Academic Year 2026

Doctoral Dissertation

ANALYSIS OF ECONOMIC FLUCTUATION IN HONG KONG SAR AND SINGAPORE

Nguyen Ngoc Mai

Supervisor
Professor Makoto Kurosaka

Osaka University of Economics

Graduate School of Economics

Doctoral degree programs

Preface

This doctoral dissertation consists of six chapters, that I conducted between 2023 and 2026. Two chapters are expanded versions of the author's previously developed working papers, while the remaining chapters contain original and previously unpublished material.

My deep appreciation for the culture and people of Hong Kong and Singapore was the primary reason for focusing my economic research on these two economies. Additionally, my keen interest in global inflation drove my selection of topics for this dissertation. I developed the specific concepts for each study in consultation with my supervisor. Understanding that this marks the beginning of my future research, I recognized the importance of adhering to fundamental theories and following expert guidance. As a result, I have created a diverse collection of research topics centered on these two economies.

This dissertation investigates macroeconomic fluctuations in Hong Kong and Singapore, which are widely regarded as two of the most successful small open economies in Asia. Despite limited domestic markets, scarce natural resources, and high exposure to external shocks, both economies have achieved remarkable economic development and reached some of the highest levels of per capita income in the region. Their economic success raises an important question: how have these two economies sustained long-term growth and macroeconomic stability despite substantial external vulnerability?

Several common features may help explain their economic performance. Both economies have adopted outward-oriented development strategies, maintained relatively open and competitive business environments, and become major international financial and trading centers. At the same time, their small size and high degree of openness make them particularly sensitive to fluctuations in the global economy. Understanding how external shocks are transmitted to domestic economic activity and how these economies

adjust to such disturbances is therefore an important issue in macroeconomic analysis.

Although Hong Kong SAR and Singapore share many structural characteristics, they differ significantly in their institutional and policy frameworks. Hong Kong operates under a currency board system that maintains a fixed exchange rate against the US dollar. In contrast, Singapore conducts monetary policy by managing the nominal effective exchange rate of the Singapore dollar. These differences provide an opportunity to examine how alternative institutional arrangements influence economic fluctuations, price adjustment, and macroeconomic stability in highly open economies.

This dissertation was undertaken as part of the graduate research program in economics and was motivated by the desire to obtain a broader understanding of macroeconomic fluctuations in small open economies. Using official macroeconomic data from the Census and Statistics Department of Hong Kong, the Department of Statistics Singapore, the Hong Kong Monetary Authority, and the Monetary Authority of Singapore, the study employs a range of modern time-series econometric methods, including unit root tests, cointegration analysis, Vector Error Correction Models (VECM), and Structural Vector Autoregression (SVAR). Rather than focusing on a single aspect of macroeconomic performance, the dissertation aims to provide a comprehensive analysis of the domestic and external factors that influence the economic adjustment process in Hong Kong SAR and Singapore.

The remainder of this dissertation is organized as follows. Chapter 1 examines the macroeconomic structure, institutional frameworks, and macroeconomic performance of Hong Kong SAR and Singapore, providing the institutional background for the subsequent analyses. Chapter 2 investigates the cyclical behavior of real wages with real GDP. Chapter 3 examines whether major macroeconomic variables are characterized by deterministic or stochastic trends using unit root and structural-break tests. Chapter 4 analyzes the validity of purchasing power parity between Hong Kong SAR and Mainland China through cointegration techniques. Chapter 5 investigates the transmission of inflation shocks originating from the United States and China to Hong Kong SAR and Singapore. Chapter 6 examines the dynamic relationship between output

and prices using a structural vector autoregression framework to identify the sources of macroeconomic fluctuations. Finally, the concluding chapter summarizes the main findings of the dissertation and suggests directions for future research.

Acknowledgements

I would like to express my deepest gratitude to my supervisor, Professor Makoto Kurosaka, for his invaluable guidance, encouragement, and continuous support throughout my doctoral studies. His insightful comments, academic expertise, and patient supervision have greatly influenced the development of this dissertation. I am especially grateful for his thoughtful advice, constructive criticism, and unwavering support at every stage of my research.

I would also like to extend my sincere appreciation to Professor Tomoyuki Fukumoto and Professor Daisuke Fujii for serving as members of my dissertation committee. Their insightful comments and thoughtful suggestions have greatly enhanced my research, and I truly appreciate the time and effort they invested in reviewing my work.

I would also like to extend my sincere appreciation to the faculty members and staff of the Graduate School of Economics for providing an excellent academic environment and for their assistance during my years of study. Their support has contributed significantly to both my academic and personal development.

My gratitude is also extended to my colleagues, fellow students, and friends who have shared ideas, offered encouragement, and provided valuable feedback throughout this journey.

I am especially thankful to the Rotary Yoneyama Scholarship Foundation and the Rotary Korien Group for their kindness and assistance while I studied in Japan. Their support not only alleviated my financial burden but also allowed me to connect with diverse individuals.

I am deeply indebted to my family for their unconditional love, patience, and understanding. Finally, I would like to acknowledge all researchers whose studies have contributed to the development of this dissertation. Any remaining errors or shortcomings are solely my responsibility.

Nguyen Ngoc Mai

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List of Abbreviations

Abbreviation	Meaning
ADF	Augmented Dickey–Fuller
AIC	Akaike Information Criterion
AC	Autocorrelation Coefficients
BBC	Basket-Band-Crawl
BIS	Bank for International Settlements
CPI	Consumer Price Index
CV	Coefficient of Variation
C&SD	Census and Statistics Department
DOS	Department of Statistics Singapore
DS	Difference–Stationary
ECT	Difference-Stationary
ECM	Error Correction Model
EG	Engle–Granger
FEVD	Forecast Error Variance Decomposition
EMP	Employment
GCD	Government Consumption Expenditure
GDP	Gross Domestic Product
GFCF	Gross Fixed Capital Formation
HIBOR	Hong Kong Interbank Offered Rate
HK	Hong Kong
HKD	Hong Kong Dollar
HKMA	Hong Kong Monetary Authority
H–P	Hodrick–Prescott
IMF	International Monetary Fund

IRF	Impulse Response Function
LERS	Linked Exchange Rate System
LT	Linear Time Trend
MAS	Monetary Authority of Singapore
MAX.	Maximum
MIN.	Minimum
NEER	Nominal Effective Exchange Rate
Nominal GDP	Nominal Gross Domestic Product
NWAGE	Nominal wage
OLS	Ordinary Least Squares
PCE	Private Consumption Expenditure
PP	Phillips–Perron
PPP	Purchasing Power Parity
Real GDP	Real Gross Domestic Product
RWAGE	Real wage
REER	Real Effective Exchange Rate
SAR	Special Administrative Region
SIC	Schwarz Information Criterion
SG	Singapore
SGD	Singapore Dollar
SIBOR	Singapore Interbank Offered Rate
SIC	Schwarz Information Criterion
SOE	Small Open Economy
STD.DEV	Standard Deviation
SVAR	Structural Vector Autoregression
TS	Trend-Stationary
UR	Unemployment Rate
US	United States
USD	United States dollar

VAR	Vector Autoregression
VECM	Vector Error Correction Model
ZA	Zivot–Andrews

Chapter 1

Macroeconomics Structure and Institutional Frameworks

Abstract

This chapter examines the macroeconomic structures, institutional frameworks, and performance of the Hong Kong Special Administrative Region (SAR) and Singapore. Although these two highly open economies have similar structural characteristics, they operate under different exchange rate regimes. Hong Kong maintains a currency board system through the linked exchange rate system (LERS), whereas Singapore adopts a managed exchange rate framework based on the basket, band, and crawl (BBC) regime. Using data from 1975 to 2025, this chapter analyzes trade openness, sectoral composition, labor-market adjustment mechanisms, and the role of exchange rate arrangements in shaping macroeconomic outcomes.

Despite their similar characteristics as small open economies (SOEs), Hong Kong and Singapore have followed different development paths. Hong Kong's economy is increasingly concentrated in financial services under a currency board regime, whereas Singapore has maintained a more diversified production structure supported by a managed exchange rate system. Evidence from the Asian Financial Crisis (AFC) and the Global Financial Crisis (GFC) reveals that the two economies adjusted to external shocks through different channels. Empirical evidence demonstrates that Singapore has achieved stronger macroeconomic performance, including higher economic growth, lower inflation and unemployment, and greater macroeconomic stability. Although Hong Kong relied primarily on internal adjustment via interest rates, employment, and output, Singapore benefited from greater exchange rate flexibility. These findings illustrate the trade-off between exchange rate credibility and policy flexibility, providing useful policy implications for SOEs in an increasingly uncertain global environment.

1.1 Introduction

This chapter examines the macroeconomic structure and institutional frameworks of Hong Kong and Singapore, a classic pair of small open economies (SOEs) in Asia. They have achieved remarkable economic development, with GDP per capita levels among the highest in Asia. Both economies share several structural characteristics, including limited domestic markets, a lack of natural resources, exceptionally high openness to trade, and important roles as international financial and logistics centers. Therefore, their economic performance is highly exposed to external shocks and fluctuations in the global economy.

Despite these similarities, Hong Kong and Singapore have adopted fundamentally different approaches to macroeconomic management. Hong Kong operates under the linked exchange rate system (LERS), which maintains a fixed exchange rate against the US dollar (USD) through a currency board arrangement. In contrast, Singapore conducts its monetary policy by managing the Singapore dollar's nominal effective exchange rate (S$NEER). These institutional differences imply distinct mechanisms for responding to external shocks, maintaining price stability, and supporting economic activity.

The structural characteristics and sources of macroeconomic fluctuations in both economies are analyzed by examining trade openness, sectoral composition, and labor-market adjustment mechanisms. Subsequently, the influences of differences in exchange rate regimes and monetary policy frameworks on the adjustment process are assessed, drawing on evidence from major episodes such as the AFC of 1997–1998 and the GFC of 2008. Finally, the macroeconomic performances of Hong Kong and Singapore are compared, discussing the implications of alternative institutional arrangements for macroeconomic stability in highly open economies.

This chapter offers a comprehensive comparative overview of Hong Kong and Singapore by integrating structural and institutional perspectives, highlighting the key factors that shape their economic resilience and adjustment to external shocks.

1.2 Structural Characteristics and Sources of Macroeconomic Fluctuations

Hong Kong and Singapore are successful, highly developed, and densely populated city-state economies. However, subtle differences in their economic structures lead to distinct vulnerabilities and transmission mechanisms for economic shocks. Following Lam (2000), Table 1.1 presents an overview of macroeconomic and institutional for Singapore and Hong Kong.

Table 1.1. Macroeconomic and Institutional Characteristics of Hong Kong and Singapore

Indicator	**Hong Kong**	**Singapore**
Geographic location	East Asia	Southeast Asia
Government form	Executive-led Special Administrative Region of China	Parliamentary republic
Previous form of state	British colony	British colony
Land area	1,115 km^2	735 km^2
Population (million, 2024)	7.5	6.04
Languages	Chinese (Cantonese as dominant), English	Chinese, English, Malay, Tamil
GDP, current prices (billions of US dollars, 2024)	406.9	547.5
GDP per capita, current prices (thousand US dollars, 2024)	54.24	90.67
Real GDP growth (%, 2024)	2.5	4.4
Economic status	Advanced economy	Advanced economy
Type of industrialization	Export-oriented	Export-oriented
Major industries by % of GDP	Services (∼95.5%), Manufacturing (<1%)	Services (∼71%), Manufacturing (∼21%)
Unemployment rate (%, 2024)	3	2
Inflation rate, average consumer prices (%, 2024)	1.7	2.4
Export partner (2025)	Mainland China, Taiwan, India	US, Mainland China, Malaysia
Import partner (2025)	Mainland China, Taiwan, Singapore	Mainland China, Taiwan, US
Exchange-rate regime	Linked Exchange Rate System	Managed float (S$NEER)
Monetary policy framework	Currency Board System	Exchange-rate-based monetary policy

Sources. International Monetary Fund (World Economic Outlook Database, 2025); Hong Kong Census and Statistics Department; Singapore Department of Statistics; World Bank World Development Indicators.

1.2.1 Trade Openness and Vulnerability to External Shocks

Given their roles as global financial and logistical hubs, Hong Kong and Singapore exhibit exceptionally high levels of trade openness. Figure 1.1 presents the evolution of trade openness, measured as the ratio of total exports and imports to real GDP (RGDP).

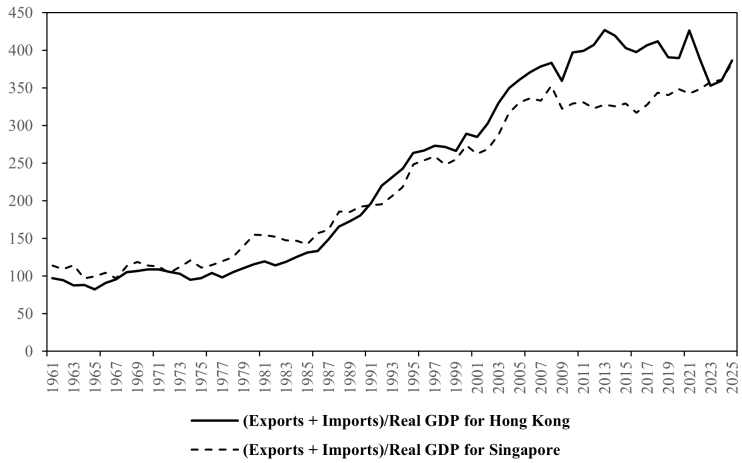


Figure 1.1. Trade Openness and GDP Growth.

From 1990 to 2007, Singapore and Hong Kong experienced substantial growth in trade. Singapore consistently outperformed Hong Kong, peaking at around 440% of GDP in 2007, and Hong Kong rose from 230% to approximately 380% by 2008. The 2008–2009 GFC affected both economies, reducing their trade - to - GDP ratios to roughly 350% of GDP in 2009.

Hong Kong rebounded strongly from 2010 to 2019, reaching nearly 450% of GDP in 2013. In contrast, Singapore shifted toward high-value-added services, stabilizing its trade openness at approximately 300%–320% of GDP.

From 2019 to 2025, Hong Kong exhibited volatility, falling to 350% in 2020 before rising to nearly 400% by 2025, whereas Singapore maintained a steady trajectory within the 310%–330% GDP range.

The high trade-to-GDP ratios indicate that both economies are highly exposed to changes in external demand, global trade conditions, and international financial developments.

1.2.2 Sectoral Composition and Growth Drivers

Changes in industry composition over the cycle enhance the procyclicality of real wages, as the durable goods manufacturing sector offers high average wages and is disproportionately sensitive to the cycle (Abraham & Haltiwanger, 1995). Tables 1.2 and 1.3 show the productive structures of Hong Kong and Singapore also evolved differently.

Hong Kong and Singapore experienced substantial structural transformation during the sample period (Tables 1.2 and 1.3). However, the direction and magnitude of these changes considerably differed between the two economies.

In Hong Kong, manufacturing declined from 2.45% of GDP in 2000 to less than 1% in 2024, reflecting the relocation of production activities to Mainland China. Additionally, the financial and insurance sector expanded significantly, accounting for nearly one-quarter of the GDP by 2024. These trends reflect an increasing dependence on financial services and other high-value-added services.

Conversely, Singapore maintained a relatively stable manufacturing base, with the sector consistently contributing around one-fifth of GDP throughout the sample period. The expansion of finance and information and communication services strengthened Singapore's diversified economic structure.

Consequently, the two economies have different principal growth drivers: Hong Kong relies heavily on financial intermediation, trade-related services, and professional services, whereas Singapore benefits from advanced manufacturing, international trade, financial services, and technological development.

Table 1.2. Gross Domestic Product by Industry Share at Constant Prices (by%) in Hong Kong.

Industry	**2000**	**2003**	**2008**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**
Manufacturing	2.45	1.69	1.22	0.90	0.91	0.90	0.93	0.94	0.92
Construction	6.06	5.20	3.16	4.04	3.81	3.57	4.00	4.21	4.30
Wholesale & Retail Trade	15.43	17.42	20.89	19.93	18.08	19.28	17.59	16.99	16.66
Transportation & Storage	6.63	6.48	6.73	6.84	4.61	4.67	4.62	5.81	6.30
Accommodation & Food Services	3.74	2.49	2.97	2.47	1.45	1.68	1.62	2.03	1.95
Information & Communications	2.61	2.99	2.83	3.17	3.44	3.32	3.46	3.38	3.37
Finance & Insurance	12.21	13.18	17.48	22.95	25.48	25.12	25.34	24.20	23.86
Real Estate, Professional Services, Administrative & Support Services	11.17	10.72	9.44	8.32	8.47	8.14	8.25	8.19	8.13
Other Services Industries	23.60	22.73	18.30	19.04	19.86	19.52	20.47	20.34	20.50

Table 1.3. Gross Domestic Product by Industry Share at Constant Prices (by%) in Singapore.

Industry	**2000**	**2003**	**2008**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**
Manufacturing	21.29	19.56	19.39	19.23	21.50	22.19	21.89	20.59	20.57
Construction	4.82	3.56	3.89	4.03	2.43	3.13	3.41	3.54	3.54
Wholesale & Retail Trade	12.18	13.49	15.04	14.64	14.89	14.92	14.88	14.75	14.81
Transportation & Storage	9.18	8.83	8.85	6.89	6.02	6.10	6.17	6.27	6.35
Accommodation & Food Services	2.83	2.24	2.13	1.96	1.43	1.27	1.37	1.48	1.46
Information & Communications	3.11	3.75	3.58	4.58	5.43	5.70	5.91	6.46	6.49
Finance & Insurance	7.63	8.75	9.64	12.80	14.13	13.94	13.45	13.62	13.94
Real Estate, Professional Services, Administrative & Support Services	12.97	13.02	14.23	13.59	12.44	11.85	12.64	12.73	12.29
Other Services Industries	11.97	12.82	10.84	10.41	9.89	9.46	9.53	9.79	9.66

1.2.3 Industrial Composition and Employment

Tables 1.4 and 1.5 illustrate the structural transformation trajectory in both economies by presenting the labor force distribution by industry.

In Hong Kong, the data show a near-complete transition to a service-based economy (Table 1.4). By 2008, manufacturing employed only 4.72% of the labor force, a figure that steadily declined to 2.40% by 2025. This decline in the secondary sector correlates with a substantial increase in employment within the tertiary industries. Specifically, the sectors of "financing, insurance, real estate, professional and business services" and "public administration, social, and personal services" experienced significant growth, collectively absorbing more than 55% of the workforce by 2025. This trend highlights a heavy reliance on high-value-added services and indicates a structural shift from traditional manufacturing.

As shown in Table 1.5, Singapore exhibits a declining trend in manufacturing employment—falling from 20.24% in 2004 to 12.01% in 2025. However, it has retained a significantly larger manufacturing workforce compared with Hong Kong. In Singapore, manufacturing remains a foundational pillar rather than a marginal sector. The steady rise in real estate, professional services, administrative and support services (from 10.88% to 15.05%) and community, social, and personal services indicates a robust shift toward services, matching the broader trend of advanced economies. However, the persistent difference in manufacturing shares illustrates contrasting patterns of structural transformation. Hong Kong has become increasingly concentrated in financial, trade-related, professional, and public services, whereas Singapore has retained a substantial manufacturing base alongside the expansion of advanced services.

Table 1.4. Employment by Industry Share (%) in Hong Kong.

Industry	2008	2014	2019	2020	2021	2022	2023	2024	2025
Manufacturing	4.72	3.47	2.70	2.83	2.57	2.54	2.41	2.34	2.40
Construction	7.56	8.27	8.75	8.42	8.88	9.18	9.41	9.52	9.21
Import/export trade and wholesale	16.78	13.42	10.11	8.98	8.62	8.83	8.41	8.03	7.70
Retail, accommodation and food services	15.72	16.92	15.80	14.10	14.06	14.15	14.48	13.91	13.44
Transportation, storage, postal and courier services, information and communications	12.36	11.90	11.67	11.86	11.72	11.41	11.37	11.42	11.40
Financing, insurance, real estate, professional and business services	18.20	19.57	21.69	23.10	23.50	22.98	22.89	23.00	23.42
Public administration, social and personal services	24.03	25.84	28.62	30.09	30.03	30.20	30.40	31.12	31.72
Other industries	0.61	0.60	0.66	0.63	0.62	0.71	0.64	0.67	0.71

Table 1.5. Employment by Industry Share (%) in Singapore.

Industry	2004	2008	2013	2019	2020	2021	2022	2023	2024	2025
Manufacturing	20.24	18.93	15.45	12.87	12.52	12.40	12.47	12.22	12.01	12.01
Construction	10.26	11.99	13.73	12.01	11.20	11.18	12.78	13.20	13.33	13.77
Wholesale and Retail Trade	15.13	14.23	13.72	12.80	12.76	12.38	11.73	11.61	11.26	10.95
Transportation and Storage	7.55	6.85	6.59	6.93	7.04	6.96	6.79	6.60	6.58	6.55
Accommodation and Food Services	5.78	6.36	6.60	7.16	6.87	6.70	6.75	6.74	6.69	6.58
Information and Communications	2.86	3.10	3.49	4.09	4.37	4.76	4.83	4.56	4.46	4.24
Financial and Insurance Services	4.90	4.81	4.83	5.32	5.67	5.81	5.70	5.80	5.74	5.86
Real Estate, Professional Services, Administrative and Support Services	10.88	13.25	14.30	15.57	15.66	15.86	15.36	15.22	15.36	15.05
Community, Social and Personal Services	21.79	19.72	20.54	22.56	23.18	23.28	22.97	23.43	23.92	24.34
Others	0.61	0.77	0.75	0.69	0.72	0.67	0.63	0.62	0.65	0.64

1.2.4 Main expenditure components

This section compares the expenditure composition of GDP in Hong Kong and Singapore, with particular attention to the evolution of gross fixed capital formation as a share of nominal GDP. Gross fixed capital formation (GFCF) is examined because investment is one component of aggregate demand and is also associated with the accumulation of productive capital over the longer run. Figure 1.2 illustrates GFCF as a proportion of GDP for both economies from 1961 to 2025.

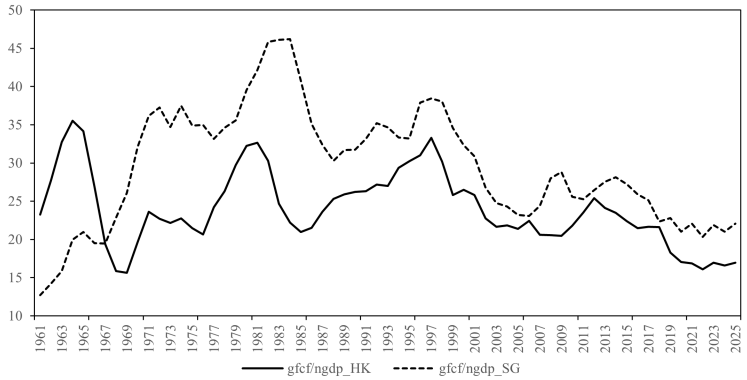


Figure 1.2. Proportion of Gross Fixed Capital Formation in nominal GDP in Hong Kong and Singapore.

The most striking divergence occurred between the late 1970s and the 1980s. During this period, Singapore's investment share surged dramatically, peaking at 40.79% of GDP in 1985. This exceptionally high investment share is consistent with the historically important role of capital formation in Singapore's development process. However, the descriptive ratio alone does not identify the relative contributions of government policy, private investment decisions, and cyclical conditions. Conversely, Hong Kong's GFCF share during the same era was significantly lower and more volatile (dropping to 20.97% in 1985), aligning closely with its laissez-faire, market-driven economic model. By 2025, Singapore continued to maintain a stronger capital formation rate at 22.08%, compared with Hong Kong's 16.94%. This difference highlights a key macroeconomic distinction: Singapore allocates more of its output to fixed investment, whereas Hong Kong depends less on capital deepening.

Table 1.6. Hong Kong and Singapore Main Expenditure Components (% of GDP).

Component	1961	1965	1970	1975	1980	1985	1990	1995	2000	2005	2010	2015	2020	2023	2025
Hong Kong															
PCE	77.29	63.37	66.23	65.47	60.04	61.46	57.45	62.16	58.64	57.48	61.38	66.43	66.34	70.02	66.24
GCE	6.32	5.17	5.66	6.00	5.62	7.01	6.84	8.03	9.37	9.25	8.86	9.64	12.75	13.31	12.58
GFCF	23.25	34.16	19.67	21.47	32.25	20.97	26.21	30.21	26.51	21.40	21.78	22.40	17.03	16.96	16.94
EX	83.04	68.82	93.19	83.40	88.75	103.92	117.27	126.21	126.03	177.45	205.32	195.90	176.30	176.85	199.93
IM	90.64	72.26	85.48	77.81	89.26	93.88	108.73	130.69	121.62	165.24	199.45	193.51	174.38	176.34	197.01
Singapore															
PCE	90.45	78.84	67.14	60.08	50.50	44.75	44.58	40.87	41.86	39.85	36.34	37.16	32.15	31.51	31.09
GCE	8.89	10.36	11.83	10.48	9.65	13.39	9.51	8.25	10.50	9.90	9.69	10.19	12.19	9.84	10.25
GFCF	12.70	20.95	32.12	34.89	39.52	40.79	31.72	33.19	32.33	23.19	25.57	27.22	21.00	21.87	22.08
EX	142.42	123.24	126.03	137.12	202.01	152.22	177.19	181.12	188.35	225.16	198.00	178.38	181.18	180.43	177.85
IM	156.98	134.30	145.03	146.45	208.93	151.92	167.14	164.34	176.01	195.27	171.69	151.09	149.90	143.27	142.45

Note. PCE denotes private consumption expenditure, GCE denotes government consumption expenditure, GFCF denotes gross domestic fixed capital formation, EX denotes exports of goods and services, and IM denotes imports of goods and services.

Table 1.6 also reveals a marked divergence in private-consumption shares. In Singapore, private consumption declined from more than 90 percent of GDP in 1961 to 31.09 percent in 2025, while Hong Kong's private-consumption share remained substantially higher, reaching 66.24 percent in 2025. This difference should be interpreted cautiously because GDP accounting ratios in highly open economies are affected by the large roles of trade, investment, and external income flows.

1.3 Institutional Exchange Rate Frameworks and Macroeconomic Adjustment

Exchange rate frameworks play a crucial role in shaping the transmission of macroeconomic shocks in SOEs. Hong Kong has operated under a LERS since October 17, 1983, whereas Singapore has conducted monetary policy under a managed exchange rate regime known as the BBC framework (Gerlach & Gerlach-Kristen, 2006; Lu & Yu, 1999; Rajan & Siregar, 2002). These institutional differences have crucial implications for the adjustment process following changes in domestic and external economic shocks. This section examines the responses of Hong Kong and Singapore to external shocks.

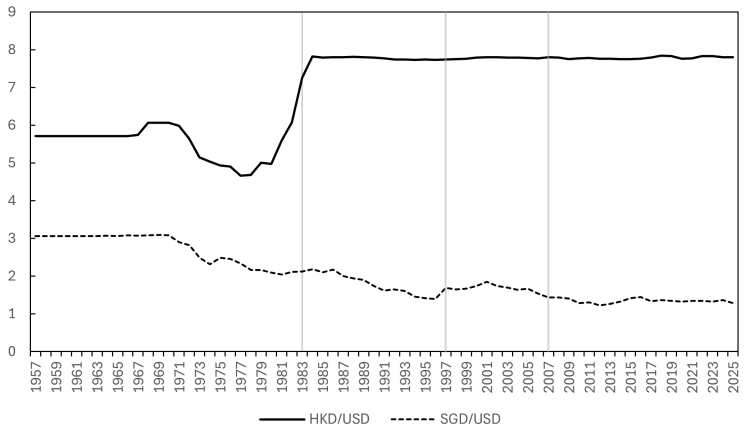


Figure 1.3. Exchange rates against USD.

Figure 1.3 shows the exchange rates of the Hong Kong dollar (HKD) and SGD against the USD (1957–2023), highlighting HKD's strict peg established in late 1983 and the gradual, managed appreciation of the SGD.

1.3.1 Core Adjustment Mechanisms

Despite their similarities as highly open economies, Hong Kong and Singapore adopt fundamentally different mechanisms to adjust to external shocks (Ma et al., 2007).

Under the LERS, the HKD is rigidly pegged to the USD through a currency board arrangement. Given that the nominal exchange rate cannot adjust in response to external shocks, macroeconomic adjustment must occur internally through changes in domestic prices, wages, employment, asset markets, and output (Ma et al., 2007; HKMA, 2013; Rajan & Siregar, 2002; Tsang, 1998). In this framework, the exchange rate does not function as a shock absorber. Consequently, restoring external competitiveness following an adverse shock requires adjustments in domestic costs and economic activity.

In contrast, Singapore manages its currency against a trade-weighted basket of currencies using the S$NEER framework (Ma et al., 2007). In this system, the nominal exchange rate acts as a "safety valve" or shock absorber, allowing the Monetary Authority of Singapore (MAS) to adjust the currency's value to directly mitigate imported inflation or stimulate external demand (Lu & Yu, 1999; Rajan & Siregar, 2002; Ong, BIS Paper No.73). Consequently, part of the adjustment process occurs through exchange rate movements rather than entirely through domestic prices and output.

1.3.2 Monetary Policy Autonomy

The contrasting exchange rate arrangements imply different degrees of monetary policy autonomy. In Hong Kong, the Hong Kong Monetary Authority (HKMA) lacks monetary autonomy and must "import" US interest rates due to the trilemma of international finance (Gerlach & Gerlach-Kristen, 2006; Ma et al., 2007). When a shock occurs, the HKMA relies on an automatic "specie-flow" mechanism in which capital outflows contract the monetary base and drive domestic interest rates up to protect the peg, typically causing "interest rate pain" for the real economy (Tsang, 2000). Rajan (2002) reported that in May 1991, the HKMA independently raised interest rates to

control inflation. The positive interest rate spread over US markets attracted large capital inflows until 1996–1997. These inflows sharply increased domestic liquidity because the exchange rate was fixed to the USD through a CBA.

In contrast, the MAS in Singapore maintains discretionary control over domestic demand through exchange rate management (Gerlach & Gerlach-Kristen, 2006; Ma et al., 2007; BIS104, 2019). It can implement active monetary policy to fine-tune the economy according to Singapore's specific business cycles rather than being strictly bound to US policy.

