such as manageable levels of government spending and low inflation rates. Furthermore, with respect to a rapid increasing in trade and financial linkage in the region, the 1997 Asian financial crisis along with large hoarding of international reserves in the aftermath of the crisis are examined.

Chapter 4 outlines the structures of three different Markov switching (MS) models: the MS model with fixed transition probabilities (FTP), the duration-dependent MS model (DDMS) and the MS model with time-varying transition probabilities (TVTP), which are used in the empirical analysis in Chapter 5 and Chapter 6. The

\textsuperscript{1}The empirical review excludes the Markov switching method, which is discussed in detail in chapter 4.
major difference among the three models is the identification of transition probabilities even though all the models take account of probabilities of shifting among different regimes. Transition probabilities in the FTP model do not vary over time; they only depend on the past state values that are considered to be relevant to the determination of the current state. The DDMS model allows transition probabilities to depend on the duration of a particular state. In this case, transition probabilities change with length of the period that the economy stays in the specific state. As the duration of the state approaches its maximum value, it is likely to switch to a different regime. In the TVTP model, transition probabilities are time-varying as well, but their shifts in regimes vary with movements in leading indicator variables. Then the expectation-maximisation algorithm (used to estimate the FTP and the TVTP models) in addition to the Bayesian analysis and the Gibbs-sampling method (employed to estimate the DDMS model) are discussed in detail. Moreover, it also includes the discussion of the methods of determining the number of regimes and lags. In the final part, a range of empirical papers that adopt these three types of the MS model are reviewed.

In Chapter 5, the FTP model is adopted in the empirical analysis. First of all, following Hamilton's (1989) paper, the conventional MS model – MSM(2)-AR(4) is applied to the individual economies (apart from China), to set out the benchmark model. It is found that the MSM(2)-AR(4) model is unable to capture fully the statistical properties of the sample economies' business cycle. Consequently, other generalised MS-AR specifications are examined. The outcomes reveal that these individual economies are not all alike. Nevertheless, there is evidence of some extent of common regime shifts among multiple economic time series. Hence, an investigation of international business cycles is carried out through dividing these economies into three groups: developing economies, developed economies and all markets.

Now, let us turn back to the questions that we asked in the introduction: first, what are the characteristics of business cycles described in these selected economies? Using the FTP model
1 Time series of each economy exhibits nonlinear properties since the linearity test is rejected in all cases.

2 All economies have two or three distinct and statistical regimes (in most of cases). Specifically, all six emerging markets (except Philippines) are classified by three states: rapid growth, moderate growth and low growth (recession). Nonetheless, the developed economies (Hong Kong and Japan) also show three growth regimes, a fact that differs from a general impression that business cycles of developed economies are divided into either expansions or recessions.

3 In general, the duration of moderate growth (or expansions) is longer than that of low growth (or recessions), apart from Singapore. This finding is also shown in the unconditional probabilities.

4 Although the proportion of time in the normal (or expansionary) phase (the unconditional probabilities) are relatively higher than other phases, excluding Singapore, the transition probabilities of remaining in the low growth (or recessionary) state are comparatively persistent in each economy.

5 Half of the sample economies display regime-dependent heteroskedasticity which represents the differences in volatility among different states. Generally, the phase of low growth (or recessions) is more volatile than other phases.

Second, what is the extent of correlations of the region’s economies conditional on the growth states? According to the estimation of the FTP model,

1 In developing economies, the estimation results show a strong relationship between the economies in the state of normal growth (or expansions), in particular, among the members of ASEAN-4 (excluding Singapore). The correlations are less related in the low growth (recessionary) state.

2 The above finding also applies to developed economies under the two-regime MS specifications. In the case of three regimes, the economies are relatively strong
related in the high expansionary and the recessionary (or low growth) regime, than in the normal expansionary regime. However, in comparison with the correlations in developing economies, these developed economies are relatively less correlated.

3 The overall contemporaneous correlation indicates significant economic relationships between the region's economies under the regime-dependent mean specification, but the magnitude decreases considerably when it is estimated by the regime-dependent intercept specification.