1.3.3 Evidence from the Asian Financial Crisis

The differences between the two adjustment mechanisms became particularly evident during the 1997–1998 AFC. Two competing interpretations of the crisis have emerged in the literature (Morisawa, 2001). One view, commonly associated with the IMF and the World Bank, emphasizes structural vulnerabilities, such as weak financial systems, excessive short-term external debt, and macroeconomic imbalances. The alternative view, advanced by Radelet and Sachs (1998), characterizes the crisis primarily as a financial panic triggered by a sudden reversal of international capital flows. The AFC spread across the region through three main channels: similarities in economic structures, financial panic that reduced international capital flows, and trade linkages (Siriwardana & Schulze, 2000). Among these channels, trade linkages were particularly relevant to Singapore because of its highly open economy.

Ohashi (2009) explained the mechanism underlying Hong Kong's economy during the Asian crisis: as the HKD is pegged to the USD, it has an automatic adjustment mechanism by external balance. When the external balance moves into deficit and leads to an outflow of excessive foreign reserves, note-issuing banks lose external assets and may stop issuing HKD. This contraction, in turn, decreases the money supply, raises interest rates, and lowers prices; the resulting decline in aggregate demand then restores the external balance.

Singapore allowed the SGD to depreciate by approximately 20% during the height

of the crisis (Lu & Yu, 1999; Rajan & Siregar, 2002). Kai (2009) noted that Singapore recovered quickly from the AFC because the government effectively controlled wage determination throughout the economy and imposed wage cuts of 5%–8% across industries during the crisis.

In contrast, Hong Kong maintained its strict commitment to the USD peg. To deter speculators and defend the currency board, overnight interbank interest rates (Hong Kong Interbank Offered Rate (HIBOR)) briefly spiked to as high as 280% (Lu & Yu, 1999; Tsang, 2000). Consequently, Hong Kong experienced a much deeper recession, with GDP declining by 5% in 1998 and the economy undergoing years of painful asset price and wage deflation to restore real competitiveness (Lu & Yu, 1999; Rajan & Siregar, 2002).

As the exchange rate remained fixed, adjustment primarily occurred through declines in asset prices, economic activity, and domestic prices. The contrasting experiences of the two economies illustrate how exchange rate flexibility can serve as an additional channel for absorbing external shocks.

1.3.4 Evidence from the Global Financial Crisis

The 2008 GFC, triggered by the collapse of Lehman Brothers, represented a major external shock for Hong Kong and Singapore. Both highly open economies experienced a sharp slowdown in economic activity, weakening external demand, and heightened volatility in financial markets. The AFC can be viewed as a form of market failure (Hamada, 2000). In Hong Kong, the crisis caused severe disruptions in USD funding markets. The spread between the 3-month HIBOR and the Overnight Indexed Swap rate surged to more than 200 basis points, and the interbank market exhibited a distinct "panic response." Disruptions in global liquidity forced institutions to rely on foreign exchange swap markets, leading to persistent deviations from covered interest parity (Fung & Yu, 2009). In response, the HKMA introduced five temporary liquidity measures to restore market efficiency and reduce these deviations. The adjustment process differed between the two economies because of their exchange rate arrange-

ments. Under the LERS, Hong Kong maintained its peg to the USD and absorbed the shock mainly through adjustments in interest rates, asset prices, and economic activity. In contrast, Singapore's managed exchange rate regime allowed the exchange rate to function as a shock absorber, providing greater flexibility in responding to adverse external conditions and reducing pressure on domestic financial markets (Tse & Yip, 2002) The coexistence of these two centers enhances global stability. Their geographic specialization—Hong Kong for China and Singapore for Southeast Asia—acts as a buffer that slows the propagation of financial shocks across the global network (Le Leslé et al., 2014). This finding illustrates the importance of institutional frameworks and complementarity in maintaining financial stability during global stress.

1.3.5 Implications for Inflation and Macroeconomic Adjustment

According to the trilemma of international finance, a country cannot simultaneously maintain exchange rate stability, monetary policy independence, and full capital mobility. Only two of these three objectives can be simultaneously achieved (Krugman & Obstfeld, 2006; Mankiw, 2010). Consequently, the monetary and exchange rate arrangements adopted by Hong Kong and Singapore imply different mechanisms for macroeconomic adjustment. These contrasting choices reflect the different priorities and constraints facing the two economies.

Under the LERS, Hong Kong has chosen exchange rate stability and free capital mobility, thereby sacrificing monetary policy independence. Therefore, domestic interest rates tend to move closely with US interest rates, limiting the authorities' ability to respond independently to domestic economic conditions. Given the fixed nominal rate, domestic prices bear the full burden of restoring equilibrium, leading to higher and more volatile inflation or deflation (Cheung & Yuen, 2002; Gerlach & Gerlach-Kristen, 2006). However, Singapore's exchange-rate–centered monetary policy framework allows greater flexibility in managing inflation and responding to external shocks through adjustments in the exchange rate band (Cheung & Yuen, 2002; Gerlach & Gerlach-Kristen, 2006).

These institutional differences explain the contrasting macroeconomic performance of the two economies. Although Hong Kong benefits from a highly credible exchange rate regime, Singapore has generally maintained lower inflation volatility and greater macroeconomic stability during periods of external uncertainty.

1.4 Macroeconomic Performance

1.4.1 Summary of Macroeconomic Performance

This chapter employs a comprehensive macroeconomic dataset for Hong Kong and Singapore, comprising nominal and real variables at quarterly and monthly frequencies. The primary sample period spans 1975.Q1–2025.Q4. Hong Kong data are sourced from the HKMA and the C&SD. Data for Singapore are primarily sourced from the MAS and SingStat. The NEER and real effective exchange rate (REER) are sourced from the Bank for International Settlements (BIS), with indices normalized such that 2020 = 100.

The main variables include real GDP (RGDP), nominal GDP (NGDP), the GDP deflator, the Consumer Price Index (CPI), the unemployment rate (UR), employment (EMP), 3-month interbank interest rates (HIBOR for Hong Kong and SIBOR for Singapore), money supply (M1, M2, M3), and the expenditure components of GDP: private consumption expenditure, government consumption expenditure (GCE), GFCF, exports (EX), and imports (IM). Hong Kong's interest rate is measured as the 3-month interbank offered rate (HIBOR) using period-average figures. In contrast, Singapore's nominal interest rate is obtained as the 3-month interbank offered rate (SIBOR). As these data are daily figures, they have to be averaged to obtain monthly figures. Given that these data are provided monthly, they are converted to the quarterly basis required for this study by taking the simple average of the three-monthly observations within each quarter. For comparative purposes, this study incorporates interest rate data for the US.

Singapore data are published in seasonally adjusted form by SingStat. For Hong

Kong, seasonality was removed using a moving-average seasonal adjustment procedure. All variables have been transformed into natural logarithms, except for interest rates. Table 1.7 provides a summary of the variables used in this chapter, together with their symbol, frequency, sample periods.

Table 1.7. Summary of Variables and Data

Variable	**Symbol**	**Frequency**	**Sample Period**
Real GDP	$rgdp^{HK}$, $rgdp^{SG}$	Quarterly	1975.Q1–2025.Q4
GDP deflator	$gdpdef^{HK}$, $gdpdef^{SG}$	Quarterly	1975.Q1–2025.Q4
Consumer Price Index	cpi^{HK}, cpi^{SG}	Quarterly	1975.Q1–2025.Q4
Unemployment	ur^{HK}, ur^{SG}	Quarterly	1992.Q1–2025.Q4
3-month Interest Rate	$ir.3m^{HK}$,$ir.3m^{SG}$, $ir.3m^{US}$	Monthly → Quarterly	1997.Q1–2025.Q3
10-year Interest Rate	$ir.10y^{HK}$,$ir.10y^{SG}$, $ir.10y^{US}$	Monthly → Quarterly	1997.Q1–2025.Q3
NEER	$neer^{HK}$, $neer^{SG}$	Monthly → Quarterly	1975.Q1–2025.Q4
REER	$reer^{HK}$, $reer^{SG}$	Monthly → Quarterly	1975.Q1–2025.Q4
PCE	pce^{HK}, pce^{SG}	Quarterly	1975.Q1–2025.Q4
GCE	gce^{HK}, gce^{SG}	Quarterly	1975.Q1–2025.Q4
GFCF	$gfcf^{HK}$, $gfcf^{SG}$	Quarterly	1975.Q1–2025.Q4
Exports	ex^{HK}, ex^{SG}	Quarterly	1975.Q1–2025.Q4
Imports	im^{HK}, im^{SG}	Quarterly	1975.Q1–2025.Q4

Note. HK denotes Hong Kong SAR; SG denotes Singapore; US denotes the United States.

Tables 1.8–1.15 summarize the key macroeconomic indicators of Hong Kong and Singapore over the sample period. The reported statistics include the mean, maximum (Max.), minimum (Min.), standard deviation (Std. Dev.), coefficient of variation (CV), and first- and second-order autocorrelation coefficients, AC(1) and AC(2). The statistics reveal differences in growth volatility, inflation dynamics, monetary conditions, and exchange rate movements that reflect the distinct structural and institutional characteristics of the two economies.

Table 1.8. Descriptive Statistics of Growth Rates of GDP Expenditure Components in Hong Kong.

Variables	Mean (%)	Max. (%)	Min. (%)	Std. Dev. (%)	CV	AC(1)	AC(2)
1976.Q1–1982.Q4							
$rgdp^{HK}$	9.47	18.65	1.24	4.32	0.46	0.49	0.29
pce^{HK}	10.17	22.86	1.16	5.18	0.51	0.40	0.61
gce^{HK}	9.33	33.35	-4.11	6.47	0.69	0.07	0.01
$gfcf^{HK}$	12.71	24.57	-5.85	6.97	0.55	0.67	0.53
ex^{HK}	11.17	27.87	-3.76	8.02	0.72	0.78	0.54
im^{HK}	13.13	29.49	-5.07	8.95	0.68	0.81	0.56
1983.Q1–1996.Q4							
$rgdp^{HK}$	5.95	16.54	-2.59	4.15	0.70	0.78	0.51
pce^{HK}	6.48	12.95	0.48	2.93	0.45	0.70	0.54
gce^{HK}	5.06	14.50	-1.00	3.24	0.64	0.32	0.22
$gfcf^{HK}$	6.03	18.01	-10.87	6.73	1.12	0.65	0.49
ex^{HK}	11.98	26.70	-3.57	7.10	0.59	0.82	0.56
im^{HK}	12.43	25.99	-5.16	7.33	0.59	0.79	0.49
1997.Q1–2007.Q4							
$rgdp^{HK}$	3.86	11.45	-8.63	4.52	1.17	0.85	0.62
pce^{HK}	2.59	10.69	-8.64	4.57	1.76	0.83	0.56
gce^{HK}	2.16	7.05	-5.97	2.94	1.36	0.36	0.29
$gfcf^{HK}$	1.13	15.76	-27.34	9.38	8.33	0.75	0.58
ex^{HK}	7.52	20.37	-8.38	7.35	0.98	0.84	0.58
im^{HK}	6.50	20.52	-13.64	8.29	1.28	0.82	0.51
2008.Q1–2025.Q4							
$rgdp^{HK}$	1.81	7.92	-9.90	3.77	2.08	0.73	0.44
pce^{HK}	2.46	11.51	-15.70	4.91	1.99	0.73	0.45
gce^{HK}	3.17	11.61	-9.33	2.88	0.91	0.65	0.50
$gfcf^{HK}$	0.80	19.81	-23.71	9.59	11.98	0.61	0.37
ex^{HK}	1.84	22.27	-25.20	9.25	5.03	0.74	0.48
im^{HK}	2.03	23.71	-23.51	9.27	4.56	0.76	0.47

Table 1.9. Descriptive Statistics of Growth Rates of GDP Expenditure Components in Singapore.

Variables	Mean (%)	Max. (%)	Min. (%)	Std. Dev. (%)	CV	AC(1)	AC(2)
1976.Q1–1982.Q4							
$rgdp^{SG}$	8.18	10.85	5.53	1.70	0.21	0.75	0.53
pce^{SG}	5.32	8.65	2.33	1.88	0.35	-0.16	0.33
gce^{SG}	7.35	24.89	-6.78	8.21	1.12	-0.27	-0.16
$gfcf^{SG}$	12.03	32.57	-13.99	12.07	1.00	0.41	0.16
ex^{SG}	13.13	23.48	1.54	6.07	0.46	0.81	0.58
im^{SG}	12.16	22.93	3.02	5.89	0.48	0.68	0.55
1983.Q1–1996.Q4							
$rgdp^{SG}$	7.55	13.00	-4.02	3.84	0.51	0.86	0.69
pce^{SG}	6.48	12.74	-2.73	3.52	0.54	0.64	0.50
gce^{SG}	6.67	29.17	-20.79	9.85	1.48	0.30	0.22
$gfcf^{SG}$	7.22	29.93	-22.62	11.08	1.53	0.68	0.62
ex^{SG}	11.39	30.17	-11.48	8.15	0.72	0.71	0.48
im^{SG}	11.01	26.52	-7.44	8.11	0.74	0.75	0.48
1997.Q1–2007.Q4							
$rgdp^{SG}$	5.55	12.81	-5.01	4.51	0.81	0.79	0.42
pce^{SG}	5.28	14.49	-6.53	4.51	0.85	0.79	0.48
gce^{SG}	5.64	41.62	-14.50	9.67	1.71	-0.14	0.04
$gfcf^{SG}$	2.49	21.27	-18.73	10.27	4.12	0.71	0.52
ex^{SG}	8.28	22.19	-12.12	8.06	0.97	0.78	0.47
im^{SG}	7.74	24.00	-18.14	10.57	1.36	0.79	0.42
2008.Q1–2025.Q4							
$rgdp^{SG}$	3.95	17.40	-12.44	4.44	1.12	0.65	0.36
pce^{SG}	3.16	24.27	-34.03	6.31	2.00	0.48	0.26
gce^{SG}	4.41	17.84	-7.77	5.41	1.23	0.10	0.27
$gfcf^{SG}$	3.97	39.56	-34.07	9.33	2.35	0.56	0.15
ex^{SG}	4.73	19.34	-17.46	6.15	1.30	0.66	0.30
im^{SG}	4.72	20.35	-17.32	6.90	1.46	0.62	0.18

Table 1.10. Descriptive Statistics of Exchange Rate and Price Indicators in Hong Kong.

Variables	Mean (%)	Max. (%)	Min. (%)	Std. Dev. (%)	CV	AC(1)	AC(2)
1976.Q1–1982.Q4							
$neer^{HK}$	-2.19	7.18	-13.37	6.19	-2.82	0.81	0.59
$reer^{HK}$	-1.64	8.06	-13.82	6.41	-3.90	0.80	0.53
cpi^{HK}	8.95	16.24	2.62	3.95	0.44	0.93	0.85
1983.Q1–1996.Q4							
$neer^{HK}$	-3.88	9.58	-20.09	7.17	-1.85	0.84	0.55
$reer^{HK}$	0.83	11.88	-15.74	7.37	8.83	0.86	0.64
cpi^{HK}	7.77	11.18	3.17	2.33	0.30	0.94	0.85
1997.Q1–2007.Q4							
$neer^{HK}$	-0.05	11.34	-9.68	5.63	-104.18	0.85	0.65
$reer^{HK}$	-1.77	14.11	-13.13	7.36	-4.16	0.89	0.72
cpi^{HK}	-0.20	5.98	-6.14	3.19	-16.00	0.94	0.84
2008.Q1–2025.Q4							
$neer^{HK}$	0.16	10.65	-10.93	4.77	30.52	0.74	0.27
$reer^{HK}$	0.87	13.37	-8.54	5.05	5.84	0.79	0.42
cpi^{HK}	2.54	6.32	-1.78	1.53	0.60	0.79	0.57

Table 1.11. Descriptive Statistics of Exchange Rate and Price Indicators in Singapore.

Variables	Mean (%)	Max. (%)	Min. (%)	Std. Dev. (%)	CV	AC(1)	AC(2)
1976.Q1–1982.Q4							
$neer^{SG}$	2.15	9.45	-4.54	4.28	1.99	0.89	0.69
$reer^{SG}$	-2.14	10.41	-14.55	6.33	-2.96	0.92	0.75
cpi^{SG}	4.15	9.81	-2.86	3.64	0.88	0.88	0.62
1983.Q1–1996.Q4							
$neer^{SG}$	1.00	7.92	-16.94	5.69	5.69	0.92	0.79
$reer^{SG}$	-0.49	6.51	-20.35	6.25	-12.78	0.93	0.82
cpi^{SG}	1.74	3.76	-2.08	1.35	0.78	0.91	0.75
1997.Q1–2007.Q4							
$neer^{SG}$	-0.75	5.22	-8.23	3.75	-5.03	0.82	0.66
$reer^{SG}$	-1.49	4.64	-9.57	3.99	-2.67	0.83	0.66
cpi^{SG}	0.85	4.16	-1.41	1.09	1.28	0.78	0.31
2008.Q1–2025.Q4							
$neer^{SG}$	1.51	7.55	-3.31	2.51	1.66	0.81	0.53
$reer^{SG}$	1.79	9.11	-3.90	3.53	1.98	0.87	0.67
cpi^{SG}	2.19	7.29	-0.92	2.33	1.07	0.93	0.80

Table 1.12. Descriptive Statistics of Interest Rate Indicators in Hong Kong, Singapore, and the US.

Variables	Mean (%)	Max. (%)	Min. (%)	Std. Dev. (%)	CV	AC(1)	AC(2)
1997.Q1–2025.Q3							
$ir.3m^{HK}$	1.57	6.95	0.05	1.43	0.91	0.94	0.83
$ir.3m^{SG}$	2.52	6.63	0.10	2.17	0.86	0.97	0.90
$ir.3m^{US}$	2.50	10.68	0.13	2.44	0.98	0.94	0.88
1997.Q1–2007.Q4							
$ir.3m^{HK}$	4.26	10.68	0.14	2.66	0.62	0.92	0.84
$ir.3m^{SG}$	2.46	6.95	0.66	1.47	0.60	0.90	0.72
$ir.3m^{US}$	4.08	6.63	1.05	1.86	0.46	0.96	0.88
2008.Q1–2025.Q3							
$ir.3m^{HK}$	1.41	5.34	0.13	1.48	1.05	0.94	0.84
$ir.3m^{SG}$	1.01	3.74	0.05	1.09	1.08	0.96	0.88
$ir.3m^{US}$	1.54	5.43	0.10	1.74	1.12	0.95	0.86

Note. $ir.3m$ denotes the three-month interest rate.

Table 1.13. Descriptive Statistics of Money Supply in Hong Kong.

Variables	Mean (%)	Max. (%)	Min. (%)	Std. Dev. (%)	CV	AC(1)	AC(2)
1991.Q1–1996.Q4							
$M1^{HK}$	2.71	16.46	-15.74	6.41	2.37	-0.27	0.16
$M2^{HK}$	3.07	6.95	0.76	1.43	0.47	-0.22	-0.17
$M3^{HK}$	2.95	7.06	0.92	1.40	0.47	-0.21	-0.22
1997.Q1–2007.Q4							
$M1^{HK}$	2.84	22.62	-12.35	6.66	2.35	-0.11	0.26
$M2^{HK}$	2.08	9.38	-2.55	2.26	1.09	0.38	0.18
$M3^{HK}$	2.02	9.35	-2.59	2.23	1.11	0.39	0.19
2008.Q1–2025.Q4							
$M1^{HK}$	2.02	23.98	-15.86	5.61	2.77	0.30	0.26
$M2^{HK}$	1.63	5.05	-3.95	1.62	0.99	0.32	0.16
$M3^{HK}$	1.63	5.06	-3.91	1.62	0.99	0.32	0.16

Table 1.14. Descriptive Statistics of Money Supply in Singapore.

Variables	Mean (%)	Max. (%)	Min. (%)	Std. Dev. (%)	CV	AC(1)	AC(2)
1991.Q1–1996.Q4							
$M1^{SG}$	2.52	17.27	-5.00	4.05	1.61	-0.27	-0.10
$M2^{SG}$	2.50	5.41	-0.66	1.52	0.61	0.01	-0.20
$M3^{SG}$	2.45	5.30	0.59	1.30	0.53	-0.06	-0.33
1997.Q1–2007.Q4							
$M1^{SG}$	1.97	7.64	-4.02	2.73	1.38	0.38	0.01
$M2^{SG}$	2.24	12.70	-1.91	2.56	1.14	0.52	0.17
$M3^{SG}$	1.68	5.88	-2.38	1.76	1.05	0.54	0.39
2008.Q1–2025.Q4							
$M1^{SG}$	3.67	84.92	-6.30	10.51	2.86	0.28	0.09
$M2^{SG}$	1.50	5.19	-1.60	1.20	0.80	0.32	0.16
$M3^{SG}$	0.04	4.45	-54.35	8.65	205.37	0.63	0.05

Table 1.15. Descriptive Statistics of Unemployment Rates in Hong Kong and Singapore.

Variables	Mean (%)	Max. (%)	Min. (%)	Std. Dev. (%)	CV	AC(1)	AC(2)
1992.Q1–2007.Q4							
ur^{HK}	4.47	8.70	1.70	1.98	0.44	0.97	0.91
ur^{SG}	2.46	4.50	1.00	0.95	0.39	0.49	0.71
2008.Q1–2025.Q4							
ur^{HK}	3.72	6.50	2.63	0.95	0.26	0.88	0.68
ur^{SG}	2.19	4.10	1.60	0.54	0.25	0.28	0.05

1.4.2 Economic Growth and Demand Composition

Hong Kong and Singapore's long-term growth trajectories exhibit distinct patterns that reflect their underlying structural characteristics and institutional frameworks. Both economies experienced a secular decline in average RGDP growth across successive subperiods (Tables 1.8 and 1.9). However, the magnitude and volatility of this decline differed considerably. During 1976–1982, both economies recorded robust

growth, with Hong Kong averaging 9.47% and Singapore 8.18%. However, Singapore exhibited significantly lower output volatility (Std. Dev. of 1.70%) than Hong Kong (4.32%), indicating a more stable growth path during this early development phase. During 1983–1996, following the establishment of Hong Kong's LERS in 1983, both economies moderated their growth rates: Hong Kong to 5.95% and Singapore to 7.55%. Singapore's growth volatility increased to 3.84%, whereas Hong Kong's remained relatively stable at 4.15%. The most pronounced divergence occurred during 1997–2007. In the aftermath of the AFC, Hong Kong's average growth fell sharply to 3.86%, with a CV of 1.17, reflecting the severe output contraction of 1998. Conversely, Singapore maintained a higher average growth rate of 5.55% with lower volatility (CV = 0.81), consistent with its exchange rate flexibility during the crisis. The 2008–2025 period (the GFC and the post-pandemic era) reveals further deceleration in both economies. Hong Kong's average growth declined to 1.81% (the lowest among all subperiods) with a CV of 2.08, indicating substantially higher output volatility. Singapore maintained a lower CV of 1.12 while moderating to 3.95% growth, reinforcing its relative macroeconomic stability. Among the GDP components, the most notable divergence between the two economies lies in investment and trade behavior. Hong Kong's GDFCF was the most volatile component (CV = 11.98 during 2008–2025), reflecting the destabilizing effects of asset-price adjustments under the currency board. Similarly, Hong Kong's exports and imports exhibited extreme fluctuations (CV = 5.03 and 4.56, respectively), as the fixed exchange rate could not accommodate trade shocks. However, Singapore's investment and trade components exhibited significantly lower volatility (CV = 2.35 and 1.30–1.46, respectively), consistent with its flexible exchange rate regime. Although consumption in both economies was highly volatile (CV $\approx$ 2.0), government expenditure was the most stable component, particularly in Hong Kong (CV = 0.91).

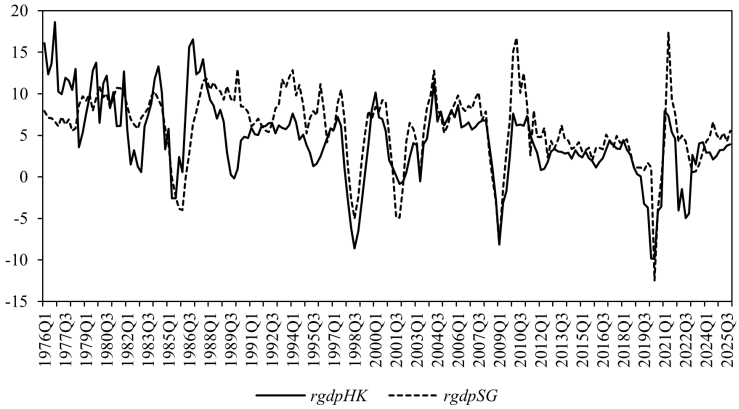


Figure 1.4. Real GDP growth rates (%) (Year on year).

Figure 1.4 compares year-on-year real GDP growth rates in Hong Kong and Singapore over the sample period. Singapore consistently outperformed Hong Kong in most subperiods, with the widest gap occurring during the AFC and pandemic-affected years (2020–2021). The differences in growth outcomes are consistent with the possibility that Singapore's exchange-rate-centred framework provided an additional adjustment margin during some external shocks. However, they also reflect differences in economic structure, fiscal policy, labor-market institutions, and exposure to country-specific disturbances. Nevertheless, Hong Kong's currency board arrangement has been associated with more pronounced output volatility and longer adjustment episodes.

1.4.3 Inflation Dynamics and Monetary Conditions

This section examines inflation, interest rates, money supply, and unemployment in Hong Kong and Singapore, drawing on the descriptive statistics presented in Tables 1.10–1.14 and Figures 1.5–1.7. The findings reveal systematic differences that reflect the distinct monetary policy frameworks and structural characteristics of the two economies.

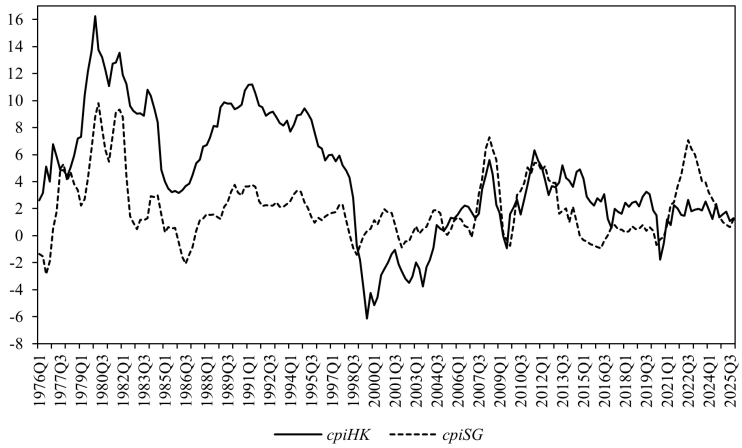


Figure 1.5. CPI inflation rates (%).

Hong Kong experienced higher inflation volatility and prolonged deflation following the AFC, with CPI averaging −0.20% during 1997–2007 (Table 1.10). Under the currency board, the fixed exchange rate forces domestic prices to bear the full adjustment burden, resulting in imported inflation during global price increases and painful deflation during downturns.

Singapore maintained lower and more stable inflation, with CPI averaging 0.85% during 1997–2007 and 2.19% during 2008–2025 (Table 1.11). The MAS uses exchange rate appreciation to mitigate imported inflation and avoid deflationary episodes.

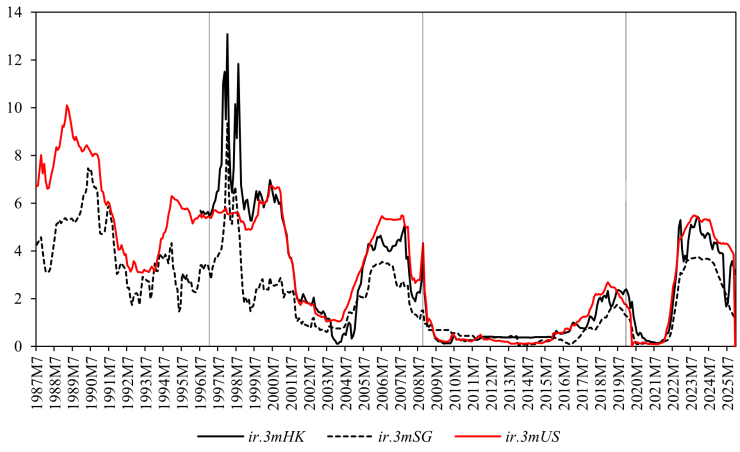


Figure 1.6. Three-Month Interest Rates in Hong Kong, Singapore, and the US.

Hong Kong's interest rates closely follow the US rates (Table 1.12), confirming the absence of monetary autonomy. HIBOR averaged 4.26% during 1997–2007 versus 4.08% for the US and 1.41% versus 1.54% during 2008–2025. This mechanical linkage

forces Hong Kong to import US monetary conditions regardless of domestic needs.

In contrast, Singapore's interest rates are lower and more independent, averaging 2.46% during 1997–2007 and 1.01% during 2008–2025. This finding reflects the MAS's exchange-rate–centered framework, which decouples domestic rates from US policy.

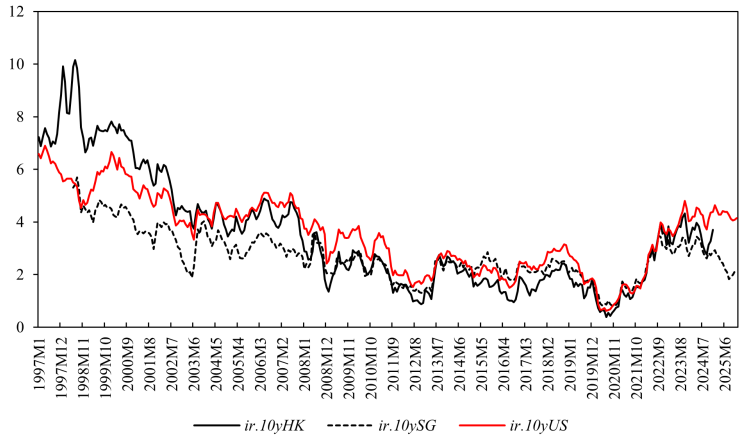


Figure 1.7. Ten-year long-term interest rates in Hong Kong, Singapore, and the US.

Figure 1.7 compares ten-year government bond yields in Hong Kong, Singapore, and the United States. Long-term yields reflect not only current and expected short-term rates but also inflation expectations, term premia, sovereign-market conditions, and global demand for safe assets. They should therefore not be interpreted as direct measures of the monetary-policy stance.

Tables 1.13 and 1.14 present several notable characteristics of money supply growth in Hong Kong and Singapore. First, M1 growth exceeded M2 and M3 growth in most subperiods. Second, regarding volatility, M1 exhibited substantially larger standard deviations and coefficients of variation than M2 and M3, indicating that narrow money was considerably more unstable than broad money. Third, the wide gap between M1's maximum and minimum growth rates suggests that short-term liquidity conditions experienced larger fluctuations than broader monetary aggregates.

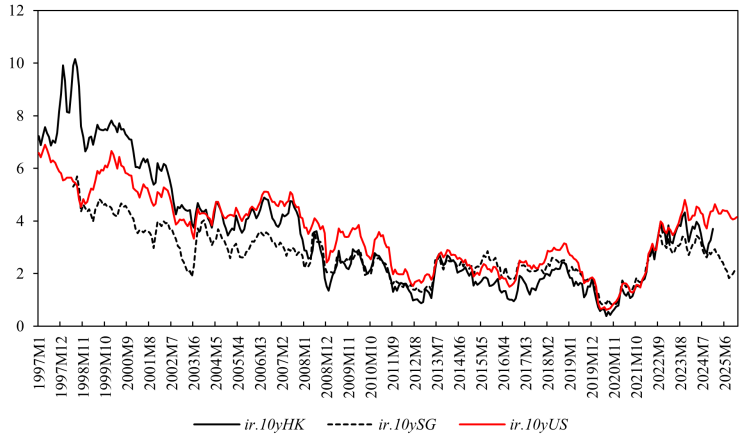


Figure 1.8. Unemployment Rates.

Table 1.15 and Figure 1.8 compare URs in Hong Kong and Singapore. The average unemployment rate was higher in Hong Kong than in Singapore (3.72% vs. 2.19% during 2008–2025) and was more volatile (Std. Dev. 0.95% vs. 0.54%) than Singapore's. Hong Kong's unemployment exhibits high persistence (autocorrelation = 0.88), indicating that unemployment shocks take a long time to dissipate. In contrast, Singapore's unemployment shows low persistence (autocorrelation = 0.28), suggesting that shocks are transitory and that recovery is quick. This finding reflects Hong Kong's fixed exchange rate, which forces adjustment through the labor market, whereas Singapore's flexible exchange rate shields employment from prolonged dislocation.

1.4.4 External Competitiveness and Exchange-Rate Performance

The behavior of the NEER and REER reflects the distinct institutional frameworks of Hong Kong and Singapore, as discussed in Section 3. Figures 1.9–1.10 illustrate the behavior of NEER and REER.

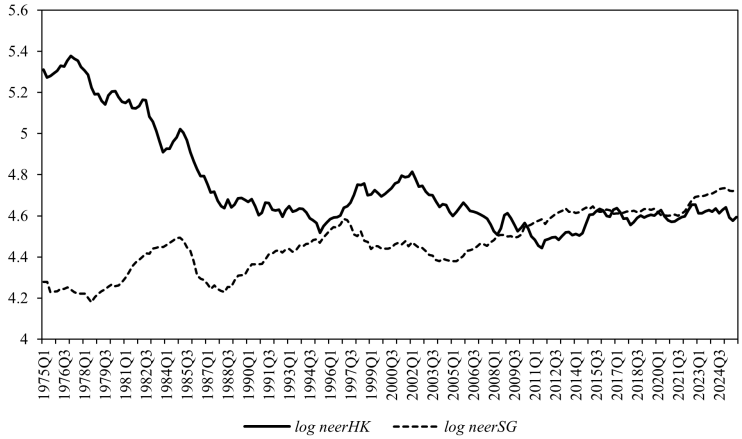


Figure 1.9. Nominal Effective Exchange Rate index.

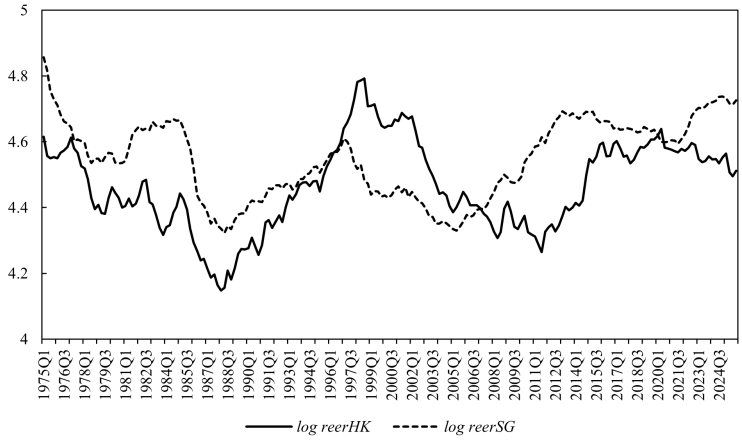


Figure 1.10. Real Effective Exchange Rate index.

Under Hong Kong's currency board, the NEER is passively determined by USD movements. Table 1.10 shows that Hong Kong's NEER exhibited modest average changes across subperiods (from −3.88% to 0.16%), with no systematic response to domestic inflation or output conditions. The HKMA does not actively manage the exchange rate, which is consistent with Gerlach and Gerlach-Kristen's (2006) observation that "the NEER has not moved in response to changes in the rate of inflation". For Hong Kong, Table 1.10 shows that the REER appreciated during 1983–1996 (mean of 0.83%) but depreciated during 1997–2007 (mean of −1.77%), reflecting the prolonged deflationary adjustment following the AFC. Because Hong Kong cannot adjust its nominal exchange rate, restoring competitiveness requires painful internal adjustments through falling domestic prices and wages. According to Ma et al. (2007),

"the exchange rate peg has rendered the economy particularly vulnerable to external economic shocks."

In contrast, Singapore's NEER is actively managed by the MAS. It appreciated by an average of 1.51% during 2008–2025, reflecting the MAS's response to inflationary pressures (Table 1.11). The REER was relatively stable during 1997–2007 (mean of −1.49%) and appreciated during 2008–2025 (mean of 1.79%). Ma et al. (2007) noted that the MAS "can exercise discretionary control over the domestic demand" through exchange rate management. The MAS actively manages the REER to maintain external competitiveness while controlling inflation. During the 1985 recession, the MAS allowed the REER to depreciate to support output recovery (Gerlach & Gerlach-Kristen, 2006).

1.5 Conclusion

This chapter provided a comprehensive comparative analysis of Hong Kong and Singapore's macroeconomic structures, institutional frameworks, and macroeconomic performance from 1975 to 2025.

Although both economies are highly open and resource-constrained, Hong Kong has become increasingly specialized in financial services (approximately 25% of GDP), and Singapore has maintained a diversified economy with manufacturing contributing approximately one-fifth of GDP.

The LERS has provided a solid anchor for macroeconomic and financial stability (IMF, 2023). Through exchange rate management, Singapore's managed float allows greater flexibility in responding to external shocks. Findings from the AFC and GFC confirmed these differences.

The empirical analysis showed that Singapore consistently outperformed Hong Kong in most macroeconomic dimensions during 2008–2025: higher growth (3.95% vs. 1.81%), lower inflation (2.19% vs. 2.54%), lower unemployment (2.19% vs. 3.72%), and lower volatility across all major indicators. Hong Kong's investment exhibited extreme volatility (CV = 11.98), indicating substantially greater fluctuations in investment

activity than in Singapore. In addition, Hong Kong's fixed exchange rate regime frequently contributes to asset price bubbles because the economy is required to import low US interest rates during periods of strong domestic growth (Lu & Yu, 1999; Rajan & Siregar, 2002). However, the underlying causes of this volatility are beyond the scope of this study and warrant further investigation.

Evidence suggests a fundamental trade-off between credibility and flexibility (Gerlach & Gerlach-Kristen, 2006; Ma et al., 2007). Hong Kong's currency board provides exchange rate credibility, which is essential to its role as an international financial gateway. Although Singapore's managed float offers greater macroeconomic stability, it requires substantial reserve buffers and institutional capacity.

Hong Kong and Singapore represent two distinct but equally credible SOE models. Their experiences underscore that institutional design must balance credibility and flexibility according to national priorities. As global financial cycles become increasingly volatile, these comparative experiences offer valuable lessons for policymakers worldwide.

Chapter 2

Real Wage Cyclicality in Hong Kong and Singapore

Abstract

This chapter examines and compares the cyclical patterns of real wages within the Hong Kong Special Administrative Region (SAR) and Singapore over the period from 2004.Q1 to 2025.Q4. Premised on the Hodrick–Prescott (HP) filter for detrending and a linear time trend, the empirical analysis focuses on the cross-correlation coefficients between real wage cycles and real gross domestic product (GDP) cycles at various leads and lags. When the linear trend method is applied, both economies exhibit negative correlation coefficients, indicating a countercyclical pattern. Application of the HP filter reveals a weakly procyclical relationship between the real wage in Hong Kong and output. In contrast, Singapore displays an ambiguous pattern, with the positive correlation peaking when GDP leads wages. Accordingly, real wages do not follow a uniform cyclical behavior across modern economies, suggesting that country-specific institutional factors, such as labor market structures, play a crucial role in shaping real wage dynamics.

2.1 Introduction

In Hong Kong, laissez-faire economic management principles have long been practiced. In contrast, Singapore has adopted a more interventionist approach, characterized by active industrial, labor market, and exchange rate policies. Given their extensive adherence to this approach, pivotal questions arise: Can this approach effectively stimulate business activity and underpin sustained economic growth? Does a higher degree of market flexibility foster rapid and frictionless price adjustments, thereby enabling the labor market to smoothly buffer external economic shocks? Addressing these fundamental questions requires scrutinizing the relationship between real wages and output aggregates. Grounded in this framework, the objective of this study is to examine and compare the cyclical patterns of real wages within Hong Kong and Singapore from 2004.Q1 to 2025.Q4, focusing on the comovements between real wages and real gross domestic product (GDP).

The remainder of this chapter is structured as follows: Section 2 reviews the relevant literature; Section 3 presents the data and preliminary analysis; Section 4 analyzes real wage cyclicality; and Section 5 offers concluding remarks and summary findings.

2.2 Literature Review

Theoretical perspectives on real wage cyclicality demonstrate considerable disparity. Keynesian economists typically posit a countercyclical relationship, suggesting that real wages move inversely to output and employment fluctuation. In contrast, Real Business Cycle theorists contend that real wages are procyclical, asserting that changes in output and employment positively influence real wage movements. Mankiw (1989) argued that a crucial implication of real business cycle theory is that the real wage is procyclical. Campbell and Mankiw (1987) noted that an unexpected 1% change in real GDP should lead to a corresponding revision in long-term forecasts.

Abraham and Haltiwanger (1995) demonstrated that several factors significantly influence the measured cyclicality of real wages: (i) the time period analyzed; (ii) whether

consumption or production deflators are used; (iii) the method employed for detrending; (iv) adjustments for industry mix and overtime; and (v) the choice of cyclical indicator. They further highlighted that aggregate real wages are generally more responsive to changes in aggregate output (real private sector GDP) or employment than manufacturing real wages are to fluctuations in manufacturing output or employment. Additionally, the degree of cyclicality difference hinges critically on the elasticities of demand and supply, as well as the factors that create a disparity between consumer and producer prices (Abraham & Haltiwanger, 1995).

Miyamoto (2015) highlighted variations in real wage cyclicality based on different price indices. Real wages constructed using the consumer price index (CPI) and the GDP deflator tend to exhibit procyclical behavior, whereas those constructed using the producer price index demonstrate countercyclical tendencies. Blanchard and Fischer (1989) observed a negligible correlation between economy-wide real wages and output across various time lags and identified a significant contemporaneous correlation between manufacturing wages and output. Cooley and Prescott (1995) reinforced this observation, drawing on empirical data from the US economy spanning several decades (1954.Q1 to 1991.Q1) to highlight the central role of the labor market in manifesting business cycle dynamics. Pauwels and Zhang (2008) documented remarkable wage and employment flexibility in Hong Kong during challenging economic episodes, such as the Asian financial crisis, deflationary periods, and outbreaks (e.g., SARS) over the past decade. However, in the context of the US, Abraham and Haltiwanger (1995) conducted a comprehensive analysis of economic fluctuations by employing methodologies such as linear time trends (LT), log first differences, and the Hodrick–Prescott (HP) filter, to discern the cyclical components of real wage and employment data spanning several decades.

Yang (1993) attributed wage increases in the late 1970s to rapid economic growth and inflationary pressures. Blanchard and Fischer (1989) noted a generally positive, albeit statistically insignificant, correlation between changes in real wages and fluctuations in output or employment.

2.3 Data and Preliminary Analysis

This chapter utilizes quarterly data on real GDP (y_t) and real wages (w_t) for Hong Kong and Singapore over the period 2004.Q1–2025.Q4, yielding 88 observations per series. Both variables of Hong Kong are sourced from the Census and Statistics Department (C&SD) . For Singapore, both variables are obtained directly from the Department of Statistics Singapore (DOS) . The two economies differ in terms of seasonal adjustment. For Hong Kong, raw series are seasonally adjusted manually using a moving average method. For Singapore, seasonally adjusted data are obtained directly from the source website and therefore require no further adjustment. The unit labor cost of overall economy is divided by the CPI to obtain data on the real wage rate of Singapore. All variables are transformed into natural logarithms to stabilize variance. y_t^{HK} and w_t^{HK} represent the real GDP and the real wages for Hong Kong, respectively; y_t^{SG} and w_t^{SG} represent the corresponding variables for Singapore. Accordingly, their first differences are denoted as Δy_t^{HK}, Δw_t^{HK}, Δy_t^{SG}, and Δw_t^{SG}.

Consistent with Abraham and Haltiwanger (1995) and Miyamoto (2015), this chapter applied two distinct detrending methods to isolate the cyclical components of macroeconomic variables: the LT and the HP filter. Figures 2.1–2.4 illustrate the cyclical components of real wages and real GDP for Hong Kong and Singapore based on the LT and HP filter. In addition, Table 2.1 presents descriptive statistics of real GDP and real wages for Hong Kong and Singapore, including the mean, maximum, minimum, standard deviation, and coefficient of variation. This table provides a preliminary overview of growth rates and volatility before detrending, highlighting differences between the two economies.

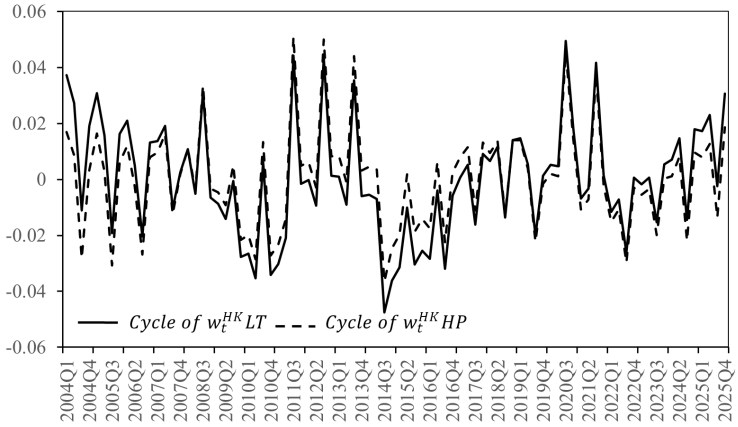


Figure 2.1. Cyclical components of real wages for Hong Kong (linear time trend and HP filter).

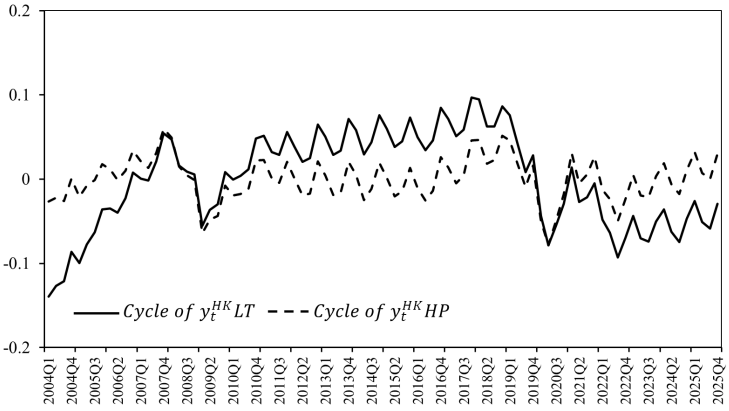


Figure 2.2. Cyclical components of real GDP for Hong Kong (LT and HP filter).

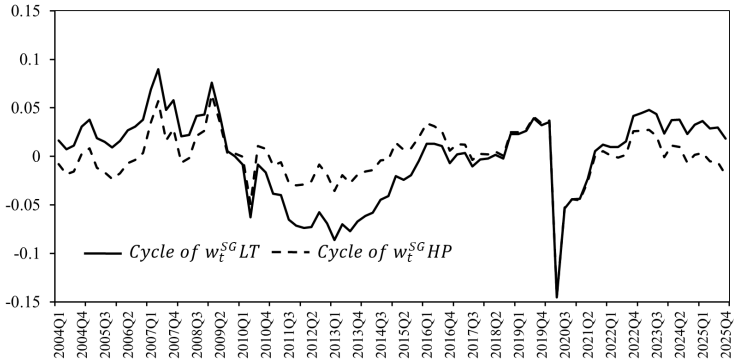


Figure 2.3. Cyclical components of real wages for Singapore (LT and HP filter).

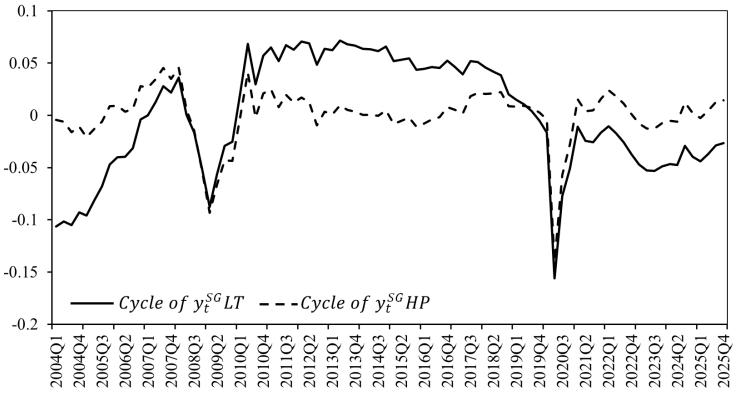


Figure 2.4. Cyclical components of real GDP for Singapore (LT and HP filter).

Figures 2.1 and 2.2 illustrate that real wages exhibit small-amplitude fluctuations around the zero line, whereas the real GDP exhibits larger movements. During the 2008–2009 global financial crisis and the COVID-19 pandemic in 2020, real GDP deviated negatively from its trend, with the largest negative deviation occurring during the pandemic. Both variables gradually recovered following these shocks; however, GDP remained below its pre-pandemic peak.

During the financial crisis, real wages and real GDP fell below the trend. Both variables declined even more sharply in 2020, with Singapore's real GDP reaching its lowest point in the sample period (Figures 2.3 and 2.4). The cyclical components recovered in the aftermath.

Singapore experienced larger cyclical fluctuations than Hong Kong, particularly during global economic stress. The COVID-19 pandemic elicited a more pronounced cyclical response than the 2008–2009 crisis, particularly in Singapore's real GDP.

Table 2.1. Descriptive statistics of real GDP and real wages in Hong Kong and Singapore (2004.Q1–2025.Q4).

Variables	**Mean (%)**	**Max.(%)**	**Min.(%)**	**Std.Dev.(%)**	**CV**
Δy_t^{HK}	0.665	4.852	-6.672	2.483	3.733
Δw_t^{HK}	0.131	6.647	-4.444	2.466	18.820
Δy_t^{SG}	1.150	8.952	-12.913	2.337	2.033
Δw_t^{SG}	-0.101	9.065	-18.182	2.752	-27.224

Table 2.1 shows that the average rate of change of real wages in Singapore is negative,

potentially reflecting the wage regulation policy of the Singaporean government.

2.4 Analysis of Real Wage Cyclicality

Autocorrelation coefficients were calculated for real GDP and real wages at different lags using the LT and the HP filter to examine the persistence of cyclical fluctuations. The results are reported in Table 2.2.

Table 2.2. Autocorrelation of each variable at different lags in Hong Kong and Singapore.

Variables	**0**	**-1**	**-2**	**-3**	**-4**	**-5**
Linear time trend						
Cycle of w_t^{HK}	1	0.255	0.176	0.160	0.518	0.012
Cycle of y_t^{HK}	1	0.902	0.797	0.767	0.746	0.619
HP filter						
Cycle of w_t^{HK}	1	0.074	-0.007	-0.022	0.453	-0.128
Cycle of y_t^{HK}	1	0.570	0.178	0.168	0.201	-0.148
Linear time trend						
Cycle of w_t^{SG}	1	0.796	0.707	0.622	0.522	0.460
Cycle of y_t^{SG}	1	0.510	0.326	0.171	0.003	-0.051
HP filter						
Cycle of w_t^{SG}	1	0.906	0.828	0.741	0.655	0.575
Cycle of y_t^{SG}	1	0.636	0.378	0.128	-0.082	-0.236

The autocorrelation structure differs markedly across filtering methods and economies (Table 2.2). Abraham and Haltiwanger (1995) emphasized that the estimated cyclical behavior of real wages depends critically on the detrending method used to extract the cyclical component.

For Hong Kong, the LT results reveal that the autocorrelation of the real wage cycle gradually declines from 0.255 at lag 1 to 0.012 at lag 5. The GDP cycle shows much higher persistence, with an autocorrelation of 0.902 at lag 1, declining to 0.619 at lag 5. Accordingly, Hong Kong's output fluctuations tend to persist longer than

real wage fluctuations. When the HP filter is applied, the autocorrelation of the real wage cycle drops sharply from 0.074 at lag 1 to –0.022 at lag 3, whereas the GDP cycle declines from 0.570 at lag 1 to 0.168 at lag 3. The HP-filtered series shows much weaker persistence, indicating that the HP filter effectively removes the trend component and isolates the cyclical fluctuations.

For Singapore, the LT results demonstrate even stronger persistence in both series. The cycle of real wage has an autocorrelation of 0.796 at lag 1, declining to 0.460 at lag 5, whereas the cycle of real GDP declines from 0.510 at lag 1 to –0.051 at lag 5. The real wage cycle remains highly persistent using the HP filter, with a correlation of 0.906 at lag 1 and 0.575 at lag 5, indicating that real wages in Singapore display strong inertia. In contrast, the GDP cycle is less persistent, dropping from 0.636 at lag 1 to –0.236 at lag 5.

Overall, the autocorrelation patterns reveal two notable points. First, the HP filter consistently reduces persistence relative to the linear trend. Therefore, it is more appropriate for extracting stationary cyclical components. Second, real wages in Singapore exhibit greater persistence than those in Hong Kong, likely due to differences in labor market institutions and flexibility.

Following the methodologies outlined by Cooley and Prescott (1995) and Miyamoto (2015), this study computed cross-correlation coefficients between real GDP and real wages at various lead and lag intervals using the LT and HP filter detrending methods. The findings of these analyses are presented in Table 2.3.

Table 2.3. Cross-correlation coefficient between real wages and real GDP at different leads and lags in Hong Kong and Singapore.

Filter	Corr (w_{t+i}, y_{t+i})										
	+5	+4	+3	+2	+1	0	–1	–2	–3	–4	–5
Hong Kong											
Linear trend	-0.288	-0.304	-0.273	-0.278	-0.261	-0.276	-0.250	-0.200	-0.195	-0.196	-0.166
HP filter	-0.046	-0.045	0.045	0.065	0.096	0.091	0.071	0.115	0.161	0.111	0.091
Singapore											
Linear trend	-0.516	-0.515	-0.557	-0.532	-0.496	-0.425	-0.452	-0.430	-0.436	-0.423	-0.423
HP filter	-0.194	-0.153	-0.243	-0.151	-0.029	0.198	0.118	0.205	0.190	0.199	0.153

When the LT method is applied, all correlation coefficients are negative for both economies, ranging from –0.166 to –0.288 for Hong Kong and from –0.423 to –0.516 for Singapore (Table 2.3). However, the correlation structure changes substantially after applying the HP filter. For Hong Kong, the coefficients become small and unstable, ranging from –0.046 to +0.161, with a contemporaneous correlation of only +0.091, indicating virtually no cyclical relationship between real wages and output. For Singapore, the HP filtered results exhibit a contemporaneous correlation of +0.198 and a peak positive correlation of +0.205 at lag –2 (real GDP leading wages by two quarters), suggesting a weak procyclical pattern.

Correcting for all measurement, estimation, and composition problems does not yield evidence of systematically procyclical or countercyclical real wages (Abraham & Haltiwanger, 1995). However, the results of this study reveal a notable difference between the two economies: although Singapore displays some evidence of procyclicality, Hong Kong exhibits no clear cyclical relationship. Consequently, country specific institutional factors, such as exchange rate regimes and labor market structures, may shape the cyclical dynamics of real wages. The results support the view that real wages do not follow a uniform cyclical pattern across economies and that the choice of detrending method is crucial for obtaining reliable inferences.

2.5 Conclusion Remark

This chapter analyzed the cyclicality of real wages in Hong Kong and Singapore, focusing on their relationship with real GDP. The analysis examined the sensitivity of this relationship to different detrending methods: the HP filter and LT. In addition, the persistence of the cyclical components was assessed using autocorrelation analysis.

The cyclical analysis showed that both economies were adversely affected by the 2008–2009 global financial crisis and the COVID-19 pandemic, with the latter generating more pronounced negative deviations from trend. Singapore exhibited greater cyclical volatility than Hong Kong, particularly in terms of real GDP.

The chapter's findings revealed that the cyclical behavior of real wages relative to real GDP depended heavily on the detrending technique. When the HP filter was applied, real wages in Hong Kong showed virtually no cyclical relationship with real GDP, as the coefficients were small and lacked statistical significance. In contrast, when a linear trend was used, the relationship between real GDP and real wages was countercyclical in Singapore and Hong Kong. These contrasting outcomes confirmed the sensitivity of real wage cyclicality to methodological choices, as emphasized by Abraham and Haltiwanger (1995).

The chapter's findings broadly aligned with those of Abraham and Haltiwanger (1995), who reported that real wages do not exhibit a systematic procyclical or countercyclical pattern once measurement and detrending issues are addressed. However, this study revealed a notable difference between the two economies: Singapore displayed some evidence of procyclicality, whereas Hong Kong showed no clear cyclical relationship. This contrast may reflect the differing exchange rate regimes and labor market structures of the two economies.

Overall, this chapter underscores the importance of methodological transparency and country-specific analysis in empirical macroeconomic research. It also contributes to the ongoing debate on real wage cyclicality by providing comparative evidence from two of Asia's most open economies.

Chapter 3

Trends and Random Walk in Macroeconomic Time Series

Abstract

This chapter examines the stationarity of key macroeconomic variables in Hong Kong and Singapore. Previous studies have argued that most macroeconomic variables in the United States follow a difference-stationary (DS) process, except for the unemployment rate. Building on their work, we investigate whether this finding holds for these two small open Asian economies. The augmented Dickey–Fuller (ADF) test, the F-test, and the Zivot–Andrews (ZA) test are applied with an endogenous structural break. Most macroeconomic variables, including real GDP, nominal GDP, the GDP deflator, Consumer Price Index (CPI), employment, and nominal wages, are DS in both economies. Although the unemployment rate in Hong Kong is also DS, it is trend-stationary (TS) in Singapore, suggesting that labor market shocks in Singapore are more transitory. The F-test results indicate that the null hypothesis of either a random walk or a random walk with drift is rejected for real GDP, nominal GDP, CPI, and nominal wages in Hong Kong. In Singapore, the null hypothesis of a random walk is rejected for the unemployment rate, as well as for nominal GDP, real GDP, GDP deflator, and CPI. The ZA test, which allows for a one-time structural break, largely confirms the ADF findings. In Hong Kong, only nominal GDP exhibits weak evidence of stationarity around a structural break (at the 10% level). In Singapore, nominal GDP and CPI reject the unit root when a break is allowed, also at the 10% level. All other variables remain DS after accounting for a structural break. However, the stationarity of Singapore's unemployment rate highlights an important cross-economy difference, which may reflect the more flexible labor market institutions in Singapore.

3.1 Introduction

This chapter examines the stationarity of key macroeconomic variables in Hong Kong and Singapore. Nelson and Plosser (1982) argued that macroeconomic variables in the United States (US) generally follow a difference-stationary process, with the unemployment rate being an exception. Building on their approach, this study investigates the stationarity of key macroeconomic variables in Hong Kong and Singapore.

Nelson and Plosser's (1982) findings are summarized as follows:

- Real shocks associated with the secular component significantly contribute to variations in observed output.
- These shocks are correlated with innovations in the cyclical component, the secular component contains transitory fluctuations, or both.

Campbell and Mankiw (1987) estimated the standard ARIMA models for the log of US real GNP using a postwar quarterly time series. They suggested that a 1% innovation in real GNP could change the long-term forecasts of real GNP by more than 1%. Their analysis supports the persistence of shocks, aligning with the evidence presented by Nelson and Plosser and their own findings, consistent with real business cycle models. Similarly, Blanchard and Fischer (1989) observed that, despite short-run fluctuations, most economists argued that the economy evolves along an underlying growth path, commonly referred to as the trend.

Perron (1989) noted that the most important implication of the unit root revolution is that random shocks have a permanent effect on the system under this hypothesis. Perron further demonstrated that standard tests of the unit root hypothesis against trend-stationary (TS) alternatives cannot reject the unit root hypothesis if the true data-generating mechanism involves stationary fluctuations around a trend function with a one-time break. In addition, a variation of Perron's test is considered in which the breakpoint is estimated rather than fixed (Zivot & Andrews, 1992).

Drawing further inspiration from Nelson and Plosser (1982), Kurosaka (2024) ex-

tended this line of inquiry by analyzing the stationarity of real wages during Japan's rule over the Korean Peninsula. Motivated by these arguments, this study investigates whether key macroeconomic variables in Hong Kong and Singapore follow a DS or TS process.