To sum up, there is evidence of comovements among business cycles of these selected economies.

What is more, this multivariate analysis provides an implication to the research on the set up of a currency union, since the correlation of business cycles is an important criterion used to evaluate the desirability of a currency union. According to the contemporaneous correlation, even if some pair-economies show a high degree of business cycle synchronization, the majorities are still considerably low. Consequently, the adoption of a monetary union is not necessary at this stage, despite evidence of increasing comovements of business cycles as suggested by the smoothed recessionary transition probabilities.

In the next chapter, the assumption of fixed transition probabilities is relaxed. First, a TVTP specification is estimated with a composite leading indicator (CLI) as the exogenous variable. Second, a DDMS vector autoregressive model (VAR) is estimated with the CLI as one of the two VAR components. Results from both models are not very encouraging and the trade-off between parsimony and performance appears to be better for the FTP model investigated in chapter 5. Even though, the underlying assumptions of the TVTP and DDMSVAR models are desirable and I intend to continue to explore them empirically.

It will also be worthwhile to investigate the effects of the most recent recession, which has mainly affected developed western economies, on the business cycle of the sample economies. Another step I am planning to take in terms of future research is
to investigate the forecasting performance of the three-type of MS models explored in this thesis. Finally, in a recently published (Sinai, 2010), the author finds that there are four fundamental changes in the US economy which are crucially related to the analysis of business cycles, which are the increasing influence of the financial sector, changes in the indicators used to measure business cycles (e.g. industrial production), a possible structural change in the labour market and the shifting global economic and financial geography. It will be worthwhile to carry out a similar reexamination on the sample economies.

Of course the results presented here are subject to limitations. First of all, in the estimation of the FTP model the choice of the number of regimes is not tested formally, but is rather based on the whole performance of the estimation models. The second limitation is that despite the very positive in-sample performance of the MS models in capturing the characteristics of business cycles of the East and Southeast Asian economies, this work does not offer an analysis of out-of-sample forecasting. Finally, the set of exogenous variables in the TVTP model and the components of the VAR in the DDMS model can be extended. These three limitations provide additional pathways for future research.
APPENDIX A

Appendix to Chapter 5

A.1 Tables
### Table A.1: Estimation results: The MS-AR models (Cont.)

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<th>Parameter</th>
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<th>Hong Kong MSMH(2)-AR(4)</th>
<th>Hong Kong MSMH(3)-AR(4)</th>
<th>Hong Kong MSMH(3)-AR(1)</th>
<th>Indonesia MSM(3)-AR(5)</th>
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Table A.4: Estimation results: The MS-AR models (Cont.)

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Table A.5: Estimation results: The MS-AR models (Cont.)

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Table A.6: Estimation results: The MS-AR models (Cont.)

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<td>0.32</td>
<td></td>
</tr>
<tr>
<td>$\sigma_{p_{22}}=3$</td>
<td>0.42</td>
<td></td>
</tr>
<tr>
<td>$\sigma_{p_{33}}=3$</td>
<td>1.24</td>
<td></td>
</tr>
<tr>
<td>$\ln L$</td>
<td>-56.07</td>
<td>-56.66</td>
</tr>
<tr>
<td>AIC</td>
<td>2.75</td>
<td>2.59</td>
</tr>
<tr>
<td>SIC</td>
<td>3.29</td>
<td>3.07</td>
</tr>
<tr>
<td>HQ</td>
<td>2.95</td>
<td>2.77</td>
</tr>
<tr>
<td>LR linearity</td>
<td>17.87</td>
<td>29.69</td>
</tr>
</tbody>
</table>

All computations reported in this thesis were carried out using the MSVAR1.31K package of Krolzig (2004) under the GiveWin 2.0 programming environment of Doonik (2004), along with the DDMSVAR package of Pelagatti (2003) under the OxMetrics 6.01 programm of Doonik (2009) and the filardo em file of Doan (2009) under the WinRATS 7.2 programm of Doan (2009).


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