This chapter is organized as follows: Section 2 describes the data sources and processing methods, along with time series plots of the main macroeconomic variables in their natural logarithms; Section 3 presents the analysis of the autocorrelation function and the results of the ADF test, F-test, and ZA test for the key macroeconomic variables; and Section 4 concludes with a summary of the key findings.

3.2 Sources of Data

Data for this chapter were obtained from the Census and Statistics Department of the Hong Kong SAR Government (C&SD) and the Singapore Department of Statistics (SingStat).

For Hong Kong, the dataset includes real gross domestic product (RGDP), nominal gross domestic product (NGDP), GDP deflator, and the Composite Consumer Price Index (CPI) from the first quarter of 1975 to the first quarter of 2025. Data on the unemployment rate (UR) and employment (EMP) are available from the first quarter of 1992 to the first quarter of 2025. Additionally, data on real wage (RWAGE) and nominal wage (NWAGE) in Hong Kong from the first quarter of 2004 to the first quarter of 2025 are also available.

For Singapore, the dataset includes RGDP, NGDP, GDP deflator, and CPI from the first quarter of 1975 to the first quarter of 2025. Data on the UR is available from the first quarter 1992 to four quarter of 2025. Additionally, data on RWAGE from the first quarter 2004 to four quarter of 2025 is also available. Singapore data are published in seasonally adjusted form by SingStat. For Hong Kong, seasonality was removed using a moving-average seasonal adjustment procedure. All variables were transformed into natural logarithms.

3.3 Analysis of the main macroeconomic variables in Hong Kong and Singapore

3.3.1 Analysis of the sample autocorrelation

Following the methodology outlined by Nelson and Plosser (1982), the autocorrelation functions of the variables for lags 1 to 6 were calculated, as presented in the tables below. Table 3.1 reports the autocorrelations of the natural logarithms of the main macroeconomic variables. Table 3.2 displays the autocorrelations of the first-order differences of the natural logarithms of all variables. Table 3.3 presents the autocorrelations of the deviations from the fitted time trend using linear detrending methods.

Table 3.1. Autocorrelations of the Natural Logarithms.

Series	**T**	$\mathbf{r_1}$	$\mathbf{r_2}$	$\mathbf{r_3}$	$\mathbf{r_4}$	$\mathbf{r_5}$
Hong Kong						
$rgdp^{HK}$	204	0.999	0.998	0.998	0.998	0.997
$ngdp^{HK}$	204	1.000	0.999	0.999	0.999	0.998
$gdpdef^{HK}$	204	1.000	0.999	0.998	0.997	0.996
cpi^{HK}	204	1.000	1.000	0.999	0.998	0.998
ur^{HK}	136	0.953	0.877	0.791	0.708	0.607
emp^{HK}	136	0.997	0.992	0.986	0.980	0.974
$rwage^{HK}$	88	0.814	0.794	0.783	0.875	0.741
$nwage^{HK}$	88	0.999	0.999	0.997	0.996	0.994
Singapore						
$rgdp^{SG}$	204	1.000	1.000	0.999	0.999	0.999
$ngdp^{SG}$	204	1.000	0.999	0.999	0.998	0.998
$gdpdef^{SG}$	204	0.997	0.994	0.992	0.990	0.986
cpi^{SG}	204	1.000	0.999	0.998	0.996	0.995
ur^{SG}	136	0.434	0.554	0.298	0.711	0.177
$rwage^{SG}$	88	0.851	0.785	0.721	0.645	0.597

Note. r_i refer to the i-th order autocorrelation of the series

The following discussion is based on Enders (2015). The autocorrelations of the natural logarithms of all variables remain close to 1 from lags 1 to 4 and decay slowly with increasing lags (Table 3.1), suggesting a unit root process. Singapore's UR exhibits a more rapid decay, with substantially lower persistence than Hong Kong's.

Table 3.2. Autocorrelations of the First Differences of the Natural Logarithms.

Series	**T**	**r(1)**	**r(2)**	**r(3)**	**r(4)**	**r(5)**
Hong Kong						
$\Delta rgdp^{HK}$	203	-0.101	-0.293	-0.033	0.580	-0.080
$\Delta ngdp^{HK}$	203	0.048	0.120	0.047	0.603	0.032
$\Delta gdpdef^{HK}$	203	0.302	0.357	0.295	0.649	0.202
Δcpi^{HK}	203	0.517	0.585	0.507	0.700	0.428
Δur^{HK}	135	0.291	0.091	-0.056	0.169	-0.193
Δemp^{HK}	135	0.322	0.091	0.114	0.040	0.010
$\Delta rwage^{HK}$	87	-0.447	-0.031	-0.273	0.577	-0.309
$\Delta nwage^{HK}$	87	0.424	0.149	0.113	0.271	0.110
Singapore						
$\Delta rgdp^{SG}$	203	0.071	0.117	0.014	-0.048	-0.005
$\Delta ngdp^{SG}$	203	0.305	0.190	0.005	-0.002	0.020
$\Delta gdpdef^{SG}$	203	0.059	-0.244	-0.020	0.340	-0.060
Δcpi^{SG}	203	0.512	0.396	0.215	0.243	0.132
Δur^{SG}	135	-0.604	0.331	-0.601	0.838	-0.609
$\Delta rwage^{SG}$	87	-0.284	-0.011	0.034	-0.098	-0.049

Note. $r(i)$ refer to the i-th order autocorrelation of the first difference of the series.

Table 3.2 shows the autocorrelations of the first differences of natural logarithms. Unlike in Table 1, most autocorrelation coefficients are small and fluctuate around zero, indicating that first-differencing significantly reduces serial correlation. For real and nominal GDPs, the coefficients are close to zero at most lags, aligning with a DS process. Inflation variables, particularly CPI in Hong Kong and Singapore, exhibit positive autocorrelation at short lags (r(1) = 0.517 for Hong Kong and 0.512 for Singapore),

indicating persistent inflation dynamics. However, some variables exhibit unusually high autocorrelation at lag 4, such as the GDP deflator in Hong Kong (r(4) = 0.649) and the UR in Singapore (r(4) = 0.838), which may reflect seasonal patterns or specific economic events. Nelson and Plosser (1982) noted that the presence of autocorrelation in first differences does not, by itself, permit a definitive conclusion regarding whether the series follows a DS or TS process, highlighting the need for formal unit root tests.

Table 3.3. Autocorrelations of the Deviations from the Linear Time Trend.

Series	**T**	**d(1)**	**d(2)**	**d(3)**	**d(4)**	**d(5)**
Hong Kong						
$rgdp^{HK}$	204	0.977	0.959	0.953	0.949	0.919
$ngdp^{HK}$	204	0.996	0.992	0.986	0.981	0.970
$gdpdef^{HK}$	204	0.998	0.995	0.990	0.984	0.975
cpi^{HK}	204	0.998	0.995	0.990	0.983	0.974
ur^{HK}	136	0.953	0.877	0.791	0.708	0.607
emp^{HK}	136	0.978	0.941	0.898	0.847	0.792
$rwage^{HK}$	88	0.255	0.176	0.160	0.518	0.012
$nwage^{HK}$	88	0.969	0.911	0.849	0.778	0.687
Singapore						
$rgdp^{SG}$	204	0.987	0.971	0.952	0.931	0.912
$ngdp^{SG}$	204	0.987	0.965	0.938	0.910	0.882
$gdpdef^{SG}$	204	0.961	0.916	0.890	0.866	0.813
cpi^{SG}	204	0.988	0.964	0.930	0.891	0.845
ur^{SG}	136	0.434	0.554	0.297	0.710	0.177
$rwage^{SG}$	88	0.796	0.707	0.622	0.522	0.460

Note. $d(i)$ refer to the i-th order autocorrelation coefficient for the detrended values of the series.

Table 3.3 presents the autocorrelations of the deviations from a linear time trend. For real GDP, nominal GDP, employment, GDP deflator, and CPI, the first-order autocorrelation coefficients remain very high and decline only gradually across subsequent lags. A notable difference emerges in the labor market. The UR in Hong Kong ex-

hibits substantially higher persistence than in Singapore, with d(1) = 0.953 and slowly declining to 0.607 at lag 5, implying a slower adjustment process following economic shocks. In contrast, Singapore's UR has a d(1) value of 0.434 and declines more sharply to 0.177 at lag 5, indicating a more rapid return toward trend.

Real wages in Hong Kong display unusually low persistence (d(1) = 0.255, d(5) = 0.012) compared with other variables, with an anomalous spike at lag 4 (d(4) = 0.518), which may reflect the lagged effects of wage negotiations or specific policy interventions. In contrast, Singapore's real wages exhibit moderate persistence (d(1) = 0.796, d(5) = 0.460).

Overall, although both economies display highly persistent business cycle fluctuations, labor market adjustment is more flexible in Singapore than in Hong Kong.

3.3.2 Augmented Dickey - Fuller test (ADF test)

An ADF test was conducted to examine the presence of a unit root in the main macroeconomic variables of Hong Kong. Following Nelson and Plosser's (1982) approach, the time series of macroeconomic variables can be appropriately modeled using the following equation:

$$\Delta y_t = \beta y_{t-1} + \sum_{i=1}^{p} \gamma_i \Delta y_{t-i} + \varepsilon_t \qquad \text{(Without constant and time trend)} \tag{3.1}$$

$$\Delta y_t = \mu + \beta y_{t-1} + \sum_{i=1}^{p} \gamma_i \Delta y_{t-i} + \varepsilon_t \qquad \text{(With constant)} \tag{3.2}$$

$$\Delta y_t = \mu + \delta t + \beta y_{t-1} + \sum_{i=1}^{p} \gamma_i \Delta y_{t-i} + \varepsilon_t \qquad \text{(With constant and time trend)} \tag{3.3}$$

Δy_t represents the differenced series of the main macroeconomic variables, and y_{t-1} is the lagged value of the series. The constant term is denoted by μ and δ represents the coefficient of the trend. The coefficient β is associated with each approach, and γ_i represents the coefficients of the lagged first-difference terms, p is the lag length, and ε_t denotes the error term (white noise).

As noted earlier, the time series data for real GDP, nominal GDP, employment,

consumer price index, nominal wage, and real wage exhibit an upward trend. According to Figure 1.6 in Chapter 1 and Figure 3.1 in this chapter, the unemployment series (ur^{HK} and ur^{SG}) do not exhibit a clear trend over the sample period. According to Enders (2015), such data can either be TS or contain a unit root with a drift term. Therefore, for these variables, it is necessary to estimate equation (3.3) and test the constraints $\beta = 0$ and $\mu = \delta = 0$. For the ur^{HK}, ur^{SG} and $rwage^{SG}$, which do not display an upward trend, equation (3.2) is estimated instead. The results of this analysis are presented in Table 3.4.

Table 3.4. Test for autoregressive unit roots.

Series	**T**	**p**	$\boldsymbol{\mu}$	$\boldsymbol{\delta}$	$\boldsymbol{\beta}$	$\boldsymbol{\beta + 1}$
$rgdp^{HK}$	204	7	0.336	0.000093	-0.025	0.975
			(2.438)	(0.767)	(-2.191)	
$ngdp^{HK}$	204	8	0.186	0.000010	-0.015	0.985
			(3.247)	(1.107)	(-2.856)	
$gdpdef^{HK}$	204	4	0.035	0.000030	-0.009	0.991
			(2.851)	(0.949)	(-2.462)	
cpi^{HK}	204	4	0.032	0.000050	-0.008	0.992
			(3.358)	(1.661)	(-2.909)	
ur^{HK}	136	9	0.107	–	-0.075*	0.925
			(2.695)		(-2.627)	
emp^{HK}	136	1	0.183	0.000014	-0.022	0.978
			(1.326)	(0.315)	(-1.296)	
$rwage^{HK}$	88	4	1.923	0.000640	-0.406	0.594
			(2.715)	(2.906)	(-2.716)	
$nwage^{HK}$	88	1	0.260	0.000460	-0.052	0.948
			(2.170)	(2.184)	(-2.137)	
$rgdp^{SG}$	204	0	0.113	0.000090	-0.010	0.990
			(1.095)	(0.518)	(-0.890)	
$ngdp^{SG}$	204	1	0.209	0.000390	-0.022	0.978
			(2.285)	(1.767)	(-2.063)	
$gdpdef^{SG}$	204	4	0.231	0.000240	-0.057	0.943
			(3.047)	(2.670)	(-2.967)	
cpi^{SG}	204	1	0.091	0.000100	-0.024	0.976
			(2.691)	(2.367)	(-2.591)	
ur^{SG}	136	0	0.168	–	-0.207**	0.796
			(3.381)		(-3.473)	
$rwage^{SG}$	88	4	0.027	–	-0.155*	0.793
			(2.550)		(-2.744)	

Note. T represents the number of observations, and p is the chosen lag length. The values in parentheses are the τ-statistics of the ordinary least squares estimates of μ, δ, and β. ***, **, and * denote significance at the 0.01, 0.05, and 0.10 levels, respectively.

Dickey and Fuller (1979) noted that the critical values for testing $\beta = 0$ depend on the regression form and sample size (Enders, 2015). Enders further reported that the traditional view of business cycles holds that GNP and production levels are TS rather than DS. According to this perspective, β must be significantly different from zero. If $\beta = 0$, the series has a unit root and is considered to be DS. Dickey and Fuller (1979) reported that the critical values for $\beta = 0$ depend on the form of the regression and sample size. The statistics called τ, τ_μ, and τ_τ are the appropriate statistics to use for 3.1-3.3, respectively (Enders, 2015, Chapter 4, p. 206–207). Consequently, the critical value of the τ-statistic for the null hypothesis $\beta = 0$ at the 0.05 significance level is -3.45.

To examine stationarity, this study compares the τ-statistic of the coefficient β to these critical values. The τ-statistic for the UR in Hong Kong (-2.627) and the τ-statistic for real wages in Singapore (-2.744) are smaller than the critical value at the 0.1 level (Table 3.4)[1]. However, as the null hypothesis is rejected at the 10% significance level, the statistical evidence against the presence of a unit root remains weak. The UR in Hong Kong and real wages in Singapore fail to reject the null hypothesis, implying a DS process. Additionally, the τ-statistic for the UR in Singapore is -3.087, which is smaller than the critical value at the 0.05 level. This finding allows us to reject the null hypothesis of a unit root (H_0: $\beta = 0$), indicating that the UR in Singapore is stationary. In contrast, the estimated values of β for the remaining variables are greater than the critical value at the 0.05 level. Therefore, the null hypothesis of a unit root cannot be rejected, suggesting that these variables follow a DS process.

Overall, the ADF results indicate that most macroeconomic variables in both economies are DS, with notable exceptions: the UR in Singapore appears to be TS.

3.3.3 F - test

Dickey and Fuller (1981) introduced three additional F-statistics (Φ_1, Φ_2, and Φ_3) to test the joint hypothesis on the coefficients (Enders, 2015). The statistical power

[1]See Enders,W. (2010), Applied Economic Time Series, p. 488, Table A .

of the F-test is greater than that of the t-test (Yamamoto, 1988). Each statistic was obtained by comparing the unrestricted model (U) with the corresponding restricted model (R). The three F-statistics are presented as follows:

(1) The unrestricted model of Φ_1 statistics is

$$(\mathrm{U}): \quad \Delta y_t = \mu + \beta y_{t-1} + \sum_{i=2}^{p} \gamma_i \Delta y_{t-i+1} + \varepsilon_t \tag{3.4}$$

The Φ_1 statistics tests the joint hypothesis:

$$\begin{aligned} H_0: &\quad \beta = \mu = 0 \qquad \text{(Random Walk)}, \\ H_A: &\quad \beta \neq 0, \text{ or } \mu \neq 0. \end{aligned}$$

Under the null hypothesis, the restricted model is reduced to

$$\Delta y_t = \sum_{i=2}^{p} \gamma_i \Delta y_{t-i+1} + \varepsilon_t \tag{3.5}$$

The Φ_1 statistic is calculated as

$$\Phi_1 = \frac{(SSR_R - SSR_U)/2}{SSR_U/(T-k)} \tag{3.6}$$

(2) The unrestricted model of Φ_2 and Φ_3 statistics is displayed as follows:

$$\Delta y_t = \mu + \delta t + \beta y_{t-1} + \sum_{i=2}^{p} \gamma_i \Delta y_{t-i+1} + \varepsilon_t \tag{3.7}$$

The Φ_2 statistic examines the joint null hypothesis:

$$\begin{aligned} H_0: &\quad \beta = \delta = \mu = 0 \qquad \text{(Random Walk)}, \\ H_A: &\quad \text{at least one of } \beta, \mu, \delta \text{ is non-zero.} \end{aligned}$$

The restricted model of Φ_2 statistics is reduced to

$$\Delta y_t = \sum_{i=2}^{p} \gamma_i \Delta y_{t-i+1} + \varepsilon_t \tag{3.8}$$

The Φ_2 statistic is calculated as

$$\Phi_2 = \frac{(SSR_R - SSR_U)/3}{SSR_U/(T-k)} \tag{3.9}$$

(3) The Φ_3 statistic tests

$$H_0: \quad \beta = \delta = 0 \qquad \text{(Random Walk with Drift)},$$
$$H_A: \quad \beta \neq 0, \text{ or } \delta \neq 0.$$

Under the null hypothesis, the restricted model becomes

$$\Delta y_t = \mu + \sum_{i=2}^{p} \gamma_i \Delta y_{t-i+1} + \varepsilon_t \tag{3.10}$$

The Φ_3 statistic is calculated as

$$\Phi_3 = \frac{(SSR_R - SSR_U)/2}{SSR_U/(T-k)} \tag{3.11}$$

where SSR_R and SSR_U are the sum of squared residuals of the restricted and unrestricted models, respectively, and k denotes the parameter of the unrestricted model.

As real GDP, nominal GDP, employment, CPI, real wage, and nominal wage have an upward trend (Section 2), these variables should be calculated using Φ_2 and Φ_3 statistics. Since the UR does not show a clear trend, only the Φ_1 statistic needs to be calculated. The results are summarized in Table 3.5.

Table 3.5. The result of F–test of each variable

Series	T	k	$\mathbf{\Phi_1}$	$\mathbf{\Phi_2}$	$\mathbf{\Phi_3}$
$rgdp^{HK}$	204	10	–	16.73***	13.39***
$ngdp^{HK}$	204	11	–	6.46**	7.79**
$gdpdef^{HK}$	204	7	–	3.57	4.50
cpi^{HK}	204	7	–	4.92**	6.43*
ur^{HK}	136	12	3.91	–	–
emp^{HK}	136	4	–	3.88	3.42
$rwage^{HK}$	88	7	–	4.01	4.50
$nwage^{HK}$	88	4	–	8.72***	2.47
$rgdp^{SG}$	204	3	–	4.76*	0.13
$ngdp^{SG}$	204	4	–	15.77***	3.91
$gdpdef^{SG}$	204	7	–	5.82**	4.77
cpi^{SG}	204	4	–	10.13***	3.88
ur^{SG}	136	3	23.05***	–	–
$rwage^{SG}$	88	7	–	1.82	2.53

Notes: An (***), (**) and (*) denote significance at the 0.01, 0.05 and 0.1 level.

Table 3.5 presents the F-test results for the random walk hypothesis, compared with the critical values calculated by Dickey and Fuller (1981)[2]. For Hong Kong, real GDP and nominal GDP strongly reject the random walk specification, whereas employment and real wages generally fail to reject the null hypothesis. The CPI series also rejects the random walk hypothesis at conventional significance levels. For the UR, the Φ_1 statistic equals 3.91, which is below the corresponding critical value, indicating that the random walk hypothesis cannot be rejected. This finding suggests that the UR follows a random walk model.

The evidence is more mixed for Singapore. Real GDP rejects the random walk hypothesis only at the 10% level ($\Phi_2 = 4.76$), whereas the nominal GDP strongly rejects it ($\Phi_2 = 15.77$). Similarly, the GDP deflator ($\Phi_2 = 5.82$) and CPI ($\Phi_2 =$

[2]See Enders,W. (2010), Applied Economic Time Series, p. 488, Table B.

10.13) reject the null hypothesis. Conversely, real wages do not reject the random walk specification ($\Phi_2 = 1.82$, $\Phi_3 = 2.53$). The UR exhibits a very large Φ_1 statistic of 23.05, providing strong evidence against the random walk hypothesis.

Overall, nominal variables, particularly nominal GDP and consumer prices, display stronger departures from a random walk process than labor market variables. Real wages and employment generally provide weaker evidence against the random walk hypothesis, implying a higher degree of persistence in these series. Based on Enders' (2015) argument, the null hypothesis of a random walk can be rejected in favor of the alternative hypothesis, indicating that the data contain an intercept, a unit root, and/or a deterministic time trend.

3.3.4 Zivot and Andrews Tests

The ZA tests were conducted to examine the presence of a unit root in the main macroeconomic variables of Hong Kong and Singapore. Perron (1989) showed that standard tests of the unit root hypothesis against TS alternatives cannot reject the unit root hypothesis if the true data-generating mechanism is that of stationary fluctuations around a trend function that contains a one-time break. This test, which extended the standard Dickey–Fuller procedure by adding dummy variables for different intercepts and slopes, was conducted at a break point known a priori. Ben-David and Papell (1995) noted that structural break tests, which assume stationary, may be unable to distinguish between a stationary process with structural change and a unit root process without structural change. Furthermore, when there are structural breaks, the various Dickey–Fuller test statistics are biased toward the nonrejection of a unit root (Enders, 2015).

The ZA test was performed based on these arguments, allowing for structural change for the macroeconomic variables of Hong Kong's economy in this study. The test is based on Perron's (1989) framework. Following the null hypothesis and the alternative hypothesis of Perron (1989), allowing for a one-time structural break at time T_B ($1 < T_B < T$), the Perron models are used as follows:

Model (A) describes what shall be referred to as the crash model:

$$H_0: \quad y_t = \mu + y_{t-1} + dD(T_B)_t + \varepsilon_t,$$
$$H_A: \quad y_t = \mu_1 + \delta t + (\mu_2 - \mu_1)DU_t + \varepsilon_t.$$

Model (B) is referred to as the "changing growth" model:

$$H_0: \quad y_t = \mu_1 + y_{t-1} + (\mu_2 - \mu_1)DU_t + \varepsilon_t,$$
$$H_A: \quad y_t = \mu + \delta_1 t + (\beta_2 - \beta_1)DT_t^* + \varepsilon_t.$$

Model (C) allows both effects to occur simultaneously (i.e., a sudden change in the level followed by a different growth path):

$$H_0: \quad y_t = \mu_1 + y_{t-1} + dD(T_B)_t + (\mu_2 - \mu_1)DU_t + \varepsilon_t,$$
$$H_A: \quad y_t = \mu + \delta_1 t + (\mu_2 - \mu_1)DU_t + (\delta_2 - \delta_1)DT_t + \varepsilon_t.$$

where T_B refers to the time of break, the period at which the change in the parameters of the trend function occurs (Perron (1989):

$$D(T_B)_t = 1, \text{ if } t = T_B + 1, \ 0, \text{ otherwise.} \tag{3.12}$$

$$DU_t = 1, \text{ if } t > T_B, \ 0, \text{ otherwise.} \tag{3.13}$$

$$DT_t^* = t - T_B. \tag{3.14}$$

and

$$DT_t = t, \text{ if } t > T_B, \ 0, \text{ otherwise.} \tag{3.15}$$

Additionally, Perron's tests for a unit root in Models A, B, and C involve the following augmented regression equations (Zivot & Andrews, 1992):

$$y_t = \hat{\mu}^A + \hat{\theta}^A DU_t + \hat{\delta}^A t + \hat{d}^A D(T_B)_t + \hat{\beta}^A y_{t-1} + \sum_{j=1}^{k} \hat{c}_j^A \Delta y_{t-j} + \hat{\varepsilon}_t \tag{3.16}$$

$$y_t = \hat{\mu}^B + \hat{\delta}^B t + \hat{\gamma}^B DT_t^* + \hat{\beta}^B y_{t-1} + \sum_{j=1}^{k} \hat{c}_j^B \Delta y_{t-j} + \hat{\varepsilon}_t \tag{3.17}$$

$$y_t = \hat{\mu}^C + \hat{\theta}^C DU_t + \hat{\delta}^C t + \hat{\gamma}^C DT_t^* + \hat{d}^C D(T_B)_t + \hat{\beta}^C y_{t-1} + \sum_{j=1}^{k} \hat{c}_j^C \Delta y_{t-j} + \hat{\varepsilon}_t \quad (3.18)$$

Therefore, following Perron's ADF testing strategy, the regression equations 3.16, 3.17, and 3.18 used to test for a unit root are modified as follows:

$$y_t = \hat{\mu}^A + \hat{\theta}^A DU_t(\hat{\lambda}) + \hat{\delta}^A t + \hat{\beta}^A y_{t-1} + \sum_{j=1}^{k} \hat{c}_j^A \Delta y_{t-j} + \hat{\varepsilon}_t \quad (3.19)$$

$$y_t = \hat{\mu}^B + \hat{\delta}^B t + \hat{\gamma}^B DT_t^*(\hat{\lambda}) + \hat{\beta}^B y_{t-1} + \sum_{j=1}^{k} \hat{c}_j^B \Delta y_{t-j} + \hat{\varepsilon}_t \quad (3.20)$$

$$y_t = \hat{\mu}^C + \hat{\theta}^C DU_t(\hat{\lambda}) + \hat{\delta}^C t + \hat{\gamma}^C DT_t^*(\hat{\lambda}) + \hat{\beta}^C y_{t-1} + \sum_{j=1}^{k} \hat{c}_j^C \Delta y_{t-j} + \hat{\varepsilon}_t \quad (3.21)$$

where $\lambda = T_B/T$, $DU_t(\lambda) = 1$ if $t > T\lambda$, and 0 otherwise; $DT_t^*(\lambda) = 1 - T\lambda$ if $t > T\lambda$, and 0 otherwise. Zivot and Andrews (1992) put "hats" on the λ parameters in 3.19, 3.20, and 3.21 to emphasize that they correspond to the estimated values of the break fraction (or breakpoint).

Based on Zivot and Andrews (1992), our null hypothesis for the three models is displayed as follows:

$$y_t = \mu + y_{t-1} + \varepsilon_t \quad (3.22)$$

The following statistics computed from equations (3.16)–(3.18) are considered based on Perron (1989). These represent the standard t-statistics $\left(t_{\hat{\beta}^i}(\lambda),\, i = A, B, C\right)$ for testing $\beta^i = 1$. The application of Zivot and Andrews's (1992)approach enables selecting the breakpoint that yields the least favorable result for our null hypothesis. λ is selected such that the one-sided t-statistic is minimum for testing $\beta^i = 1$. The notation $\hat{\lambda}_{\text{inf}}^i$ is defined as

$$t_{\hat{\beta}^i}\left(\hat{\lambda}_{\text{inf}}^i\right) = \inf_{\lambda} t_{\hat{\beta}^i}(\lambda), \qquad (i = A, B, C). \quad (3.23)$$

Although Zivot and Andrews (1992) followed Perron's test methodology, they conducted their analysis under the assumption that the break point was not known a priori. The ZA test was employed because shocks occur unpredictably. Following Perron (1989), this study applied Model B to real GDP, nominal GDP, employment, and CPI and Model C to real wage and nominal wage. The UR was omitted because this series is determined to be stationary based on the F-test.

This study calculated lag k using Schwer's rule (1989) and then sequentially com-

puted the t-statistic for each lag k. The significance of the t-statistic was assessed at the last lag, setting a threshold of 1.6, and finally the optimal lag length k was selected based on the methods outlined by Perron (1989). The results corresponding to the minimum values of the t-statistic of β^i in the two respective models are summarized in Table 3.6, where the three smallest values are selected.

Table 3.6. Minimum t Statistics

Series	T	k	Rank 1		Rank 2		Rank 3	
			t stat	Year.Q	t stat	Year.Q	t stat	Year.Q
Model B								
$rgdp^{HK}$	204	8	-2.690	2007Q4	-2.690	2007Q3	-2.686	2007Q2
$ngdp^{HK}$	204	8	-4.136*	1992Q3	-4.126	1992Q2	-4.123	1992Q4
$gdpdef^{HK}$	204	11	-3.747	1992Q2	-3.739	1992Q1	-3.737	1991Q4
cpi^{HK}	204	5	-4.082	1993Q3	-4.079	1993Q4	-4.076	1993Q2
emp^{HK}	136	1	-3.625	2016Q2	-3.620	2016Q1	-3.614	2015Q4
$rgdp^{SG}$	204	0	-2.626	1995Q3	-2.624	1995Q4	-2.620	1995Q1
$ngdp^{SG}$	204	2	-4.176*	1994Q2	-4.173	1994Q1	-4.168	1994Q3
$gdpdef^{SG}$	204	8	-2.991	2018Q3	-2.985	2018Q2	-2.974	2018Q1
cpi^{SG}	204	11	-4.367*	1990Q3	-4.367	1990Q2	-4.366	1990Q1
Model C								
$rwage^{HK}$	88	4	-3.577	2014Q3	-3.500	2016Q4	-3.450	2014Q2
$nwage^{HK}$	88	4	-4.167	2011Q1	-4.053	2010Q4	-3.489	2012Q3
$rwage^{SG}$	88	1	-4.380	2009Q3	-4.282	2009Q2	-3.936	2009Q4

Note. T represents the number of observations. k is the chosen lag length. An (***), (**) and (*) indicate that the unit root hypothesis is rejected at the 0.01, 0.05, and 0.1 levels, respectively, using Perron's critical values.

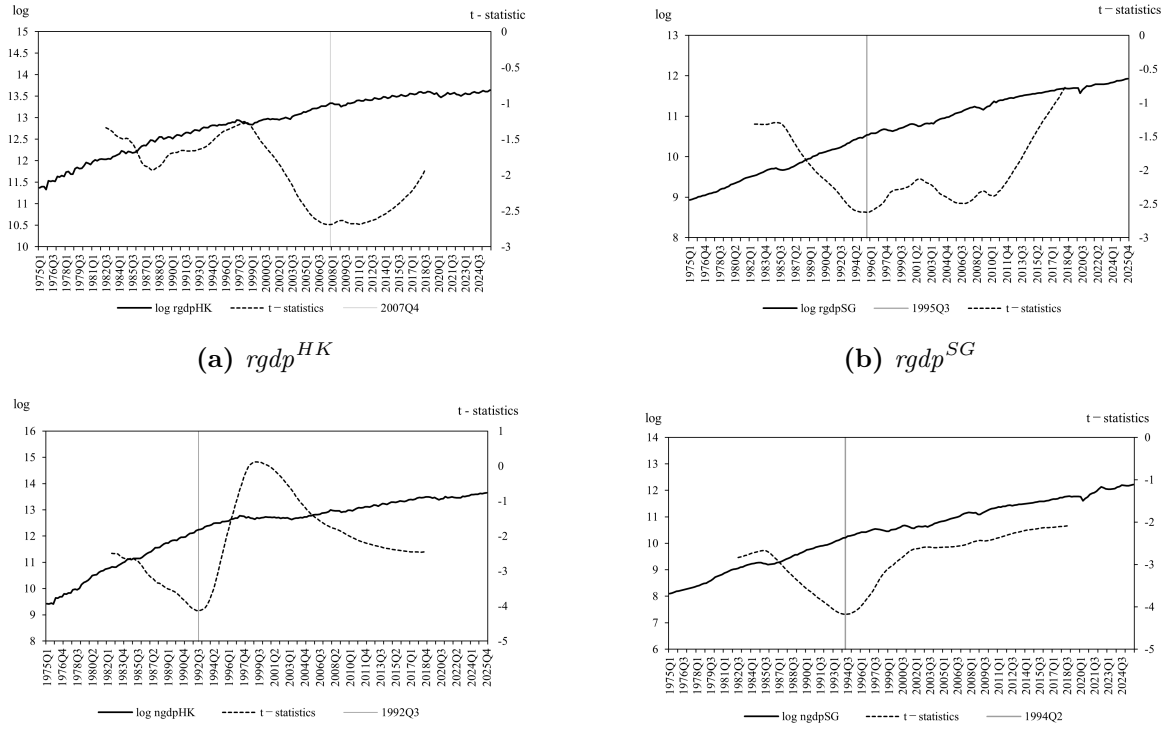
Table 3.7. Zivot and Andrews Test for a Unit Root with Structural Change

Model B									
Series	T	T_B	k	λ	$\hat{\mu}^B$	–	$\hat{\delta}^B$	$\hat{\gamma}^B$	$\hat{\beta}^B$
$rgdp^{HK}$	204	2007Q4	8	0.65	0.667	–	0.00054	-0.00040	-0.055
					(2.816)		(2.057)	(-1.928)	(-2.690)
$ngdp^{HK}$	204	1992Q3	8	0.35	0.845	–	0.00320	-0.00240	-0.086
					(4.339)		(3.628)	(-3.533)	(-4.136)*
$gdpdef^{HK}$	204	1992Q2	11	0.34	0.110	–	0.00070	-0.00060	-0.038
					(4.241)		(2.800)	(-2.610)	(-3.747)
cpi^{HK}	204	1993Q3	5	0.37	0.105	–	0.00070	-0.00060	-0.036
					(4.396)		(3.572)	(-3.398)	(-4.082)
emp^{HK}	136	2016Q2	1	0.72	0.952	–	0.00040	-0.00060	-0.119
					(3.639)		(3.274)	(-3.410)	(-3.625)
$rgdp^{SG}$	204	1995Q3	0	0.40	0.549	–	0.00120	-0.00050	-0.060
					(2.724)		(2.522)	(-2.506)	(-2.626)
$ngdp^{SG}$	204	1994Q2	2	0.38	0.839	–	0.00270	-0.00110	-0.102
					(4.280)		(3.986)	(-3.547)	(-4.176)*
$gdpdef^{SG}$	204	2018Q3	8	0.86	0.253	–	0.00020	0.00050	-0.062
					(3.103)		(2.394)	(1.713)	(-2.991)
cpi^{SG}	204	1990Q3	11	0.31	0.223	–	0.00030	-0.00008	-0.061
					(4.467)		(3.363)	(-1.398)	(-4.367)*
Model C									
Series	T	T_B	k	λ	$\hat{\mu}^C$	$\hat{\theta}^C$	$\hat{\delta}^C$	$\hat{\gamma}^C$	$\hat{\beta}^C$
$rwage^{HK}$	88	2014Q3	4	0.49	2.958	-0.013	0.00080	0.00060	-0.624
					(3.574)	(-1.722)	(2.698)	(1.621)	(-3.577)
$nwage^{HK}$	88	2011Q1	4	0.33	0.613	0.015	0.00070	0.00020	-0.123
					(4.172)	(3.823)	(3.196)	(1.056)	(-4.167)
$rwage^{SG}$	88	2009Q3	1	0.26	0.095	-0.047	0.00020	0.00002	-0.385
					(3.881)	(-3.079)	(0.206)	(0.022)	(-4.380)

Notes. T represents the number of observations. k is the chosen lag length. The value in parentheses corresponds to the t-statistic of $\hat{\mu}$, $\hat{\theta}$, $\hat{\delta}$, $\hat{\gamma}$, and $\hat{\beta}$. The value in the λ column corresponds to the estimated break fraction ($\lambda = T_B/T$). An (***) , (**) and (*) indicate that the unit root hypothesis is rejected at the 0.01, 0.05 and 0.1 levels, respectively.

Table 3.7 presents the estimated regression results for all series using the regression equation (3.20) and (3.21); t-statistics are set in parentheses. Figure 3.1 shows the natural logarithm and the t-statistics derived from the ZA test for all series.

Comparing these results to the critical values[3], this study can reject the unit root null hypothesis at the 10% significance level for nominal GDP in Hong Kong and nominal GDP and CPI in Singapore, indicating limited support for stationarity around a structural break. The unit root null hypothesis for real GDP, GDP deflator, CPI, employment, RWAGE, and NWAGE in Hong Kong and for real GDP, GDP deflator, and RWAGE in Singapore cannot be rejected. Most macroeconomic variables in Hong Kong, including real GDP, nominal GDP, GDP deflator, CPI, employment, and UR, are characterized as DS processes. Accordingly, shocks to these variables have permanent effects, consistent with the seminal findings of Nelson and Plosser (1982). The ZA test results for nominal GDP indicate that it does not follow a random walk model and can be stationary with a structural break. Overall, the evidence supports the DS representation of macroeconomic time series, consistent with the findings of Nelson and Plosser (1982) and the endogenous break literature of Zivot and Andrews (1992).

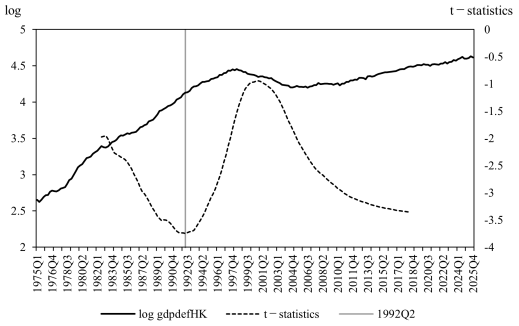


(a) $rgdp^{HK}$ **(b)** $rgdp^{SG}$

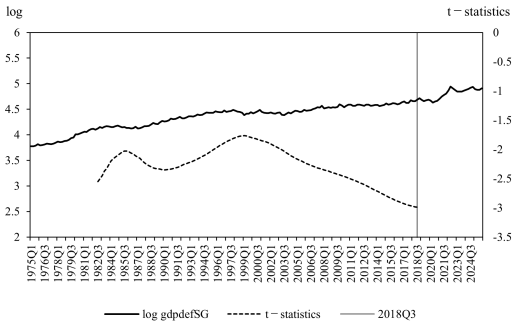
(c) $ngdp^{HK}$ **(d)** $ngdp^{SG}$

Figure 3.1. Time plots of the t-statistics (continued on the next page).

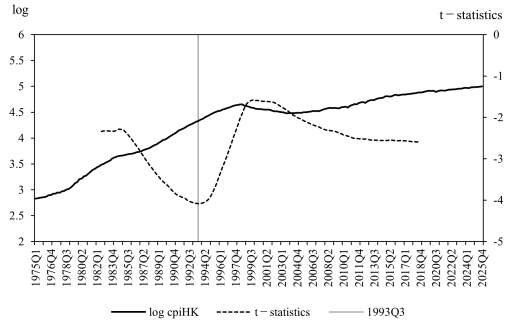
[3]See Zivot and Andrews, 1992.



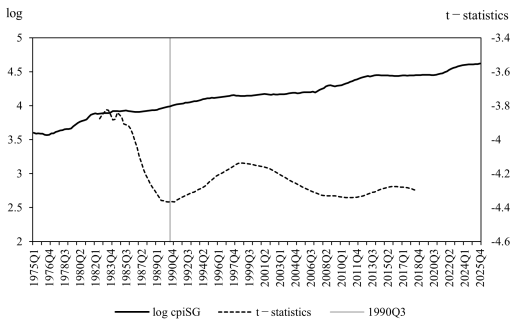
(e) $gdpdeflator^{HK}$



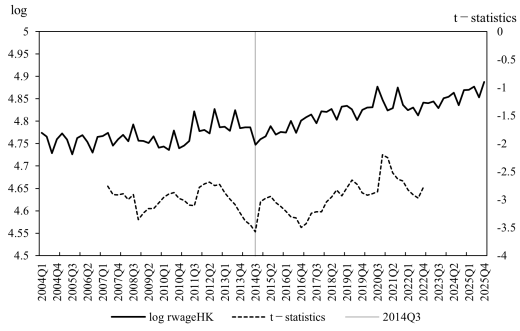
(f) $gdpdeflator^{SG}$



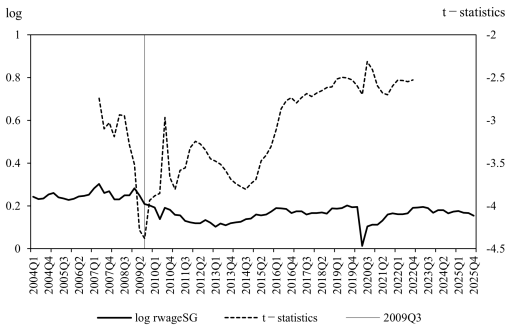
(g) cpi^{HK}



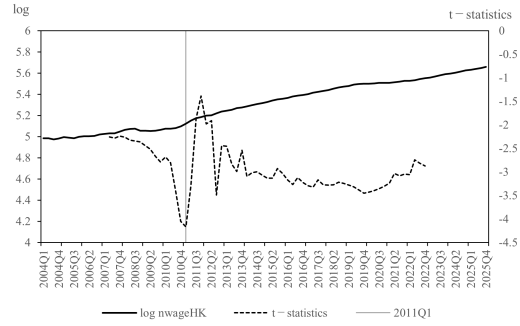
(h) cpi^{SG}



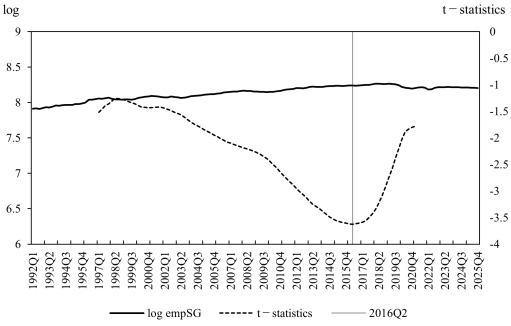
(i) $rwage^{HK}$



(j) $rwage^{SG}$



(k) $nwage^{HK}$



(l) emp^{SG}

Figure 3.1. Time plots of the t-statistics (continued).

3.4 Conclusion

Four types of analysis were conducted to examine the stationarity of key macroeconomic variables in Hong Kong and Singapore: sample autocorrelation, ADF test, F-test, and ZA test.

The autocorrelation analysis provided preliminary insights into the time-series properties of the variables. The autocorrelations of the natural logarithms remained close to unity and decayed slowly across all lags for most series, suggesting the presence of a unit root. When the first differences were examined, the autocorrelations declined substantially, supporting the view that most series are DS. However, the detrended series exhibited high persistence for real GDP, nominal GDP, and prices, whereas the persistence of real wages was markedly lower, particularly in Singapore.

The ADF test results indicated that most macroeconomic variables in both economies are DS. However, notable exceptions emerged: the UR in Singapore appeared to be TS.

The F-test results provided mixed evidence against the random walk hypothesis. Real and nominal GDP in Hong Kong and Singapore strongly rejected the random walk specification, whereas employment and real wages generally failed to reject the null hypothesis. For the UR, the evidence differed across economies: the null hypothesis could not be rejected for Hong Kong, whereas it was strongly rejected for Singapore. Overall, nominal variables exhibited stronger departures from a random walk process than labor market variables.

The ZA test, which allows for a one-time structural break, confirmed the ADF test findings for most variables. In Hong Kong, nominal GDP showed evidence of stationarity around a structural break. In Singapore, nominal GDP and CPI rejected the unit root when a break was allowed. All other variables remained DS even after accounting for a structural break.

A notable cross-economy difference emerged in the labor market. The UR was trend stationary in Singapore but difference stationary in Hong Kong, implying that

labor market shocks in Singapore were more transitory. This finding might reflect Singapore's more flexible labor market institutions. Overall, our findings are broadly consistent with those of Nelson and Plosser (1982), who argued that most macroeconomic variables in the US are DS. For Hong Kong, the evidence strongly supported the DS representation of macroeconomic time series, except for Singapore's UR, which appeared to be TS.

Theoretically, Campbell and Mankiw (1987) suggested various mechanisms through which aggregate demand shocks could have permanent or near-permanent effects on the level of output. These shocks may have lasting impacts if technological innovation is influenced by the business cycle. These mechanisms represent potential avenues for future research.

Chapter 4

Testing Purchasing Power Parity between Hong Kong and Mainland China: Cointegration Test Evidence

Abstract

This chapter examines whether purchasing power parity (PPP) holds between the Hong Kong Special Administrative Region (SAR) and Mainland China in the context of their deepening economic integration. Previous studies have highlighted the relocation of Hong Kong's manufacturing base to Guangdong and the intensifying cross-border linkages. If two economies were fully integrated, PPP would hold between Hong Kong and Mainland China. Therefore, this chapter conducts an empirical assessment of the PPP hypothesis. The Engle–Granger test results reveal that a long-run PPP relationship does not hold between Hong Kong and Mainland China over the sample period (March 1995 to February 2025). However, the Johansen (trace) test identifies a single cointegrating vector, indicating a long-term association. The evidence suggests that economic integration between Hong Kong and Mainland China remains insufficient for the strict validity of the PPP hypothesis.

4.1 Introduction

This chapter examines whether purchasing power parity (PPP) holds between Hong Kong and Mainland China. It is motivated by the deepening economic integration between the two economies, particularly following the relocation of Hong Kong's manufacturing sector to Guangdong in Southern China (Shinohara, 2003).

This growing interconnectedness raises an important question: To what extent has the Hong Kong economy become integrated with that of Mainland China? If full integration were achieved, the PPP hypothesis would hold between Hong Kong and Mainland China.

Despite its strong theoretical foundations, empirical studies have yielded mixed results regarding PPP validity. Enders (1988) noted that the ARIMA test results produced mixed support for the PPP hypothesis. Enders further argued that because Canada is a relatively small country compared with the United States (US), deviations from the PPP-implied bilateral price level would not be expected to induce any meaningful adjustment in US prices.

Similarly, Shirai (2000) reported that PPP does not hold when comparing the CPIs of Hong Kong and its major trading partners. Liang (1999) tested the generalized PPP hypothesis to examine the behavior of the long-run real exchange rate (RER) of Hong Kong and China. However, Genberg et al. (2006) and He et al. (2015) observed that Hong Kong's short-term business cycle remains more closely synchronized with the US owing to dominant transitory shocks. In contrast, its long-term output trend is increasingly shaped by permanent shocks originating from Mainland China, reflecting deeper structural integration and cross-border productivity gains.

This chapter contributes to the ongoing debate by focusing on the relationship between Hong Kong and Mainland China and employing cointegration techniques to evaluate the long-run validity of PPP. Rogoff (1996) aptly noted that "While few empirically literate economists take PPP seriously as a short-term proposition, most instinctively believe in some variant of PPP as an anchor for long-run real exchange

rates." Therefore, this study aims to determine whether a long-run anchor exists between these two increasingly interconnected economies.

Motivated by these developments, this study undertakes an empirical investigation using time-series techniques, including unit root tests and cointegration analysis, to provide additional evidence on the degree of price convergence between the two economies. The results offer insights into the conditions under which PPP may hold in emerging and highly open economies, particularly in highly differentiated exchange rate systems.

This chapter is organized as follows: Section 2 describes the data description and preliminary analysis; Section 3 presents the empirical results; and Section 4 concludes with a summary of the key findings and their implications.

4.2 Data Description and Preliminary Analysis

4.2.1 Data Description

The dataset employed in this chapter comprises monthly consumer price indices (CPIs) for Hong Kong (cpi^{HK}), Mainland China (cpi^{CN}), and the US (cpi^{US}), along with the nominal exchange rate between the Chinese Renminbi (CNY) and the US dollar (USD) ($e^{(CN/US)}$) and the nominal exchange rate between the Hong Kong dollar (HKD) and the USD ($e^{(HK/US)}$). The sample period spans from March 1995 to February 2025, yielding a total of 360 monthly observations for each series. The Hong Kong CPI were obtained from the Census and Statistics Department of the Hong Kong SAR Government, whereas the US CPI data were sourced from the US Bureau of Labor Statistics. The CPI data for Mainland China and both exchange rate series were retrieved from the Bank for International Settlements. All data series were seasonally adjusted [1] and converted into natural logarithms before analysis.

[1] The method of moving average was used.

4.2.2 Construction of Real Exchange Rates

This section explains how the RER of the HKD against the Chinese renminbi is constructed. Using the respective CPIs of the two economies, the RER is defined as follows:

$$RER^{HK/CN} = \frac{e^{HK/CN}\, cpi^{CN}}{cpi^{HK}} \tag{4.1}$$

The exchange rate data for the HKD and the Chinese renminbi are constructed as follows:

$$e^{HK/CN} = e^{HK/US} \cdot \frac{1}{e^{CN/US}} \tag{4.2}$$

The following equation can be obtained from the definition of the RER:

$$RER^{HK/CN} = \frac{e^{HK/US} \cdot cpip^{CN}}{e^{CN/US} \cdot cpi^{HK}} \tag{4.3}$$

Taking natural logarithms yields a convenient linear form:

$$\ln RER_t^{HK/CN} = \ln\left(e_t^{HK/US}\right) - \ln\left(e_t^{CN/US}\right) + \ln\left(cpi_t^{CN}\right) - \ln\left(cpi_t^{HK}\right) \tag{4.4}$$

This specification provides the empirical foundation for testing the PPP hypothesis between Hong Kong and Mainland China, using unit root and cointegration tests.

4.2.3 Visual Inspection of Data

Figure 4.1 presents the logged CPIs of Hong Kong, Mainland China, and the US from March 1995 to February 2025. Each series exhibits a clear upward trend over the sample period, reflecting the sustained long-run increases in consumer prices. A visual inspection indicates a potential long-run relationship between the two, a possibility which is examined more rigorously through the formal econometric tests that follow.

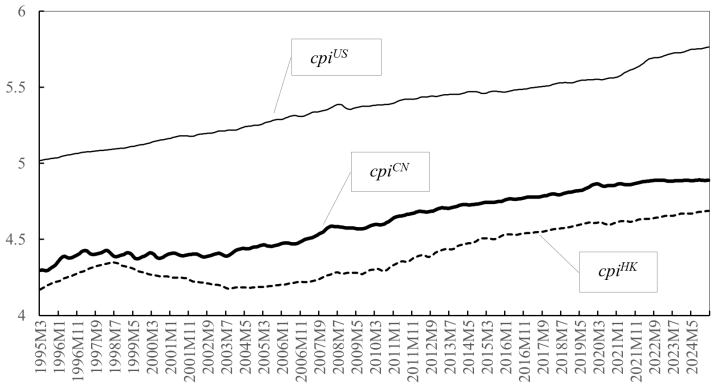


Figure 4.1. Natural logarithm CPI of Hong Kong, Mainland China and US

A notable disruption occurred around the 2008–2009 Lehman shock. During this period, the slope of the US consumer prices flattened markedly, indicating a sharp deceleration of US inflation, as the financial crisis suppressed aggregate demand. The Chinese CPI series exhibits only a brief pause before resuming its upward trajectory, consistent with the sizable fiscal stimulus launched by Beijing in late 2008. Hong Kong's price level remains almost flat throughout 2008–2009, indicating strong disinflationary pressures in its highly open, trade-dependent economy.

Following the crisis, all three series regained their upward momentum, experiencing moderate increases through the early 2010s. This period was followed by a temporary slowdown during the COVID-19 outbreak and a renewed acceleration—particularly pronounced in the US—during the postpandemic inflation surge of 2021–2023.

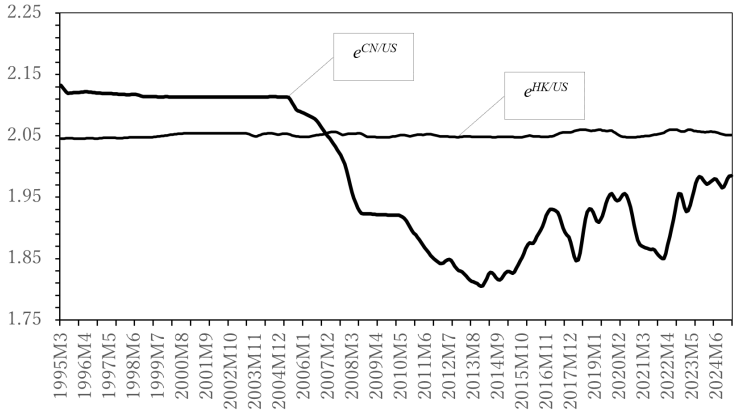


Figure 4.2. Logarithms of $e_t^{HK/US}$ and $e_t^{US/CN}$ (1995.M3–2025.M2)

Figure 4.2 plots the logarithms of the nominal exchange rate between the HKD and

the USD ($\log e_t^{HK/US}$) and the value of the renminbi in terms of the USD ($\log e_t^{CN/US}$). The HKD/USD rate remained remarkably stable throughout the sample period, reflecting Hong Kong's currency board arrangement. In contrast, the CNY/USD rate exhibits significant fluctuations, including the renminbi's gradual appreciation after 2005, a period of stability during the global financial crisis (2008–2010), and more flexible movements in subsequent years.

Based on Shirai's (2000) research, this study calculated the real bilateral exchange rates for the HKD against the CNY and the HKD against the USD. The results are presented in Figure 4.3.

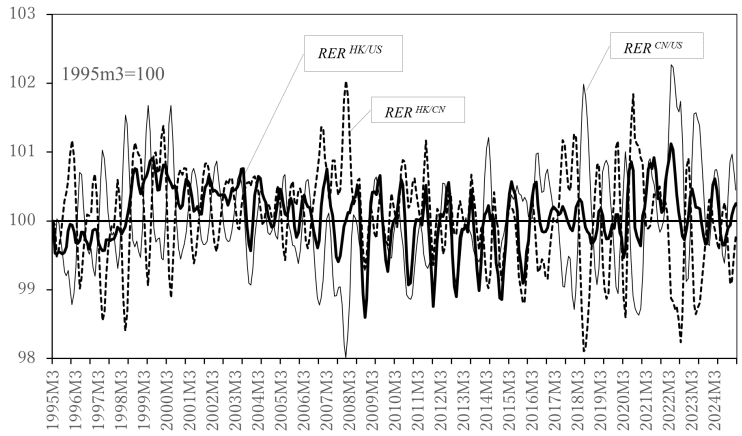


Figure 4.3. Real bilateral exchange rate between HKD/CNY and HKD/USD (1995.M3–2025.M2).

Shirai (2000) reported that the real effective exchange rate of the HKD against the USD appreciated from 1983, when the currency board system was adopted, until 1998. However, such an upward trend was not observed during our sample period (1995.M3–2025.M2). Shirai further noted that the RER of the HKD against the Chinese renminbi has remained relatively stable since 1995. This observation is also consistent with the patterns observed in our sample period.

4.3 Empirical Results

This section presents the empirical analysis of the relationship between CPIs of Hong Kong and Mainland China. The investigation proceeds in three steps: (1) testing the

stationarity of the variables using unit root tests, (2) examining the existence of a long-run equilibrium relationship using the Engle–Granger (EG) and Johansen cointegration tests, and (3) estimating a Vector Error Correction Model (VECM) to capture both the short-run dynamics and the speed of adjustment toward the long-run equilibrium.

4.3.1 Unit Root Tests

The stationarity properties of the individual time series are investigated using the augmented Dickey–Fuller (ADF) and Phillips–Perron (PP) tests[2] The tests are conducted on both the levels and the first differences of the natural logarithm of the variables. The null hypothesis for each test is that the series contains a unit root (i.e., nonstationary). Tables 4.1 and 4.2 present the results of these two tests.

Table 4.1. Results of ADF test

Variables	**Lag**	**None**	**Constant**	**Constant and trend**	**Decision**
$e^{HK/US}$	14	0.23	-3.29	-3.482	
$\Delta e^{HK/US}$	13	-4.843**	-4.837**	-4.854**	I(1)
$e^{US/CN}$	15	-0.564	-1.508	-1.086	
$\Delta e^{US/CN}$	14	-3.467**	-3.495**	-3.655**	I(1)
cpi^{CN}	14	3.09	-0.115	-2.087	
Δcpi^{CN}	13	-3.685**	-4.839**	-4.83**	I(1)
cpi^{HK}	12	1.23	0.107	-2.409	
Δcpi^{HK}	11	-2.656	-2.909	-3.154	I(0)

Notes. The lag length is selected based on the Schwarz Information Criterion (SIC). The reported values are t-statistics. Δ denotes the first difference of the corresponding variable. An (**) denotes significance at the 0.05 level.

[2]In deriving the bandwidth,the formula $l = \left\lfloor 4\left(\frac{T}{100}\right)^{2/9} \right\rfloor$ is used, where T denotes the number of observations.

Table 4.2. Results of PP test

Variables	Bandwidth	None	Constant	Constant and trend	Decision
$e^{HK/US}$	5	0.286	-2.681	-2.727	
$\Delta e^{HK/US}$	5	-6.15**	-6.145**	-6.151**	I(1)
$e^{US/CN}$	5	-0.882	-1.35	-0.397	
$\Delta e^{US/CN}$	5	-5.794**	-5.803**	-5.849**	I(1)
cpi^{CN}	5	4.406	-0.819	-1.671	
Δcpi^{CN}	5	-6.202**	-6.643**	-6.642**	I(1)
cpi^{HK}	5	4.167	0.606	-0.785	
Δcpi^{HK}	5	-5.202**	-5.615**	-5.672**	I(1)

Notes. The reported values are t-statistics. The bandwidth is selected based on Newey and West (1994). Δ denotes the first difference of the corresponding variable. An (*) denotes significance at the 0.01 level.

The ADF test results (Table 4.1) indicate that all variables in the levels are nonstationary. However, most variables become stationary after first differencing, implying that they are integrated of order one, I(1). For Hong Kong's consumer price series, the null hypothesis of nonstationarity cannot be rejected at this level.

The PP test results (Table 4.2) demonstrate that all variables in the levels are nonstationary, whereas their first differences are stationary at the 1% significance level. Accordingly, the series is integrated of order one, I(1). These results confirm the robustness of the integration order and provide a valid basis for subsequent cointegration analysis.

4.3.2 Cointegration Test

As all variables are confirmed to be integrated of order one I(1), the next step in the analysis involves testing for the existence of a long-run equilibrium relationship. A dual approach was applied to ensure the robustness of the findings: the EG two-step procedure to test for cointegration between specific pairs of variables of interest and the Johansen (1988) cointegration framework to determine the number of cointegrating

relationships.

This study follows Enders's (1988) empirical approach, which applied the EG two-step method to test PPP among major economies. Accordingly, we examine whether cpi^{HK} is cointegrated with cpi^{CN}, and $e^{HK/CN}$. Based on the equation (4.4), the following equation is estimated to perform the EG test.

$$\ln cpi_t^{HK} = \alpha + \beta \ln e_t^{HK/US} + \gamma \ln e_t^{US/CN} + \delta \ln cpi_t^{CN} + \varepsilon_t \tag{4.5}$$

where $\hat{\varepsilon}_t$ is the residual from the regression equation. The EG test residual are presented in Table 4.3.

Table 4.3. ADF test on the residuals of Equation (4.5)

Variable	Lag	t-Statistic	5% Critical Value
$\hat{\varepsilon}_t$	14	-1.914	-3.772

Note. Lag length for the ADF test was selected by using the SIC.

The null hypothesis of no cointegration cannot be rejected at the 5% significance level[3], we cannot reject the null hypothesis of no cointegration. Therefore, there is no statistical evidence of a long-run PPP relationship between the two economies.

(2) Given that all variables are integrated of order one, I(1), this study examines the presence of a long-run equilibrium relationship using the maximum likelihood cointegration framework proposed by Johansen (1988, 1991) and Johansen and Juselius (1990). The test is conducted on a vector autoregression (VAR) model that includes the four variables. The lag length for the VAR model was selected based on the Schwarz information criterion (SIC). The SIC[4] results indicate a lag length of 11.

Table 4.4. Johansen Cointegration Test – Trace Test Statistics

Null hypothesis	Alternative hypothesis	Eigenvalue	Test Statistic	5% Critical Value (**)
None	$r > 0$	0.069	50.907*	47.856
$r \leq 1$	$r > 1$	0.045	26.028	29.797
$r \leq 2$	$r > 2$	0.020	9.873	15.495
$r \leq 3$	$r > 3$	0.008	2.861	3.841

Note. r is the number of cointegrating vectors. An (*) denotes rejection of the hypothesis at the 0.05 level. An (**) is the critical value of MacKinnon–Haug–Michelis (1999).

[3]From Table C. Enders, W. (2010), Applied Economic Time Series, Third Edition
[4]Refer to the appendix: Table A-1.

Table 4.5. Johansen Cointegration Test – Maximum Eigenvalue Test Statistics

Null hypothesis	Alternative hypothesis	Eigenvalue	Test Statistic	5% Critical Value (**)
None	$r = 1$	0.069	24.879	27.584
$r = 1$	$r = 2$	0.045	16.155	21.132
$r = 2$	$r = 3$	0.020	7.012	14.265
$r = 3$	$r = 4$	0.008	2.861	3.841

Note. r is the number of cointegrating vectors. An (**) is the critical value of MacKinnon–Haug–Michelis (1999).

The Johansen test results, based on the trace and maximum eigenvalue test statistics, are used to determine the number of cointegrating relationships. In Table 4.4, the trace statistic indicates the presence of at least one cointegrating vector (r = 1). However, the maximum eigenvalue test in Table 4.5 does not confirm the existence of a cointegrating vector.

According to Lütkepohl et al. (2001), the trace tests have more heavily distorted sizes but comparable or even stronger power performance than their maximum-eigenvalue counterparts. In particular, the trace tests are preferable when there are at least two more cointegrating relationships than specified under the null hypothesis. The trace test exhibits greater empirical power and robustness than the maximal eigenvalue test, as it is less sensitive to skewness and excess kurtosis in the innovations (Cheung & Lai, 1993). Therefore, this study relies on the trace test statistics and concludes that there is a single cointegrating relationship among the four variables.

4.3.3 Estimation of VECMs

VECMs are estimated under the assumption that the cointegrating relation and the short-run dynamics include a constant. Notably, the theoretical long-run PPP requires the domestic price coefficient (often denoted by β) in the cointegrating vector to equal unity ($\beta_1 = 1$), and μ_t is stationary[5]. (see Enders, 2014). Based on the estimated results, the cointegrating regression equation is obtained as follows:

[5]The formula $f_t = e_t + p_t^*$ is used, and long-run purchasing power parity (PPP) asserts the presence of a linear combination of the form $f_t = \beta_0 + \beta_1 p_t + \mu_t$, where f_t denotes the logarithm of the foreign price level expressed in domestic currency, e_t, p_t^*, and p_t denote the logarithms of the price of foreign exchange, the foreign price level, and the domestic price level, respectively (Ender, 2014).

$$cpi_t^{HK} = 164.968 \quad + 2.134\, cpi_t^{CN} \quad - 1.18\, e_t^{US/CN} \quad - 84.211\, e_t^{HK/US} \tag{4.6}$$
$$\qquad\qquad\qquad\qquad\qquad\qquad (0.538) \qquad\qquad (0.803) \qquad\qquad (17.127)$$

The numbers reported in parentheses below the estimated coefficients correspond to their t-statistics. This equation captures a clear long-run relationship between Hong Kong and Mainland China in terms of consumer prices, incorporating the US–China and Hong Kong–US exchange rates. The estimated cointegrating vector includes a constant term (β_0) that is significantly different from zero and slope coefficients (β_i) that deviate significantly from the theoretical PPP value of unity ($\beta_i = 1$). Furthermore, the residual-based EG unit root test reveals that the RER is nonstationary, implying the presence of a unit root. These findings suggest that long-run PPP has failed between Hong Kong and Mainland China.

The empirical results of this study reveal that only the $e_t^{HK/US}$ exchange rate coefficient is statistically significant in the long-run cointegrating vector ($t = 17.127$), while the price coefficient cpi_t^{CN} is statistically insignificant, firmly supporting the conclusion that PPP does not hold between Hong Kong and Mainland China.

This equation (4.6) shows that, holding other variables constant, a 1 percentage-point increase in China's CPI leads to a 2.134 percentage-point increase in Hong Kong's CPI. A 1 percentage-point increase in the exchange rate of HKD against USD causes an 84.211 percentage-point decrease in Hong Kong's CPI, and a 1 percentage-point increase in the exchange rate of Chinese renminbi against USD leads to a 1.18 percentage-point decrease in Hong Kong's CPI. This study's empirical results align closely with Shirai's (2000) conclusion that PPP does not hold when examining the CPIs of Hong Kong and its major trading partners. The estimated coefficients of the VECM and their t-statistics are summarized in Table 4.6.

Table 4.6. Estimates of Vector Error Correction Model

Variables	Δcpi_t^{HK}	Δcpi_t^{CN}	$\Delta e_t^{HK/US}$	$\Delta e_t^{US/CN}$
CointEQ1	-0.00032 [-1.117]	-0.00003 [-0.139]	-0.00021 [-4.453]	-0.00009 [-0.341]
Δcpi_{t-1}^{HK}	1.470 [25.129]	-0.069 [-1.549]	0.021 [2.218]	0.034 [0.609]
Δcpi_{t-2}^{HK}	-0.895 [-8.694]	0.164 [2.099]	-0.023 [-1.395]	-0.168 [-1.710]
Δcpi_{t-3}^{HK}	0.550 [5.121]	-0.076 [-0.936]	0.016 [0.929]	0.151 [1.477]
Δcpi_{t-4}^{HK}	-1.094 [-10.149]	0.063 [0.769]	-0.013 [-0.717]	-0.083 [-0.806]
Δcpi_{t-5}^{HK}	1.396 [11.201]	-0.211 [-2.228]	0.023 [1.140]	0.064 [0.536]
Δcpi_{t-6}^{HK}	-0.825 [-5.775]	0.227 [2.090]	-0.035 [-1.518]	-0.083 [-0.609]
Δcpi_{t-7}^{HK}	0.303 [2.421]	-0.090 [-0.943]	0.027 [1.337]	0.060 [0.502]
Δcpi_{t-8}^{HK}	-0.544 [-5.063]	0.033 [0.403]	-0.023 [-1.306]	-0.017 [-0.171]
Δcpi_{t-9}^{HK}	0.774 [7.238]	-0.139 [-1.706]	0.013 [0.759]	0.029 [0.282]
Δcpi_{t-10}^{HK}	-0.401 [-3.865]	0.182 [2.310]	-0.008 [-0.462]	-0.104 [-1.056]
Δcpi_{t-11}^{HK}	0.149 [2.503]	-0.114 [-2.524]	-0.008 [-0.810]	0.071 [1.248]
Δcpi_{t-1}^{CN}	0.165 [2.172]	1.841 [31.767]	0.003 [0.280]	-0.010 [-0.138]
Δcpi_{t-2}^{CN}	-0.185 [-1.214]	-1.407 [-12.137]	-0.021 [-0.853]	0.151 [1.041]
Δcpi_{t-3}^{CN}	0.170 [1.035]	0.754 [6.048]	0.017 [0.656]	-0.273 [-1.751]
Δcpi_{t-4}^{CN}	-0.184 [-1.134]	-1.217 [-9.855]	-0.005 [-0.178]	0.368 [2.382]
Δcpi_{t-5}^{CN}	0.260 [1.418]	1.773 [12.698]	0.009 [0.304]	-0.340 [-1.947]
Δcpi_{t-6}^{CN}	-0.223 [-1.073]	-1.260 [-7.957]	-0.013 [-0.381]	0.298 [1.502]
Δcpi_{t-7}^{CN}	0.117 [0.635]	0.532 [3.795]	-0.009 [-0.292]	-0.262 [-1.493]
Δcpi_{t-8}^{CN}	-0.044 [-0.269]	-0.750 [-6.031]	0.006 [0.229]	0.330 [2.119]
Δcpi_{t-9}^{CN}	0.132 [0.804]	1.106 [8.875]	0.023 [0.879]	-0.360 [-2.308]
Δcpi_{t-10}^{CN}	-0.137 [-0.910]	-0.629 [-5.482]	-0.044 [-1.785]	0.292 [2.035]
Δcpi_{t-11}^{CN}	0.048 [0.633]	0.178 [3.110]	0.023 [1.847]	-0.095 [-1.329]
$\Delta e_{t-1}^{HK/US}$	-0.216 [-0.612]	0.019 [0.072]	1.858 [32.443]	0.249 [0.739]
$\Delta e_{t-2}^{HK/US}$	0.120 [0.161]	0.198 [0.349]	-1.760 [-14.619]	-0.060 [-0.084]
$\Delta e_{t-3}^{HK/US}$	0.086 [0.092]	-0.389 [-0.548]	1.424 [9.425]	-0.433 [-0.487]
$\Delta e_{t-4}^{HK/US}$	0.316 [0.312]	0.528 [0.683]	-1.502 [-9.135]	-0.259 [-0.268]

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Variables	Δcpi_t^{HK}	Δcpi_t^{CN}	$\Delta e_t^{HK/US}$	$\Delta e_t^{US/CN}$
$\Delta e_{t-5}^{HK/US}$	-0.513 [-0.462]	-0.240 [-0.284]	1.595 [8.871]	1.128 [1.067]
$\Delta e_{t-6}^{HK/US}$	1.013 [0.865]	0.097 [0.109]	-1.169 [-6.168]	-1.170 [-1.049]
$\Delta e_{t-7}^{HK/US}$	-1.050 [-0.959]	-0.055 [-0.066]	0.891 [5.022]	0.814 [0.781]
$\Delta e_{t-8}^{HK/US}$	0.468 [0.471]	-0.103 [-0.136]	-0.927 [-5.770]	-0.749 [-0.793]
$\Delta e_{t-9}^{HK/US}$	-0.031 [-0.034]	0.352 [0.505]	0.877 [5.914]	0.556 [0.638]
$\Delta e_{t-10}^{HK/US}$	-0.123 [-0.170]	-0.119 [-0.216]	-0.434 [-3.698]	-0.103 [-0.149]
$\Delta e_{t-11}^{HK/US}$	0.054 [0.157]	-0.062 [-0.238]	0.126 [2.276]	-0.373 [-1.143]
$\Delta e_{t-1}^{US/CN}$	-0.020 [-0.340]	0.049 [1.082]	0.016 [1.665]	2.319 [40.886]
$\Delta e_{t-2}^{US/CN}$	0.080 [0.549]	-0.143 [-1.291]	-0.010 [-0.443]	-2.583 [-18.631]
$\Delta e_{t-3}^{US/CN}$	-0.065 [-0.333]	0.188 [1.262]	-0.023 [-0.724]	2.149 [11.503]
$\Delta e_{t-4}^{US/CN}$	-0.044 [-0.206]	-0.178 [-1.091]	0.057 [1.632]	-2.179 [-10.670]
$\Delta e_{t-5}^{US/CN}$	0.181 [0.795]	0.203 [1.172]	-0.081 [-2.203]	2.511 [11.581]
$\Delta e_{t-6}^{US/CN}$	-0.262 [-1.099]	-0.260 [-1.435]	0.090 [2.327]	-2.354 [-10.379]
$\Delta e_{t-7}^{US/CN}$	0.225 [0.963]	0.298 [1.674]	-0.061 [-1.602]	1.826 [8.200]
$\Delta e_{t-8}^{US/CN}$	-0.199 [-0.895]	-0.303 [-1.798]	0.025 [0.700]	-1.629 [-7.709]
$\Delta e_{t-9}^{US/CN}$	0.223 [1.102]	0.254 [1.648]	-0.022 [-0.668]	1.582 [8.203]
$\Delta e_{t-10}^{US/CN}$	-0.191 [-1.267]	-0.154 [-1.343]	0.022 [0.898]	-1.014 [-7.085]
$\Delta e_{t-11}^{US/CN}$	0.071 [1.152]	0.046 [0.987]	-0.009 [-0.874]	0.289 [4.962]
C	-0.000049 [-0.648]	0.000133 [2.315]	0.000025 [2.027]	-0.000052 [-0.727]
R^2	0.9217	0.9680	0.9303	0.9670

Note. The value in parentheses [ ] is the t-statistic of each parameter estimate.

Note that only the error-correcting term (ECT) for the HKD/USD exchange rate ($\Delta e_t^{HK/US}$) is statistically significant ($t = -4.453$). The t-statistics for the ECTs of both consumer prices are insignificant, implying that cpi_t^{HK} and cpi_t^{CN} do not adjust to restore the long-run equilibrium. This result confirms the rejection of the PPP hypothesis.

4.4 Conclusion and Further Research

This chapter provided mixed evidence regarding the long-run price relationship between Hong Kong and Mainland China. The EG tests do not support PPP, whereas the Johansen cointegration (trace) approach suggests the presence of at least one long-run relationship linking Hong Kong prices, Mainland China prices, and the two nominal exchange rates.

The VECM estimation results reveal that adjustment toward long-run equilibrium occurs primarily through the Hong Kong–US exchange rate. In contrast, price levels in Hong Kong and Mainland China exhibit little response to deviations from equilibrium. This outcome reflects the institutional reality of Hong Kong's currency board system, under which the HKD–USD exchange rate bears the primary burden of adjustment.

Overall, the findings report some price transmission from Mainland China to Hong Kong; however, strict PPP does not hold. These results highlight the importance of exchange rate arrangements in shaping the adjustment process and suggest that further research incorporating structural breaks, alternative price indices, and robustness checks would be valuable for a more comprehensive assessment of the long-run validity of PPP between Hong Kong and Mainland China.

Hong Kong's monetary policy is primarily aimed at maintaining HKD stability against the USD and is therefore strongly influenced by the US economic conditions. If Hong Kong's consumer prices are correlated with its money supply, they may be significantly affected by US economic fluctuations. Moreover, the Hong Kong CPI may be strongly influenced by movements in the domestic real estate market. In recent years, Hong Kong residents have increasingly purchased goods directly from Mainland China through online platforms, a growing trend that indicates local consumers may be affected by price movements in China's consumer markets. These factors warrant further investigation in future empirical research.

Chapter 5

Effects of US-China Inflation on Hong Kong and Singapore

Abstract

This chapter examines the extent to which consumer prices in Hong Kong Special Administrative Region and Singapore are influenced by those in the United States and Mainland China, respectively. Previous findings indicate that consumer prices in Hong Kong respond more strongly to US price shocks than those in Singapore. However, the results of this study reveal that consumer prices in Singapore are more responsive to price shocks from both the US and China than those in Hong Kong. This finding contradicts the insulating effect associated with floating exchange rate regimes. When the analysis is extended to three countries using the Johansen cointegration test, only Hong Kong shows a stable long-run equilibrium relationship with the US and China, as indicated by one cointegrating vector. In contrast, Singapore does not exhibit any cointegration with the US and China. The error-correction coefficient is negative and statistically significant only in the US inflation equation, indicating that the US adjusts toward long-run equilibrium. In Hong Kong, the coefficient is insignificant, reflecting weak adjustment dynamics. China's coefficient is significant but positive, indicating divergence from long-run equilibrium.

5.1 Introduction

This chapter analyzes the influence of inflation shocks from the US and China on price dynamics in Hong Kong and Singapore from 2008 to 2025.

Singapore and Hong Kong are highly susceptible to external shocks. Although they share several similarities, their exchange rate regimes differ. This chapter focuses on Singapore and Hong Kong to examine the effect of these differences on the transmission of external shocks to the domestic economy.

Cheung and Yuen (2002) examined the relationship between consumer prices in Hong Kong and Singapore and those in the US, concluding that consumer prices in Hong Kong react more strongly to US price shocks than those in Singapore. Their finding supports the insulating property of floating exchange rates: floating regimes can buffer external shocks more effectively than fixed regimes. In contrast, the findings herein reveal that consumer prices in Singapore are more vulnerable to price shocks originating from the US and China than those in Hong Kong. This evidence challenges the insulating effect of floating exchange rate regimes.

The remainder of the chapter is organized as follows: Section 2 reviews the relevant literature; Section 3 describes the data; Section 4 presents the empirical results; Section 5 concludes.

5.2 Literature Review

This chapter first introduces the main views on the similarities between Hong Kong and Singapore. Gerlach and Gerlach-Kristen (2006) remarked that these two economies are "similar in important ways: they are extremely small, highly open to international trade, and very advanced." This characterization is reinforced by subsequent comparative studies describing their structural similarities as small, open metropolitan economies lacking natural resources (Ma et al., 2007). Hong Kong and Singapore are considered particularly vulnerable to price fluctuations in major global economies because they rely heavily on international trade and imported goods.

As noted by Cheung and Yuen (2002), a major difference between Hong Kong and Singapore lies in their exchange rate regimes. Although Hong Kong operators operate under a rigid currency board arrangement as their fundamental framework, these systems differ markedly in design regarding the degree of monetary autonomy and discretionary control over domestic demand they permit (Ma et al., 2007). Since October 1983, Hong Kong has operated under a linked exchange rate system (LERS), maintaining a rigid peg between the Hong Kong dollar and the US dollar. Conversely, Singapore has operated under an exchange-rate–centered framework since 1981, managing the Singapore dollar against a trade-weighted basket of currencies with an explicit emphasis on price stability as the foundation for sustainable growth (Gerlach & Gerlach-Kristen, 2006).

Devereux (2003) noted that under a floating exchange rate regime, as in Singapore, the economy should be effectively insulated from foreign price shocks, but not from real interest rate shocks. However, under a fixed exchange rate regime, foreign price and real interest rate shocks will affect the domestic economy. This provides an argument for the superiority of floating exchange rate regimes over fixed regimes, as monetary policy can be assigned to price stabilization.

Cheung and Yuen (2002) provided empirical evidence that although US inflation transmits to the economies of Hong Kong and Singapore, Hong Kong exhibits a much stronger response than Singapore, a finding consistent with the standard predictions of a fixed exchange rate arrangement. The authors argued that although exchange rate flexibility does not completely insulate Singapore from external price movements, it makes the economy less responsive to US shocks. Accordingly, the Monetary Authority of Singapore effectively employs its monetary policy to absorb some of the impact of foreign price shocks and curb imported inflation. In contrast, Hong Kong remains subject to significant influences from the large economy. Cheung and Yuen's findings indicate that US price shocks exert a dominant and sustained impact on the inflation dynamics of Hong Kong and Singapore.

These monetary frameworks may lead to different responses to external inflation-

ary shocks, underscoring the importance of examining how these economies manage imported inflation in a volatile global market.

Kim and Roubini (2000) applied a structural vector autoregressive (SVAR) model in first differences with short-run restrictions to isolate structural shocks and trace their propagation across economies using impulse response functions (IRFs) and forecast error variance decomposition (FEVD).

Nevertheless, modeling inflation transmission from these major economies is a complex issue. Cheung and Yuen (2002) focused on long-run cointegration among the price indices of the US, Hong Kong, and Singapore. However, using more recent data, our empirical findings provide no evidence of a cointegrating relationship among the variables.

5.3 Data and Preliminary Analysis

The analysis uses monthly data on consumer price indices (CPIs) for Hong Kong, Singapore, Mainland China, and the US from 2008.M9 to 2025.M9. CPI data for Hong Kong, Singapore, China, and the US were obtained from the website of the Bank for International Settlements[1]. All series were transformed into natural logarithms and seasonally adjusted using the moving-average method. The variables are denoted as $logcpi^{CN}$, $logcpi^{HK}$, $logcpi^{SG}$, and $logcpi^{US}$, and their first differences are denoted as $\Delta logcpi^{CN}$, $\Delta logcpi^{HK}$, $\Delta logcpi^{SG}$, and $\Delta logcpi^{US}$.

Table 5.1. Descriptive statistics.

Variables	**Mean (%)**	**Max. (%)**	**Min. (%)**	**Std. Dev. (%)**	**CV**
$\Delta logcpi^{CN}$	0.151	1.257	-1.285	0.417	2.770
$\Delta logcpi^{HK}$	0.210	2.903	-2.708	0.786	3.746
$\Delta logcpi^{SG}$	0.158	1.700	-1.415	0.450	2.842
$\Delta logcpi^{US}$	0.194	1.294	-1.580	0.310	1.599

Table 5.1 shows that consumer price fluctuations are smaller in Singapore than in Hong Kong. This finding suggests that Singapore has managed inflation more effec-

[1]Available from: https://www.bis.org.

tively.

Figures 5.1 and 5.2 present the time-series behavior of the CPI variables for Hong Kong, Singapore, China, and the United States. Figure 5.1 displays the level series in natural logarithms, while Figure 5.2 shows the corresponding first-differenced series. The level series exhibits clear upward trends over time, suggesting non-stationarity. In contrast to the level series, the differenced series fluctuates around zero without exhibiting a clear upward or downward trend. Although several temporary spikes are observed, particularly for Hong Kong during periods of heightened economic uncertainty, the fluctuations remain bounded and relatively stable over time. These visual characteristics suggest that the first-differenced series are stationary, providing preliminary support for the unit root test results reported in the following section.

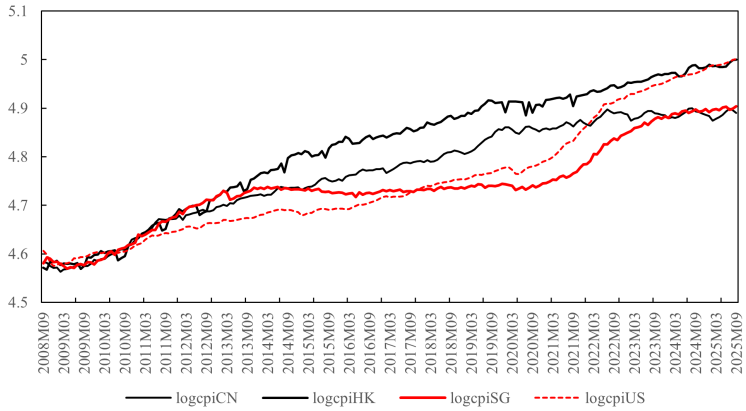


Figure 5.1. Time series plots of level series (natural logarithms).

Subsequently, this study examines merchandise import trade among Hong Kong, Singapore, China, and the US.

Figure 5.3 presents the proportion of Hong Kong's imports of goods from the US and China. The data were obtained from the Census and Statistics Department of the Hong Kong SAR Government[2]. Figure 5.4 shows the proportion of Singapore's imports of goods from the US and China. The data were obtained from the Singapore Department of Statistics[3].

In Hong Kong, China's share of total imports consistently exceeds that of the US.

[2]Available from: https://www.censtatd.gov.hk/en/
[3]Available from: https://www.singstat.gov.sg.

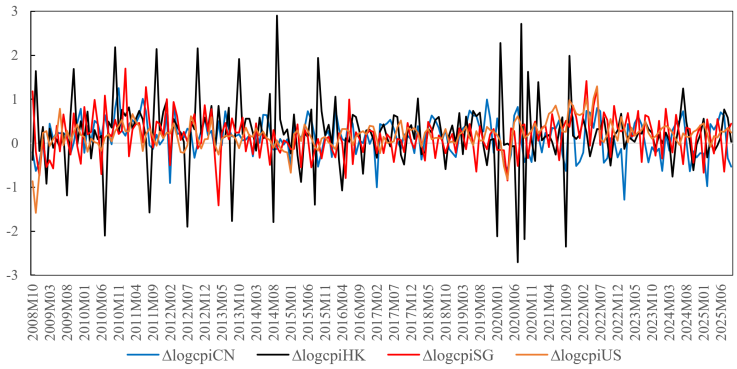


Figure 5.2. Time series plots of first-differenced series.

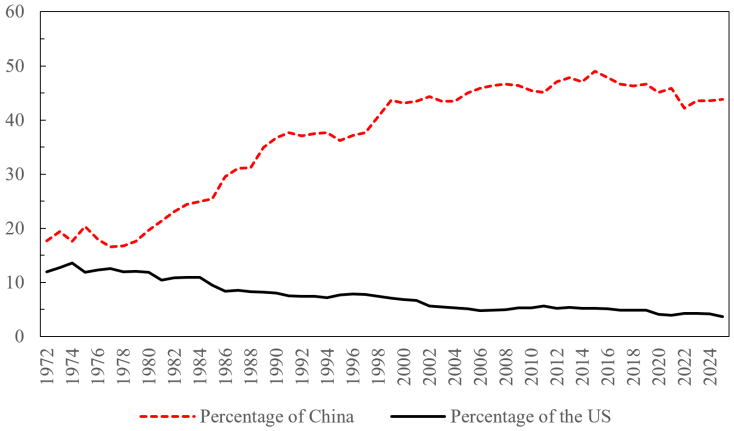


Figure 5.3. Proportion of Hong Kong's imports of goods from the US and China.

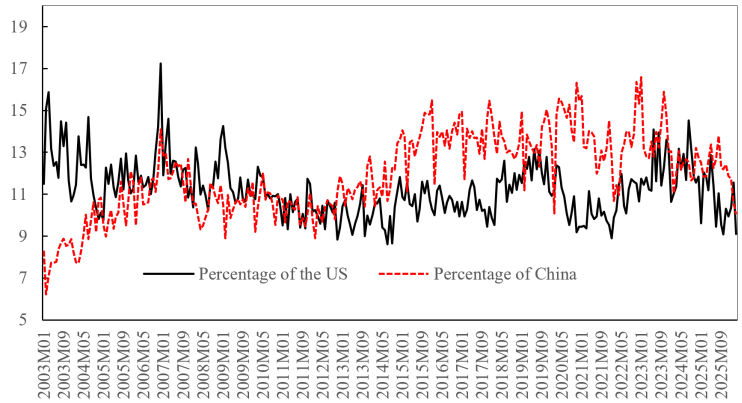


Figure 5.4. Proportion of Singapore's imports of goods from the US and China.

In recent years, the US share of Hong Kong's total imports has fallen below 5%. Consequently, changes in US consumer prices are unlikely to have a large impact on consumer prices in Hong Kong. In Singapore, the US and China have each accounted for approximately 10%–15% of total imports since 2003. Given the proportion of goods imports, the US and China are likely to influence changes in Singapore's consumer prices.

5.4 Empirical Results

This section presents an empirical analysis of the relationship between consumer price change rates in Hong Kong and Singapore and those in the US and China, respectively. The empirical analysis is conducted in five steps. First, unit root tests are employed to examine the stationarity properties of the variables. Second, the presence of a long-run equilibrium relationship is assessed using the Engle–Granger (EG) method and the Johansen cointegration test. Third, an SVAR model is estimated to capture short-run dynamics and identify structural shocks. Fourth, IRFs and FEVD are used to evaluate the dynamic effects of shocks and quantify their relative contributions to system variability across time horizons. Finally, to evaluate systemic interdependence and assess the robustness of the pairwise results, the analysis is extended to a three-country framework (comprising US–China–Hong Kong and US–China–Singapore) using multivariate cointegration approaches.

5.4.1 Unit Root Tests

The stationarity properties of the individual time series are examined using the augmented Dickey–Fuller (ADF) and Phillips–Perron tests. These tests are applied to the levels and the first differences in the variables natural logarithms. The null hypothesis in each case is that the series contains a unit root, indicating nonstationarity. The results of these tests are presented in Tables 5.2 and 5.3.

Table 5.2. The ADF test results.

Variables	Constant		Constant, Linear Trend		None		Decision
$logcpi^{CN}$	-1.825	(1)	-0.987	(1)	3.849	(1)	I(1)
$\Delta logcpi^{CN}$	-11.332^{***}	(0)	-11.496^{***}	(0)	-10.287^{***}	(0)	
$logcpi^{HK}$	-2.951	(1)	-1.661	(1)	2.208	(1)	I(1)
$\Delta logcpi^{HK}$	-19.490^{***}	(0)	-19.603^{***}	(0)	-17.755^{***}	(0)	
$logcpi^{SG}$	-1.727	(11)	-3.188^{***}	(11)	1.585	(11)	I(0)
$\Delta logcpi^{SG}$	-2.283	(10)	-2.277	(10)	-1.604	(10)	
$logcpi^{US}$	0.926	(7)	-0.940	(7)	2.966	(7)	I(1)
$\Delta logcpi^{US}$	-3.623^{***}	(6)	-3.827^{***}	(6)	-2.098	(6)	

Notes. The reported values are adjusted t-statistics. Values in parentheses indicate the lag length in the ADF test. The lag length is selected based on the Schwarz Information Criterion (SIC). (***) denotes rejection of the null hypothesis at the 1% significance level.

Table 5.3. The PP test results.

Variables	Constant		Constant, Linear Trend		None		Decision
$logcpi^{CN}$	-1.761	(2)	-0.703	(1)	4.637	(1)	I(1)
$\Delta logcpi^{CN}$	-11.261^{***}	(4)	-11.293^{***}	(6)	-10.397^{***}	(4)	
$logcpi^{HK}$	-1.694	(4)	-1.494	(4)	5.281	(4)	I(1)
$\Delta logcpi^{HK}$	-20.145^{***}	(4)	-20.458^{***}	(4)	-17.505^{***}	(4)	
$logcpi^{SG}$	-0.246	(7)	-1.118	(7)	4.146	(7)	I(1)
$\Delta logcpi^{SG}$	-16.392^{***}	(8)	-16.372^{***}	(8)	-16.025^{***}	(9)	
$logcpi^{US}$	2.344	(7)	-1.257	(7)	5.277	(8)	I(1)
$\Delta logcpi^{US}$	-8.061^{***}	(0)	-8.154^{***}	(2)	-6.039^{***}	(4)	

Note. The reported values are adjusted t-statistics. Values in parentheses indicate the bandwidth in the PP test. The bandwidth is selected based on Newey and West(1994). (***) denotes rejection of the null hypothesis at the 1% significance level.

The ADF and PP test results reveal that all variables are nonstationary at levels but become stationary after first differencing. This finding indicates that the variables are integrated of order one, denoted as I(1). As indicated in Tables 5.2 and 5.3, all series are I(1) variables at the 1% level.

5.4.2 Cointegration Test

This chapter conducted cointegration tests for the following pairs of economies: Hong Kong–China, Singapore–China, Hong Kong–the US, and Singapore–the US. Two methodologies were employed: the EG and Johansen tests.

(1) The EG two-step procedure was employed to test for cointegration in each bilateral pair. In the first step, the test was applied to two model specifications: one with only a constant and another with both a constant and a linear trend. The long-run equilibrium equation was first estimated using ordinary least squares. The second step involved applying the ADF test to the residuals to assess stationarity. The lag length for the ADF test was selected based on the Schwarz Information Criterion (SIC). Because linear regression requires specifying a dependent variable and an explanatory variable, this study estimated both directions for each pair. Table 5.4 reports the first direction, and Table 5.5 reports the reverse direction.

Table 5.4. Engle–Granger test (1) (ADF test for residuals).

Pair	Lag	t-statistic	Conclusion
$logcpi^{CN}$ – $logcpi^{HK}$	0	$-3.361(**)$	Cointegration at 5%
$logcpi^{CN}$ – $logcpi^{SG}$	12	-2.133	No cointegration
$logcpi^{US}$ – $logcpi^{HK}$	1	-0.597	No cointegration
$logcpi^{US}$ – $logcpi^{SG}$	9	-1.410	No cointegration

Note. Lag length for the ADF test was selected using the Schwarz Bayesian Information Criterion(SIC). Critical values for the 5% significance level were obtained from MacKinnon (1991). (**) denotes rejection of the null hypothesis of no cointegration at the 5% significance level.

Table 5.5. Engle–Granger test (2) (ADF test for residuals).

Pair	Lag	t-statistic	Conclusion
$logcpi^{HK}$ – $logcpi^{CN}$	0	-3.368^{**}	Cointegration at 5%
$logcpi^{SG}$ – $logcpi^{CN}$	12	-2.444	No cointegration
$logcpi^{HK}$ – $logcpi^{US}$	1	-1.621	No cointegration
$logcpi^{SG}$ – $logcpi^{US}$	9	-3.044	No cointegration

Note. Lag length for the ADF test was selected using the Schwarz Bayesian Information Criterion (SIC). Critical values for the 5% significance level were obtained from MacKinnon (1991). (**) denotes rejection of the null hypothesis of no cointegration at the 5% significance level.

Based on the EG test results, the empirical findings for each of the four pairs from

both estimation directions are analyzed as follows. For the $logcpi^{CN} - logcpi^{HK}$ pair, the ADF test statistics are -3.361 (Table 5.4) and -3.368 (Table 5.5). Both values exceed the MacKinnon critical value at the 5% level. Thus, the null hypothesis of no cointegration is rejected in both directions. The results are similar for the remaining three pairs. The test statistics are below the MacKinnon critical values (Tables 5.4 and 5.5). This study failed to reject the null hypothesis of no cointegration at any conventional significance level. The results are consistent across both directions.

(2) For the Johansen test, the optimal lag length for the underlying VAR of the pair is selected using the SIC, with detailed results reported in the Appendix (Tables A-2 - A-5). Given that price-level data (log CPI) typically exhibit persistent growth and distinct deterministic trends over time, the Johansen cointegration test with the restricted trend specification was employed[4]. However, the restricted trend specification assumes a linear trend directly toward the cointegrating vector. The empirical results are presented in Tables 5.6 - 5.9.

Table 5.6. Johansen cointegration test results for the China and Hong Kong CPIs.

Lag interval: 1–2				
Unrestricted cointegration rank test (trace)				
Null hypothesis	**Alternative hypothesis**	**Eigenvalue**	**Trace statistic**	**5% critical value (**)**
None	$r > 0$	0.050172	16.305	25.872
$r \leq 0$	$r > 1$	0.028499	5.885	12.518
Unrestricted cointegration rank test (max-eigenvalue)				
Null hypothesis	**Alternative hypothesis**	**Eigenvalue**	**Max-eigen. statistic**	**5% critical value (**)**
None	$r = 1$	0.050172	10.419	19.387
$r = 1$	$r = 2$	0.028499	5.885	12.518

Note. r is the number of cointegrating vectors. (**) is the critical value of MacKinnon et al. (1999).

[4]Following Johansen (1995).

Table 5.7. Johansen cointegration test results for the China and Singapore CPIs.

Lags interval: 1–4				
Unrestricted cointegration rank test (trace)				
Null hypothesis	**Alternative hypothesis**	**Eigenvalue**	**Trace statistic**	**5% critical value (**)**
None	$r > 0$	0.038181	9.699	25.872
$r \leq 0$	$r > 1$	0.009518	1.913	12.518
Unrestricted cointegration rank test (max-eigenvalue)				
Null hypothesis	**Alternative hypothesis**	**Eigenvalue**	**Max-eigen. statistic**	**5% critical value (**)**
None	$r = 1$	0.038181	7.786	19.387
$r = 1$	$r = 2$	0.009518	1.913	12.518

Note. r is the number of cointegrating vectors. (**) is the critical value of MacKinnon et al. (1999).

Table 5.8. Johansen cointegration test results for the US and Hong Kong CPIs.

Lags interval: 1–2				
Unrestricted cointegration rank test (trace)				
Null hypothesis	**Alternative hypothesis**	**Eigenvalue**	**Trace statistic**	**5% critical value (**)**
None	$r > 0$	0.075134	19.943	25.872
$r \leq 0$	$r > 1$	0.020409	4.165	12.518
Unrestricted cointegration rank test (max-eigenvalue)				
Null hypothesis	**Alternative hypothesis**	**Eigenvalue**	**Max-eigen. statistic**	**5% critical value (**)**
None	$r = 1$	0.075134	15.778	19.387
$r = 1$	$r = 2$	0.020409	4.165	12.518

Note. r is the number of cointegrating vectors. (**) is the critical value of MacKinnon et al. (1999).

Table 5.9. Johansen cointegration test results for the US and Singapore CPIs.

Lags interval: 1–4				
Unrestricted cointegration rank test (trace)				
Null hypothesis	**Alternative hypothesis**	**Eigenvalue**	**Trace statistic**	**5% critical value (**)**
None	$r > 0$	0.067331	21.835	25.872
$r \leq 0$	$r > 1$	0.038699	7.893	12.518
Unrestricted cointegration rank test (max-eigenvalue)				
Null hypothesis	**Alternative hypothesis**	**Eigenvalue**	**Max-eigen. statistic**	**5% critical value (**)**
None	$r = 1$	0.067331	13.941	19.387
$r = 1$	$r = 2$	0.038699	7.893	12.518

Note. r is the number of cointegrating vectors. (**) is the critical value of MacKinnon et al. (1999).

The trace and maximum eigenvalue tests consistently indicate no cointegrating vec-

tors at the 5% significance level for each pair of variables (Tables 5.6 - 5.9.). These results suggest the absence of a stable long-run equilibrium relationship among the variables.

The EG and Johansen tests yield different results: EG indicates cointegration for the CN–HK pair, whereas the Johansen test fails to detect cointegration for any pair. This study selected the Johansen results. Johansen uses a system-based maximum likelihood method; it is more efficient and avoids the arbitrary choice of the dependent variable. Consequently, this study concluded that no cointegrating relationship exists among the variables.

Given the absence of cointegration between the variables, a structural VAR (SVAR) model was estimated using the first differences of the natural logarithms with short-run restrictions.

5.4.3 Structural VAR

An SVAR model was applied to first differences with short-run restrictions. The inflation rates in the US and China were assumed to be more exogenous than those in Hong Kong and Singapore. This approach enabled isolating structural shocks in the US and China and tracing their propagation through the economies of Hong Kong and Singapore using IRFs and FEVD.

5.4.3.1 Impulse Response Function

Figures 5.5–5.8 present the IRFs for each country pair over a 24-month horizon. Figures 5.5 and 5.6 display the China–Hong Kong and China–Singapore pairs, whereas Figures 5.7 and 5.8 present the US–Hong Kong and US–Singapore pairs. Throughout these figures, the structural innovations are standardized and defined as follows: Shock 1 represents China's inflation shock; Shock 2, Hong Kong's inflation shock; Shock 3, the US's inflation shock; and Shock 4, Singapore's inflation shock.

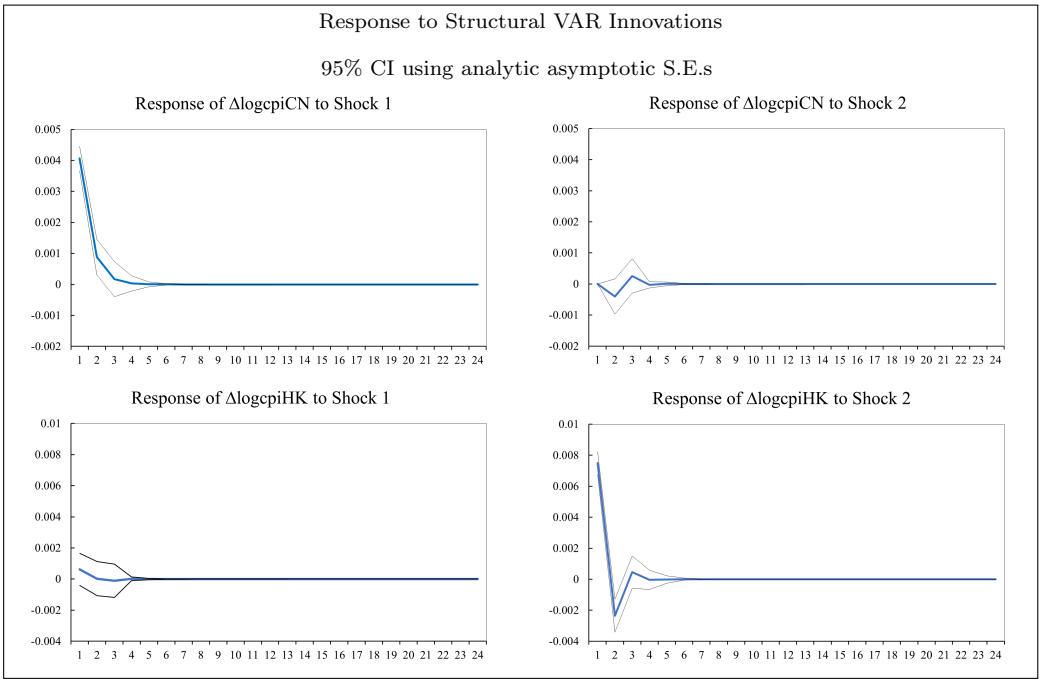


Figure 5.5. Impulse responses of China and Hong Kong inflation to inflation shocks.

The IRF results reveal a significant asymmetry in how price dynamics in Hong Kong and Mainland China respond to external shocks. $\Delta logcpi^{HK}$ exhibits a sharp and immediate response to Shock 2, peaking at approximately 0.008, followed by a brief period of volatility before converging to the steady state by the sixth period. In contrast, the impact of Shock 2 on $\Delta logcpi^{CN}$ is statistically insignificant. This finding is consistent with the small open economy characteristics of Hong Kong, as domestic shocks there have no feedback effects on Mainland China.

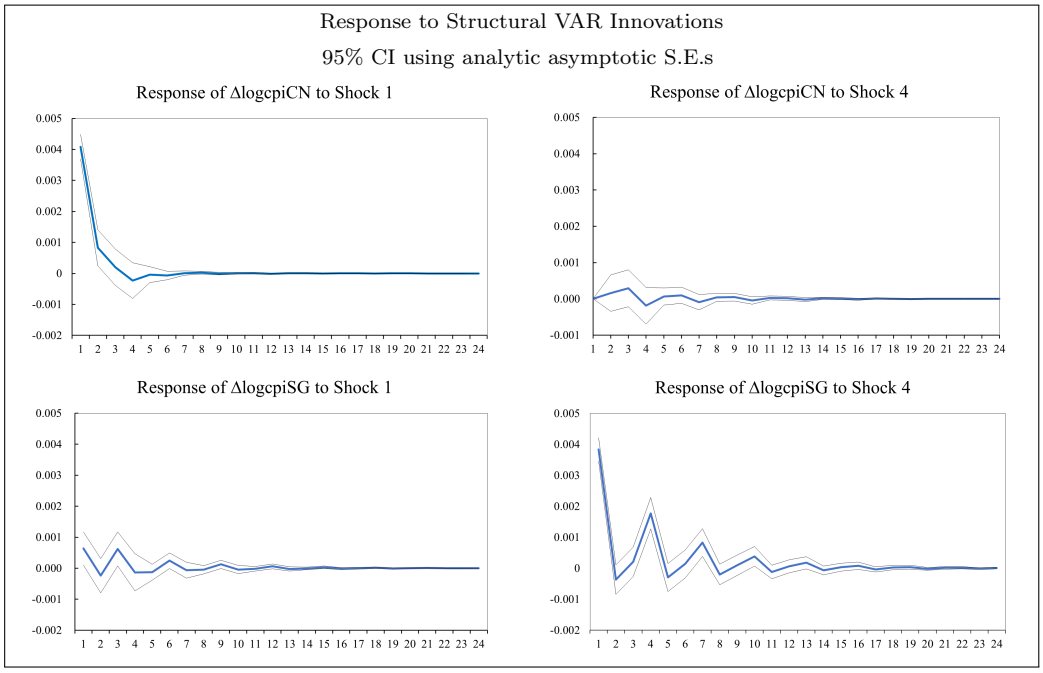


Figure 5.6. Impulse responses of China and Singapore inflation to inflation shocks.

Although China's inflation ($\Delta logcpi^{CN}$) demonstrates a standard monotonic decay following a 0.004 peak from Shock 1, Singapore's inflation ($\Delta logcpi^{SG}$) exhibits a cyclical adjustment in response to Shock 2. In particular, the response in Singapore peaks at 0.0038 and is characterized by a series of dissipating oscillations.

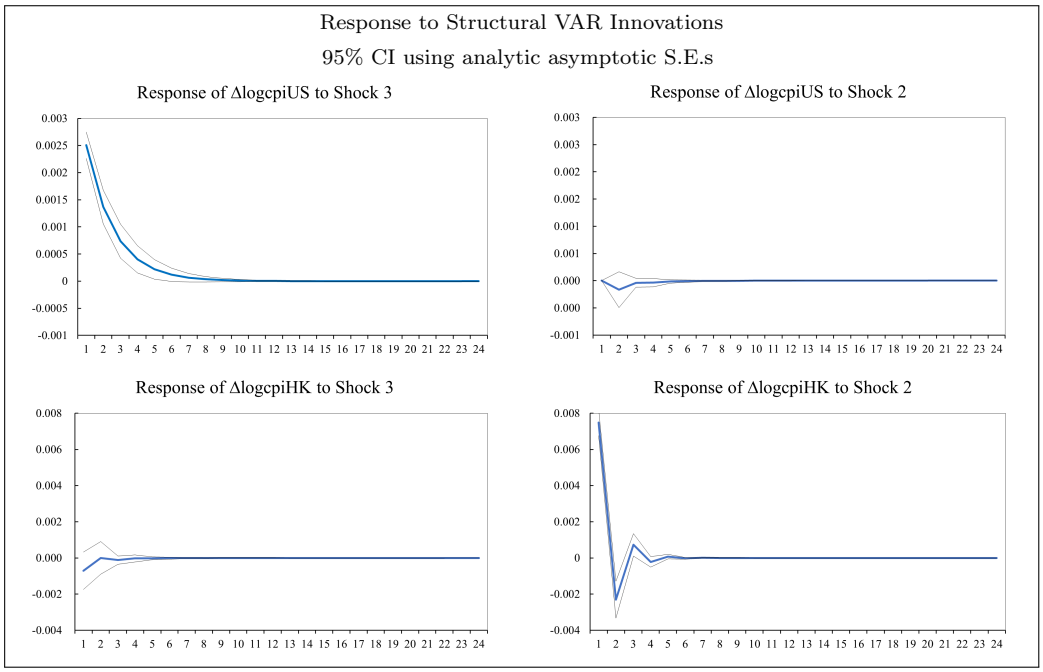


Figure 5.7. Impulse responses of the US and Hong Kong inflation to inflation shocks.

Based on the IRFs, the US inflation rate ($\Delta logcpi^{US}$) remains largely unresponsive to both shocks, displaying a peak of only 0.0025 and a rapid return to equilibrium. In contrast, Hong Kong's inflation rate ($\Delta logcpi^{HK}$), as illustrated in Figure 5.4, exhibits a much stronger response to domestic innovations, peaking at a significant level of 0.008.

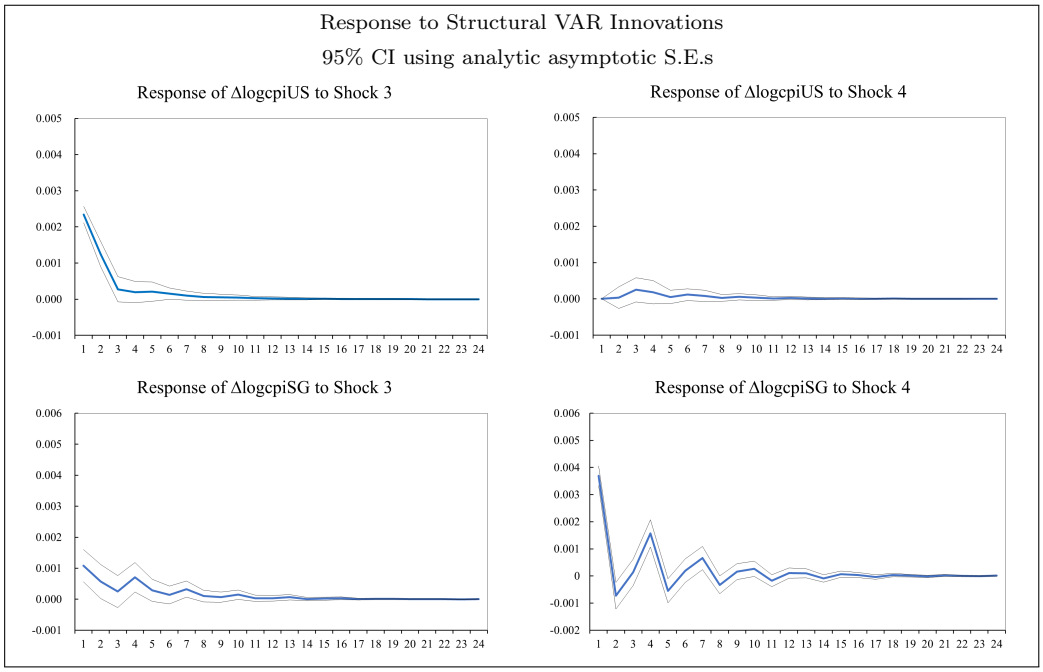


Figure 5.8. Impulse responses of the US and Singapore inflation to inflation shocks.

Although US inflation ($\Delta logcpi^{US}$) responds to its own domestic shock by 0.0024 and follows a smooth, monotonic decay, Singapore's inflation ($\Delta logcpi^{SG}$) exhibits a more fluctuating adjustment mechanism. Singapore's response to domestic innovations peaks sharply at 0.0038 before immediately reversing to -0.0008 in the second period.

Hong Kong's inflation dynamics closely track the US shock, reflecting the high nominal convergence under the LERS (Figure 5.7). Conversely, Singapore's managed floating exchange rate framework acts as a partial insulator, allowing domestic inflation to absorb the US shock through a temporary adjustment before both systems stabilize at their initial equilibrium (Figure 5.8).

5.4.3.2 Forecast Error Variance Decomposition

The FEVD results indicate the relative importance of each structural shock in explaining inflation volatility across the model economies. Detailed results for time periods 1–24 are reported in Tables 5.10–5.13.

Table 5.10. Variance decomposition of $\Delta logcpi^{CN}$ and $\Delta logcpi^{HK}$.

	$\Delta logcpi^{CN}$ fluctuations (%)		$\Delta logcpi^{HK}$ fluctuations (%)	
Horizon	$\Delta logcpi^{CN}$	$\Delta logcpi^{HK}$	$\Delta logcpi^{CN}$	$\Delta logcpi^{HK}$
1	100.00	0.00	0.68	99.32
4	98.69	1.31	0.64	99.36
8	98.69	1.31	0.64	99.36
12	98.69	1.31	0.64	99.36
16	98.69	1.31	0.64	99.36
18	98.69	1.31	0.64	99.36
24	98.69	1.31	0.64	99.36

China's inflation is almost entirely driven by its own shocks. Hong Kong's shocks contribute only approximately 1.31% from period 4 onward, with no increase over time. Conversely, Hong Kong's inflation is overwhelmingly explained by its own shocks ($\approx$ 99.36%). Chinese shocks play a negligible role ($\approx 0.64\%$), suggesting a limited spillover from Mainland China into Hong Kong inflation.

Table 5.11. Variance decomposition of $\Delta logcpi^{CN}$ and $\Delta logcpi^{SG}$.

	$\Delta logcpi^{CN}$ fluctuations (%)		$\Delta logcpi^{SG}$ fluctuations (%)	
Horizon	$\Delta logcpi^{CN}$	$\Delta logcpi^{SG}$	$\Delta logcpi^{CN}$	$\Delta logcpi^{SG}$
1	100.00	0.00	2.70	97.30
4	99.17	0.83	4.60	95.41
8	99.04	0.96	4.80	95.20
12	99.01	0.99	4.85	95.15
16	99.00	1.00	4.85	95.15
18	99.00	1.00	4.85	95.15
24	99.00	1.00	4.85	95.15

Singapore shocks explain only approximately 1% of China's inflation fluctuations. China remains largely insulated from this regional transmission channel.

Table 5.12. Variance decomposition of $\Delta logcpi^{US}$ and $\Delta logcpi^{HK}$.

	$\Delta logcpi^{US}$ fluctuations (%)		$\Delta logcpi^{HK}$ fluctuations (%)	
Horizon	$\Delta logcpi^{US}$	$\Delta logcpi^{HK}$	$\Delta logcpi^{US}$	$\Delta logcpi^{HK}$
1	100.00	0.00	0.90	99.10
4	99.66	0.35	0.84	99.16
8	99.65	0.35	0.84	99.16
12	99.65	0.35	0.84	99.16
16	99.65	0.35	0.84	99.16
18	99.65	0.35	0.84	99.16
24	99.65	0.35	0.84	99.16

Table 5.12 presents the variance decomposition results for $\Delta logcpi^{US}$ and $\Delta logcpi^{HK}$. Empirical evidence confirms that US inflation is nearly unaffected by domestic shocks from Hong Kong, with Hong Kong contributing a negligible 0.35 to US price fluctuations across all horizons. In contrast, Hong Kong's inflation dynamics remain heavily driven by domestic innovations, accounting for approximately 99.16% of its total variance. However, the direct contemporaneous contribution of US price shocks remains below 1%.

Table 5.13. Variance decomposition of $\Delta logcpi^{US}$ and $\Delta logcpi^{SG}$.

	$\Delta logcpi^{US}$ fluctuations (%)		$\Delta logcpi^{SG}$ fluctuations (%)	
Horizon	$\Delta logcpi^{US}$	$\Delta logcpi^{SG}$	$\Delta logcpi^{US}$	$\Delta logcpi^{SG}$
1	100.00	0.00	7.94	92.06
4	98.68	1.32	11.03	88.97
8	98.39	1.61	11.53	88.47
12	98.32	1.68	11.57	88.43
16	98.32	1.68	11.58	88.42
18	98.32	1.68	11.58	88.42
24	98.32	1.68	11.58	88.42

Table 5.13 presents the variance decomposition results for $\Delta logcpi^{US}$ and $\Delta logcpi^{SG}$.

At the long-term 24-period horizon, the forecast error variance of US inflation is overwhelmingly driven by US inflation shocks, accounting for 98.32% of its total fluctuations.

Shocks from Singapore have a negligible effect on US prices, accounting for only 1.68% of their variation. This finding confirms that the US remains a dominant, exogenous block in this bivariate setting. The transmission of inflation from the US to Singapore shows the most significant cross-border price spillover in this comparative study. Inflation shocks originating from the US explain 7.94% of Singapore's inflation fluctuations in the first period; this share then steadily rises and stabilizes at 11.58% by period 24.

5.4.4 Three-Country Cointegration Analysis

The cointegration analysis was extended to a three-country framework to capture simultaneous long-run structural linkages and assess the robustness of the empirical findings across model specifications. In particular, the multivariate Johansen cointegration test was performed under two configurations: Hong Kong–US–China and Singapore–US–China.

5.4.4.1 Multivariate Johansen Cointegration Tests for Three-Country Pairs

To examine the presence of long-run equilibrium relationships among the three economies, this study applied the Johansen cointegration test to each of the four three-country pairs: US–China–Hong Kong and US–China–Singapore. The optimal lag length for each system was selected using the SIC, with detailed lag-selection results reported in the appendix (Tables A-6 and A-7). The unrestricted constant specification was employed, including an intercept in the cointegrating equation but no linear trend in the level data. The empirical results are reported in Tables 5.14–5.15

Table 5.14. Johansen cointegration test results for the US, China, and Hong Kong CPIs.

Lags interval: 1–2

Unrestricted cointegration rank test (trace)

Null hypothesis	**Alternative hypothesis**	**Eigenvalue**	**Trace statistic**	**5% critical value (**)**
None	$r > 0$	0.108	31.169(*)	29.797
$r \leq 0$	$r > 1$	0.039	8.125	15.495
$r \leq 1$	$r > 2$	0.000	0.001	3.841

Unrestricted cointegration rank test (max-eigenvalue)

Null hypothesis	**Alternative hypothesis**	**Eigenvalue**	**Max-eigen. statistic**	**5% critical value (**)**
None	$r = 1$	0.108	23.044(*)	21.132
$r = 1$	$r = 2$	0.039	8.124	14.265
$r = 2$	$r = 3$	0.000	0.001	3.841

Note. r is the number of cointegrating vectors. (*) denotes rejection of the hypothesis at the 0.05 level. (**) is the critical value of MacKinnon et al. (1999).

Table 5.15. Johansen cointegration test results for the US, China, and Singapore CPIs.

Lags interval: 1–2

Unrestricted cointegration rank test (trace)

Null hypothesis	**Alternative hypothesis**	**Eigenvalue**	**Trace statistic**	**5% critical value (**)**
None	$r > 0$	0.080	27.540	29.797
$r \leq 0$	$r > 1$	0.041	10.689	15.495
$r \leq 1$	$r > 2$	0.011	2.156	3.841

Unrestricted cointegration rank test (max-eigenvalue)

Null hypothesis	**Alternative hypothesis**	**Eigenvalue**	**Max-eigen. statistic**	**5% critical value (**)**
None	$r = 1$	0.080	16.851	21.132
$r = 1$	$r = 2$	0.041	8.533	14.265
$r = 2$	$r = 3$	0.011	2.156	3.841

Note. r is the number of cointegrating vectors. (**) is the critical value of MacKinnon et al. (1999).

As shown in Tables 5.14 and 5.15, only the cases that include Hong Kong, the US, and China exhibit one cointegrating vector ($r = 1$). This finding indicates a stable long-term equilibrium in consumer prices across the three countries. Conversely, no evidence of cointegration is observed in any of the cases involving Singapore.

5.4.4.2 VECM Estimates: Long-Run Equilibrium Among CPIs of Hong Kong, the US, and China

Given the presence of one cointegrating vector ($r = 1$) among the CPIs of Hong Kong, the US, and China, a vector error-correction model (VECM) was estimated to examine the long-run equilibrium relationship and the speed of short-run adjustment. Based on the estimates, the cointegrating regression equation was obtained as follows:

$$logcpi_t^{HK} = -1.759 + 0.084\, logcpi_t^{US} + 1.295\, logcpi_t^{CN} \tag{5.1}$$
$$[-0.972] \qquad [-12.673]$$

The numbers reported in parentheses below the estimated coefficients denote t-statistics. The coefficient on China (-1.295) is statistically significant at the 1% level, with a t-statistic of -12.673. In contrast, the coefficient on the US (-0.084) is not statistically significant at the 5% level, as indicated by a t-statistic of -0.972. Despite the insignificance of the US coefficient, the Johansen test confirms a stable long-run equilibrium relationship among the three economies.

Table 5.16 summarizes the estimated coefficients of the VECM, along with their t-statistics.

Table 5.16. Estimates of VECM.

	$\Delta \log cpi_t^{HK}$	$\Delta \log cpi_t^{US}$	$\Delta \log cpi_t^{CN}$
COINTEQ1	−0.029	−0.022	0.039
	[−1.147]	[−2.813]	[2.858]
$\Delta \log cpi_{t-1}^{HK}$	−0.303	−0.016	−0.072
	[−4.177]	[−0.740]	[−1.863]
$\Delta \log cpi_{t-2}^{HK}$	−0.024	0.010	0.018
	[−0.331]	[0.464]	[0.467]
$\Delta \log cpi_{t-1}^{US}$	−0.302	0.484	0.163
	[−1.370]	[7.130]	[1.384]
$\Delta \log cpi_{t-2}^{US}$	0.306	−0.126	0.015
	[1.405]	[−1.886]	[0.126]
$\Delta \log cpi_{t-1}^{CN}$	0.075	0.006	0.209
	[0.558]	[0.151]	[2.922]
$\Delta \log cpi_{t-2}^{CN}$	−0.087	−0.067	0.004
	[−0.644]	[−1.628]	[0.059]
C	0.003	0.001	0.001
	[3.755]	[6.442]	[2.511]
R^2	0.115	0.321	0.102

Note. The values in parentheses represent the t-statistics of each parameter estimate.

The error-correction coefficient is statistically significant and negative only in the US inflation equation (−0.022, t = -2.813), indicating that the US adjusts toward the long-run equilibrium. In Hong Kong, the coefficient is statistically insignificant, suggesting weak adjustment dynamics. Although the coefficient for China is statistically significant, its positive sign (0.039, t = 2.858) implies divergence from the long-run equilibrium rather than convergence.

This chapter employs the IRF framework within a VEC model, identified via Cholesky decomposition, to examine the dynamic responses of inflation across Hong Kong, the US, and China. The variables are ordered as follows: $\log cpi^{US} \rightarrow \log cpi^{CN} \rightarrow \log cpi^{HK}$. Figure 5.9 presents the impulse responses over a 24-month horizon. The

results reveal that Hong Kong's CPI responds positively to inflation shocks from China and the US, with the effect of Chinese shocks stronger and more persistent. In contrast, shocks originating from Hong Kong exert relatively limited influence on the US and Chinese CPIs. These findings highlight Hong Kong's vulnerability to external inflationary pressures and its role as a net recipient of inflation transmission within the three-economy system.

Furthermore, the FEVD framework is employed to quantify the dynamic transmission of shocks within the US–China–Hong Kong CPI. The findings are presented in Tables 5.17, 5.18, and 5.19, covering forecast horizons of 1–24 periods, respectively.

Table 5.17. Variance decomposition of $\log cpi^{US}$

Horizon	$\log cpi^{US}$	$\log cpi^{CN}$	$\log cpi^{HK}$
1	100.000	0.000	0.000
4	98.647	0.023	1.330
8	94.881	0.618	4.501
12	90.003	2.115	7.883
16	85.533	3.736	10.730
18	83.580	4.492	11.929
24	78.822	6.416	14.762

According to Table 5.17, US consumer prices are also largely driven by their own shocks, with self-influence accounting for 100% in period 1 and declining to 78.82% by period 24. US price shocks explain 14.76% of the variance in Hong Kong consumer prices by period 24, indicating a surprisingly significant spillover effect from a small open economy.

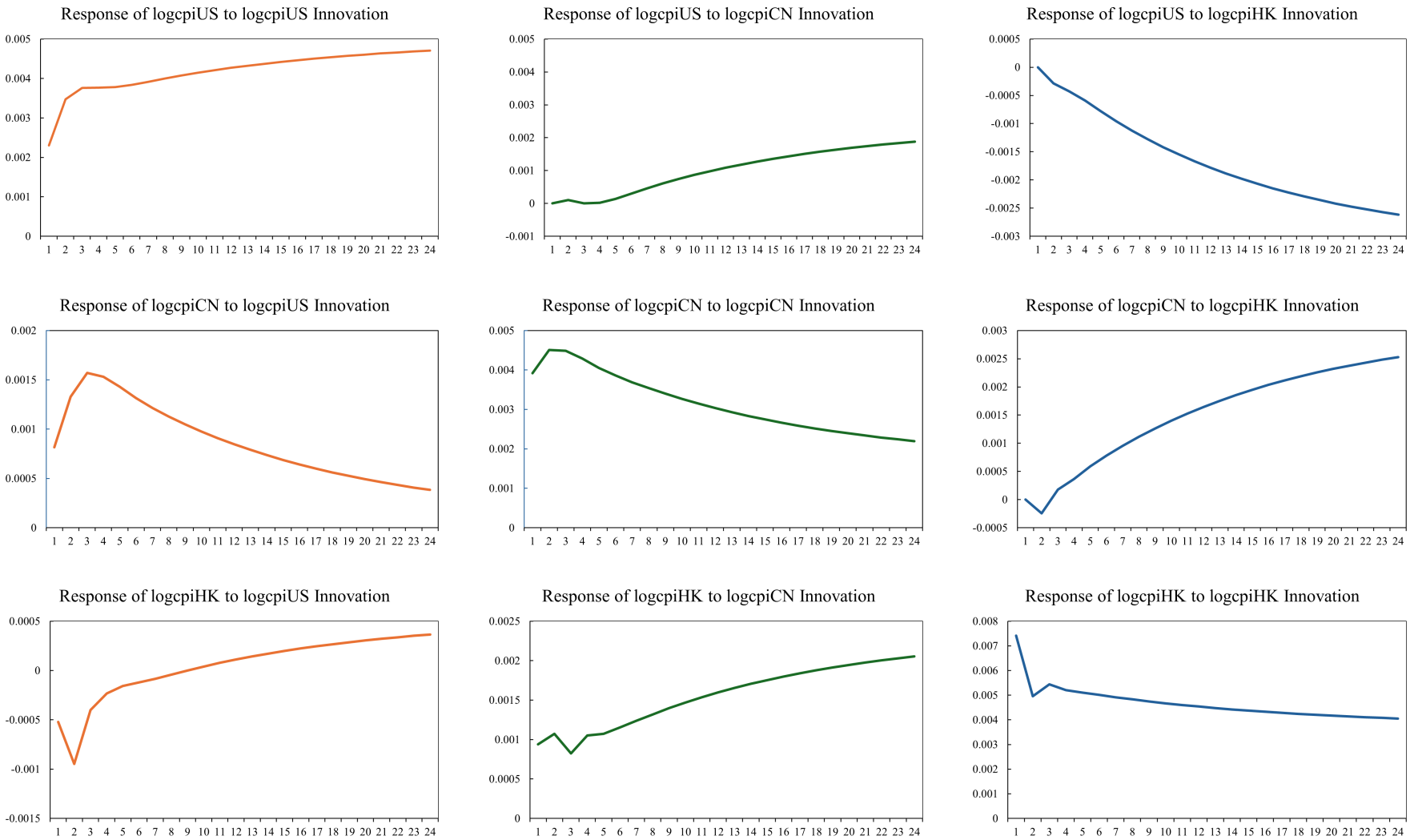


Figure 5.9. Impulse response functions of CPI shocks among the US, China, and Singapore.

Table 5.18. Variance decomposition of $\log cpi^{CN}$

Horizon	$\log cpi^{US}$	$\log cpi^{CN}$	$\log cpi^{HK}$
1	4.151	95.849	0.000
4	8.872	90.855	0.273
8	9.252	88.510	2.239
12	8.585	85.517	5.898
16	7.767	81.680	10.553
18	7.361	79.584	13.055
24	6.253	73.163	20.584

As shown in Table 5.18, China's inflation is predominantly driven by its own shocks, accounting for more than 85% of the variance even at the 12-month horizon. The contribution of US inflation shocks remains modest, peaking at 9.25% at month 8 and gradually declining thereafter. Notably, the explanatory power of Hong Kong's inflation increases steadily over time, reaching 20.58% at the 24-month horizon, surpassing that of the US.

Table 5.19. Variance decomposition of $\log cpi^{HK}$

Horizon	$\log cpi^{US}$	$\log cpi^{CN}$	$\log cpi^{HK}$
1	0.484	1.577	97.938
4	0.978	2.700	96.322
8	0.582	3.891	95.526
12	0.426	5.451	94.124
16	0.369	7.094	92.536
18	0.364	7.904	91.732
24	0.396	10.190	89.415

Hong Kong's consumer prices are primarily driven by domestic shocks, which account for 97.94% of the variance in period 1 and remain significant at 89.42% by period 24 (Table 5.19). In comparison, Chinese price shocks increase steadily over time, from 1.58% at month 1 to 10.19% at month 24, whereas the US contribution

remains marginal, staying below 1% throughout. Accordingly, China is the dominant external source of inflationary pressure on Hong Kong, consistent with its close trade integration and geographic proximity.

5.5 Concluding Remarks

This study estimated an SVAR model with short-run restrictions for the consumer price inflation rates of China–Hong Kong, China–Singapore, the US–Hong Kong, and the US–Singapore. The FEVD results indicate the following:

- Shocks to China's consumer price inflation explain only 0.64% of the variation in Hong Kong's consumer price inflation.
- Shocks to China's consumer price inflation explain 4.85% of the variation in Singapore's consumer price inflation.
- Shocks to the US consumer price inflation explain 0.84% of the variation in Hong Kong's consumer price inflation.
- Shocks to the US consumer price inflation explain 11.58% of the variation in Singapore's consumer price inflation.

Compared with Singapore, Hong Kong's inflation rate is more responsive to US price shocks (Cheung & Yuen, 2002). The findings of this study contradict Cheung and Yuen's conclusion: the Monetary Authority of Singapore has been more successful in stabilizing consumer price fluctuations than Hong Kong, even though Singapore's consumer prices are more susceptible to external shocks. The findings differ from those reported in previous studies, possibly due to differences in empirical methodology and sample period.

The Johansen cointegration test was applied to two pairs to extend the analysis to a three-country framework: the US–China–Hong Kong and the US–China–Singapore. A fundamental asymmetry between Hong Kong and Singapore was observed. Only the case involving Hong Kong exhibited a single cointegrating vector, confirming a stable

long-run equilibrium relationship between US, China, and Hong Kong consumer prices. In contrast, no cointegration was identified for any case involving Singapore.

Given cointegration among the US–China–Hong Kong, this study estimated a VECM for this framework. The error-correction terms for the US and China are statistically significant, indicating that both are converging toward, rather than diverging from, the long-run equilibrium. In Hong Kong, the coefficient is statistically insignificant, indicating weak adjustment dynamics. Inflation in a small country (not a large one) adjusts to deviations from the cointegration relationship between the CPIs (Cheung & Yuen, 2002). Our estimates have shown contradicting results. The IRF and FEVD results reveal that Hong Kong's inflation is primarily driven by domestic factors, accounting for more than 90% of its forecast error variance over the long run. Among external sources, China exerts the strongest and most persistent influence on Hong Kong's CPI, reflecting the close economic integration between Hong Kong and Mainland China. Conversely, the contribution of US inflation shocks remain relatively limited. Consequently, while Hong Kong is exposed to external inflationary pressures, the transmission of inflation from China is considerably more important than that from the US.

Overall, the evidence from the bivariate SVAR models indicates that external inflation spillovers to Hong Kong are relatively limited compared with Singapore. Both Chinese and U.S. inflation shocks explain only a small proportion of Hong Kong's inflation variability. In contrast, Singapore's inflation is more responsive to external price shocks, particularly those originating from the United States. Nevertheless, the three-country cointegrated framework (VECM) reveals that China plays a considerably more important role than the United States in explaining Hong Kong's inflation dynamics. Thus, while Hong Kong's inflation remains predominantly driven by domestic factors, China has become the dominant external source of inflation transmission over the long run.

Chapter 6

Analysis of Fluctuation of Real Output and Price

Abstract

This chapter examines the relationship between real output and the domestic price level in Hong Kong and Singapore from 1975 to 2025. The Johansen cointegration test reveals a long-run equilibrium relationship between real gross domestic product (GDP) and the GDP deflator in Hong Kong. In contrast, no evidence of cointegration is found between these variables for Singapore. This study analyzes the transmission of output and price shocks using a vector error correction model (VECM) for Hong Kong and a structural vector autoregression (SVAR) model for Singapore. Significant differences are observed between the two economies. The VECM results reveal that deviations from this equilibrium are gradually corrected over time, indicating a slow adjustment process. In addition, the variance decomposition results demonstrate that output and price shocks contribute to macroeconomic fluctuations, with price shocks accounting for a relatively larger share of output variability than in Singapore. For Singapore, output fluctuations are overwhelmingly explained by output shocks, which account for more than 96% of the forecast error variance of real GDP under short- and long-run restrictions. The similarity of the results across alternative identification schemes suggests a robust macroeconomic structure. Overall, different findings are obtained: (1) output–price dynamics differ substantially between Hong Kong and Singapore, (2) output and prices are linked in the long run in Hong Kong, and (3) Singapore's fluctuations are primarily driven by output-side disturbances.

6.1 Introduction

This chapter examines the dynamic relationship between real output and domestic price level in Hong Kong and Singapore. Understanding the sources and propagation mechanisms of output and price fluctuations is a central concern in macroeconomics, particularly for small open economies that are highly exposed to external shocks. Building on the evidence presented in the previous chapter that domestic price dynamics are largely driven by internal factors, this chapter examines the relationship between real output and the GDP deflator within each economy.

The relationship between real output and the price level has been extensively studied in the macroeconomic literature. Choy (2011) documented the stylized facts of business cycles in Singapore, a small open economy characterized by high exposure to external shocks. The transmission of price shocks between economies has also received considerable attention. Cheung and Yuen (2002) examined the effects of US price shocks on CPIs in Hong Kong and Singapore using generalized impulse response and forecast error variance decomposition techniques. Their findings reveal that despite Singapore's more flexible exchange rate arrangement, US price shocks exert a stronger impact on Hong Kong CPI than on Singapore CPI. Cheung and Yuen further noted that although inflation in Hong Kong responds to deviations from the long-run relationship with US prices, inflation in the US does not adjust to such deviations, confirming unidirectional inflation transmission from large to small economies.

This chapter addresses the following research questions:

- Do real output and the domestic price level share a long-run equilibrium relationship in each economy?
- How do output and price shocks transmit to each other over time?

This study employs a systematic empirical approach to answer these questions, as outlined in the previous chapter. The remainder of this chapter is organized as follows: Section 2 describes the data and presents preliminary descriptive statistics; Section 3

reports the empirical results; and Section 4 presents the conclusion.

6.2 Literature Review

Campbell and Mankiw (1987) questioned the traditional view that business cycles represent only temporary deviations from a stable growth path. They argued that if this conventional view were correct, an unexpected shock to output would have little effect on long-term forecasts. However, their analysis of postwar US quarterly data yielded a different conclusion: "The data suggest that an unexpected change in real GNP of 1 percent should change one's forecast by over 1 percent over a long horizon." Singapore's business cycles are influenced by domestic and international factors (Choy, 2003). Domestic productivity shocks are the most critical cause of Singapore's business cycles, as they account for the majority of the short-term variability in output at 58

Furthermore, Blanchard and Quah (1989) used a structural VAR framework to distinguish between supply and demand disturbances. They noted that demand shocks have only temporary effects on output, whereas supply shocks generate persistent changes in economic activity. Their findings indicate that supply-side factors largely drive long-run output movements.

Devereux (2003) argued that exchange rate regimes influence the transmission of external shocks and output and price adjustment. Comparing Hong Kong and Singapore, he observed that Hong Kong's fixed exchange rate regime absorbed real appreciation primarily through domestic inflation, whereas Singapore's managed exchange rate regime allowed adjustment through nominal exchange rate appreciation with lower inflation. Devereux also reported that output is more volatile under fixed exchange rate arrangements.

Domestic and external factors contribute to business cycle fluctuations in Singapore, with domestic productivity shocks accounting for approximately 58 percent of short-run output variability (Choy, 2003). Crosby and Otto (2001) further reported that the persistence of output fluctuations is not systematically related to the choice of exchange rate regime. Consequently, real economic shocks play a central role in shaping output

dynamics in small open economies.

Several studies have documented a positive relationship between economic activity and inflation. Choy (2011) observed that consumer prices in Singapore are procyclical and lag output movements, providing support for the Phillips curve relationship. Similarly, Ma et al. (2007) argued that excessive domestic demand directly contributes to inflationary pressures.

For Hong Kong, Gerlach-Kristen (2006) noted that stronger economic activity is associated with higher inflation, consistent with the New Keynesian Phillips Curve framework. The literature suggests that output and prices are closely interconnected, with output expansions generating inflationary pressures. However, rising prices may trigger adjustment mechanisms that help restore macroeconomic equilibrium. Since the nominal exchange rate in Hong Kong cannot adjust in response to external shocks, macroeconomic adjustment must occur internally through changes in domestic prices, wages, employment, asset markets, and output (Ma et al., 2007; HKMA, 2013; Rajan & Siregar, 2002; Tsang, 1998).

6.3 Data and Preliminary Analysis

This study utilizes quarterly data from 1975.Q1 to 2025.Q4. The variables are real GDP and the GDP deflator. For Singapore, both variables are obtained directly from the Department of Statistics Singapore. For Hong Kong, real GDP and nominal GDP are sourced from the Census and Statistics Department. The Hong Kong GDP deflator is calculated as the ratio of nominal GDP to real GDP multiplied by 100. All series are seasonally adjusted at the source. Before conducting empirical analysis, all variables are transformed into natural logarithms to stabilize variance. The variables are denoted as follows: $rgdp^{HK}$, $gdpdef^{HK}$, $rgdp^{SG}$, and $gdpdef^{SG}$. Accordingly, their first differences are denoted as $\Delta rgdp^{HK}$, $\Delta gdpdef^{HK}$, $\Delta rgdp^{SG}$, and $\Delta gdpdef^{SG}$.

Table 1 presents the descriptive statistics for the log-transformed variables for Singapore and Hong Kong. Empirical data reveal that Singapore's real GDP (SD = 0.882) exhibits greater volatility than Hong Kong's (SD = 0.632). Conversely, Hong

Kong's domestic price level (SD = 0.541) exhibits significantly larger fluctuations than Singapore's (SD = 0.275).

6.4 Empirical Results

This section presents an empirical analysis of the relationship between real output and the GDP deflator (domestic price level) in Hong Kong and Singapore. The analysis proceeds in five steps: (1) unit root tests are used to assess the stationarity of the variables in each country; (2) the presence of a long-run equilibrium relationship in each economy is evaluated using the Johansen cointegration test; (3) depending on the cointegration results, a VECM or SVAR model is estimated to capture short-run dynamics; (4) impulse response functions (IRFs) are used to assess the dynamic effects of domestic output and price shocks; and (5) forecast error variance decomposition (FEVD) is employed to quantify the relative contributions of these shocks to each system's variability over different time horizons.

6.4.1 Unit root tests

This study assesses the stationarity of each time series using the augmented Dickey–Fuller (ADF) and Phillips–Perron (PP) tests. These tests are applied to the log levels and the first differences in the variables. The null hypothesis for all tests is that the series contains a unit root, indicating nonstationarity. The complete empirical results are presented in Tables 6.1 and 6.2.

Table 6.1. The ADF test results.

Variables	Constant	Constant, Linear Trend	None	Decision
$rgdp^{HK}$	-5.048^{***} (7)	-1.927 (7)	3.098 (8)	I(1)
$\Delta rgdp^{HK}$	-4.615^{***} (7)	-7.977^{***} (6)	-3.153^{***} (7)	
$gdpdef^{HK}$	-2.740 (4)	-2.441 (4)	0.946 (4)	I(1)
$\Delta gdpdef^{HK}$	-2.352 (3)	-2.823 (3)	-1.985^{**} (3)	
$rgdp^{SG}$	-2.845^{*} (0)	-0.747 (0)	10.262 (0)	I(1)
$\Delta rgdp^{SG}$	-13.036^{***} (0)	-13.486^{***} (0)	-5.435^{***} (1)	
$gdpdef^{SG}$	-1.034 (4)	-2.777 (4)	2.719 (4)	I(1)
$\Delta gdpdef^{SG}$	-5.303^{***} (3)	-5.296^{***} (3)	-4.428^{***} (3)	

Notes. The reported values are adjusted t-statistics. Values in parentheses indicate the lag length in the ADF test. The lag length is selected based on the Schwarz Information Criterion (SIC). (***), (**), and (*) denote rejection of the null hypothesis at the 1%, 5%, and 10% significance levels, respectively.

Table 6.2. The PP test results.

Variables	Constant	Constant, Linear Trend	None	Decision
$rgdp^{HK}$	-5.340^{***} (11)	-2.007 (11)	5.241 (11)	I(1)
$\Delta rgdp^{HK}$	-15.613^{***} (10)	-18.252^{***} (10)	-14.460^{***} (11)	
$gdpdef^{HK}$	-4.192^{***} (10)	-2.027 (10)	2.974 (11)	I(1)
$\Delta gdpdef^{HK}$	-13.016^{***} (11)	-13.933^{***} (11)	-10.887^{***} (11)	
$rgdp^{SG}$	-2.695^{*} (3)	-0.855 (3)	8.851 (4)	I(1)
$\Delta rgdp^{SG}$	-13.032^{***} (1)	-13.501^{***} (4)	-10.536^{***} (8)	
$gdpdef^{SG}$	-1.026 (8)	-2.328 (8)	4.010 (8)	I(1)
$\Delta gdpdef^{SG}$	-13.199^{***} (8)	-13.175^{***} (8)	-12.589^{***} (9)	

Notes. The reported values are adjusted t-statistics. Values in parentheses indicate the bandwidth in the PP test. The bandwidth is selected according to Newey and West (1994). (***) and (*) denote rejection of the null hypothesis at the 1% and 10% significance levels, respectively.

The unit root test results confirm that all four series—real GDP and the GDP deflator in Hong Kong and Singapore—are nonstationary in levels but stationary in first differences (Tables 6.1 and 6.2). Therefore, they are integrated in order one, I(1). This finding is consistent across the ADF and PP tests, except for the PP test for Hong Kong's GDP deflator in levels, which yields a conflicting result. Given the

overall evidence for the PP test, this study treats all series as I(1) and proceeds to test for cointegration. This condition is necessary for a long-run equilibrium relationship, as examined in the next section.

6.4.2 Cointegration Tests

Given that all series are integrated of I(1), cointegration tests are conducted to assess whether a stationary long-run equilibrium relationship exists among the variables. The Johansen cointegration approach is applied to pairs of variables for each country. In addition, the optimal lag structure of the baseline VAR models is determined using the Schwarz information criterion to implement the Johansen tests. The corresponding lag selection diagnostics are detailed in Tables A-8 and A-9. Under the framework of Johansen (1995), the cointegration test was performed under the assumption that the variables contain stochastic trends and an intercept in the cointegrating relationship, but no deterministic linear trend. The empirical results are presented in Tables 6.3 and 6.4.

Table 6.3. Johansen cointegration test results for the real GDP and GDP deflator of Hong Kong.

Lag interval: 1–5

Unrestricted cointegration rank test (trace)

Null hypothesis	**Alternative hypothesis**	**Eigenvalue**	**Trace statistic**	**5% critical value (**)**
None	$r > 0$	0.087964	21.021*	15.495
$r \leq 0$	$r > 1$	0.013991	2.790	3.841

Unrestricted cointegration rank test (max-eigenvalue)

Null hypothesis	**Alternative hypothesis**	**Eigenvalue**	**Max-eigen. statistic**	**5% critical value (**)**
None	$r = 1$	0.087964	18.231*	14.265
$r = 1$	$r = 2$	0.013991	2.790	3.841

Note. r is the number of cointegrating vectors. (*) denotes rejection of the null hypothesis at the 5% significance level. (**) is the critical value of MacKinnon, Haug, and Michelis (1999).

Table 6.4. Johansen cointegration test results for the real GDP and GDP deflator of Singapore.

Lag interval: 1–1

Unrestricted cointegration rank test (trace)

Null hypothesis	**Alternative hypothesis**	**Eigenvalue**	**Trace statistic**	**5% critical value (**)**
None	$r > 0$	0.033931	11.811	15.495
$r \leq 0$	$r > 1$	0.023665	4.834	3.841

Unrestricted cointegration rank test (max-eigenvalue)

Null hypothesis	**Alternative hypothesis**	**Eigenvalue**	**Max-eigen. statistic**	**5% critical value (**)**
None	$r = 1$	0.033931	6.973	14.265
$r = 1$	$r = 2$	0.023665	4.834	3.841

Note. r is the number of cointegrating vectors. (**) is the critical value of MacKinnon, Haug, and Michelis (1999).

The variables for Hong Kong have one cointegrating vector (r = 1), indicating a stable long-run equilibrium between real GDP and GDP deflator (Table 6.3). A VECM is estimated to capture long- and short-run dynamics. Conversely, no evidence of cointegration is observed for Singapore (r = 0), indicating the absence of a binding long-run relationship between real GDP and GDP deflator (Table 6.4). In addition, an SVAR model are estimated using first-difference variables with short- and long-run restrictions.

6.4.3 VECM for Hong Kong

Based on the Johansen cointegration test results in Table 6.3, this study estimates a VECM to examine the short-run dynamics and the speed of adjustment toward the long-run equilibrium. Based on the estimates, the cointegrating regression equation is obtained as follows:

$$rgdp_t^{HK} = 20.314 - 1.827\, gdpdefl_t^{HK} \tag{6.1}$$
$$[2.607]$$

The numbers in square brackets below the estimated coefficients represent their t-statistics. The empirical estimation reveals a long-run relationship between real GDP and the GDP deflator in Hong Kong, as evidenced by a t-statistic that is statistically

significant at the 1% level. A 1 percent increase in the GDP deflator is associated with a 1.827 percent decrease in real GDP in the long run.

Table 6.5 presents the short-run dynamic vector error correction estimates and the corresponding vector error correction terms (ECT).

Table 6.5. Estimates of the VECM for Hong Kong.

Variables	$\Delta rgdp_t^{HK}$	$\Delta gdpdef_t^{HK}$
COINTEQ1	-0.007	-0.001
	[-4.125]	[-0.615]
$\Delta rgdp_{t-1}^{HK}$	-0.027	0.086
	[-0.380]	[2.309]
$\Delta rgdp_{t-2}^{HK}$	-0.282	0.120
	[-4.439]	[3.644]
$\Delta rgdp_{t-3}^{HK}$	-0.140	0.079
	[-2.215]	[2.396]
$\Delta rgdp_{t-4}^{HK}$	0.339	0.008
	[5.333]	[0.248]
$\Delta rgdp_{t-5}^{HK}$	-0.092	-0.029
	[-1.367]	[-0.841]
$\Delta gdpdef_{t-1}^{HK}$	0.183	0.079
	[1.304]	[1.078]
$\Delta gdpdef_{t-2}^{HK}$	0.148	0.159
	[1.207]	[2.507]
$\Delta gdpdef_{t-3}^{HK}$	-0.313	0.039
	[-2.533]	[0.613]
$\Delta gdpdef_{t-4}^{HK}$	-0.045	0.498
	[-0.366]	[7.887]
$\Delta gdpdef_{t-5}^{HK}$	-0.262	-0.089
	[-1.893]	[-1.234]
C	0.016	0.000
	[5.118]	[-0.089]
R^2	0.447	0.540

Note. Values in square brackets [ ] are the t-statistics of the corresponding parameter estimates.

The error correction coefficient is statistically significant and negative only in the real output equation (-0.007, t $= -4.125$), indicating that real output in Hong Kong adjusts toward the long-run equilibrium. Approximately 0.7% of the disequilibrium is corrected within the subsequent quarter. In contrast, the coefficient in the price equation equals -0.001 and is statistically insignificant (t $= -0.615$). Accordingly, the domestic price level exhibits weak adjustment dynamics and does not actively respond to restore the long-run steady state.

In this study, IRFs and FEVDs derived from the VECM framework are employed to examine the dynamic responses of real output and the price level in Hong Kong. Tables 6.6 and 6.7 show the FEVDs for $rgdp^{HK}$ and $gdpdef^{HK}$, respectively, ranging from 1 to 24 horizons. Figure 6.1 shows the IRFs of $rgdp^{HK}$ and $gdpdef^{HK}$ over a 24-quarter horizon.

Table 6.6. Variance decomposition of $rgdp^{HK}$.

Horizon	$rgdp^{HK}$	$gdpdef^{HK}$
1	100.000	0.000
4	98.757	1.243
8	98.190	1.810
12	94.646	5.354
16	90.021	9.979
18	87.670	12.330
24	81.132	18.868

Hong Kong's real output is overwhelmingly driven by its own innovations (Table 6.6), which account for 100% of the variance in period 1 and remain dominant at 81.13% by period 24. In comparison, domestic price shocks account for 18.87% of the variance over the 24-quarter horizon, indicating a gradual but modest increase in their structural impact over the longer term.

Table 6.7. Variance decomposition of $gdpdef^{HK}$.

Horizon	$rgdp^{HK}$	$gdpdef^{HK}$
1	0.694	99.306
4	4.914	95.086
8	6.548	93.452
12	7.426	92.574
16	7.790	92.210
18	7.789	92.211
24	7.848	92.152

Hong Kong's price level is largely insulated from real output fluctuations in the short run (Table 6.7), with its own innovations explaining 99.31% of the variance in period 1. Over the 24-quarter horizon, the domestic price level remains predominantly self-driven at 92.15%, whereas real output shocks exert a moderate transmission effect, contributing 7.85% to the total variance by the final period.

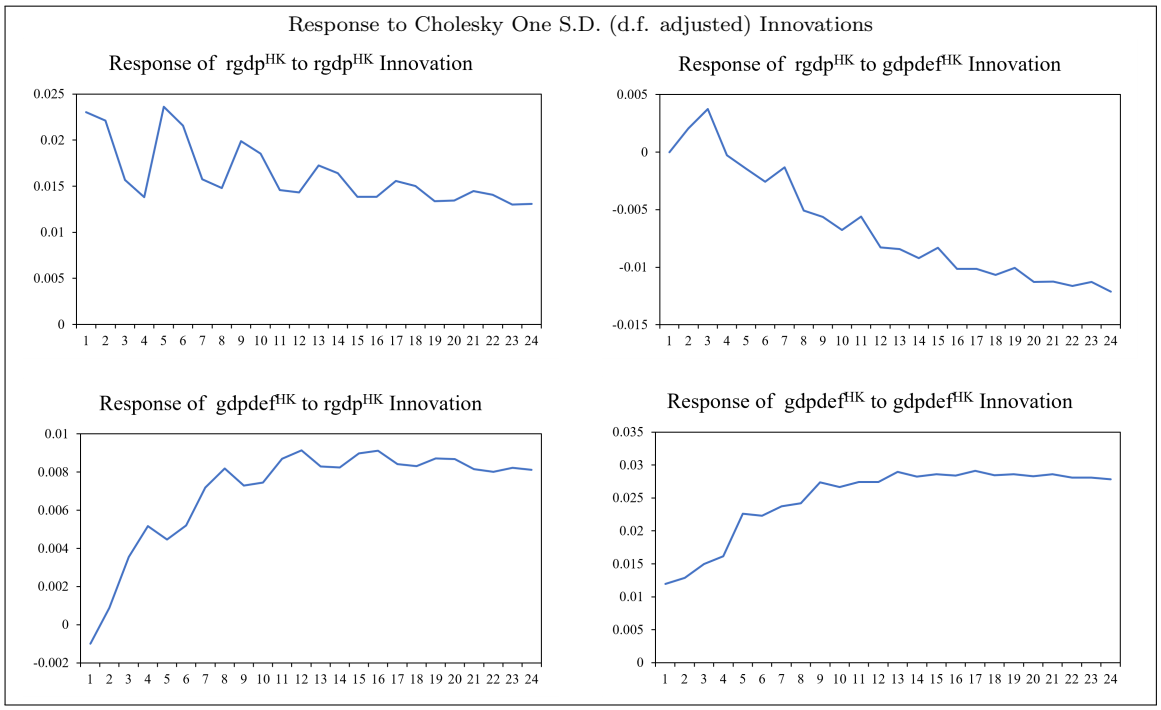


Figure 6.1. Impulse responses of real GDP and GDP deflator for Hong Kong.

Hong Kong's price level responds positively to real output innovations and its own shocks, with real output shocks exerting stronger and highly persistent effects. Con-

versely, shocks originating from the price level exert a negative and relatively limited influence on Hong Kong's real output over the 24-month horizon. These findings highlight the asymmetric dynamic interactions between the two sectors, emphasizing that real economic activity is a major driver of price dynamics, whereas aggregate price shocks do not trigger an expansion in real output.

6.4.4 SVAR for Singapore

Fukumoto (2006) employed the classical approach based on long-run restrictions (Bayoumi, 1992) and the Keynesian approach based on short-run restrictions to ensure the robustness of the structural shocks. According to the Johansen cointegration test results (Table 6.4), this study estimates an SVAR model in first differences, imposing short- and long-run restrictions. The findings suggest that shocks to Singapore's real GDP immediately affect the macroeconomic system, whereas the GDP deflator responds with a time lag. This framework enables isolating independent structural shocks and tracing their dynamic impacts using IRFs and FEVDs.

Tables 6.8 and 6.9 show the FEVDs for $\Delta rgdp^{SG}$ and $\Delta gdpdef^{SG}$ in short and long-run restrictions, respectively. Figures 6.2 and 6.3 present the IRFs of $\Delta rgdp^{SG}$ and $\Delta gdpdef^{SG}$ over a 12-quarter (short-run restrictions) and 24-quarter (long-run restrictions) horizon, respectively. In Figures 6.2 and 6.3, structural innovations are standardized and defined as follows: Shock 1 represents Singapore's real GDP shock, and Shock 2 represents its GDP deflator shock.

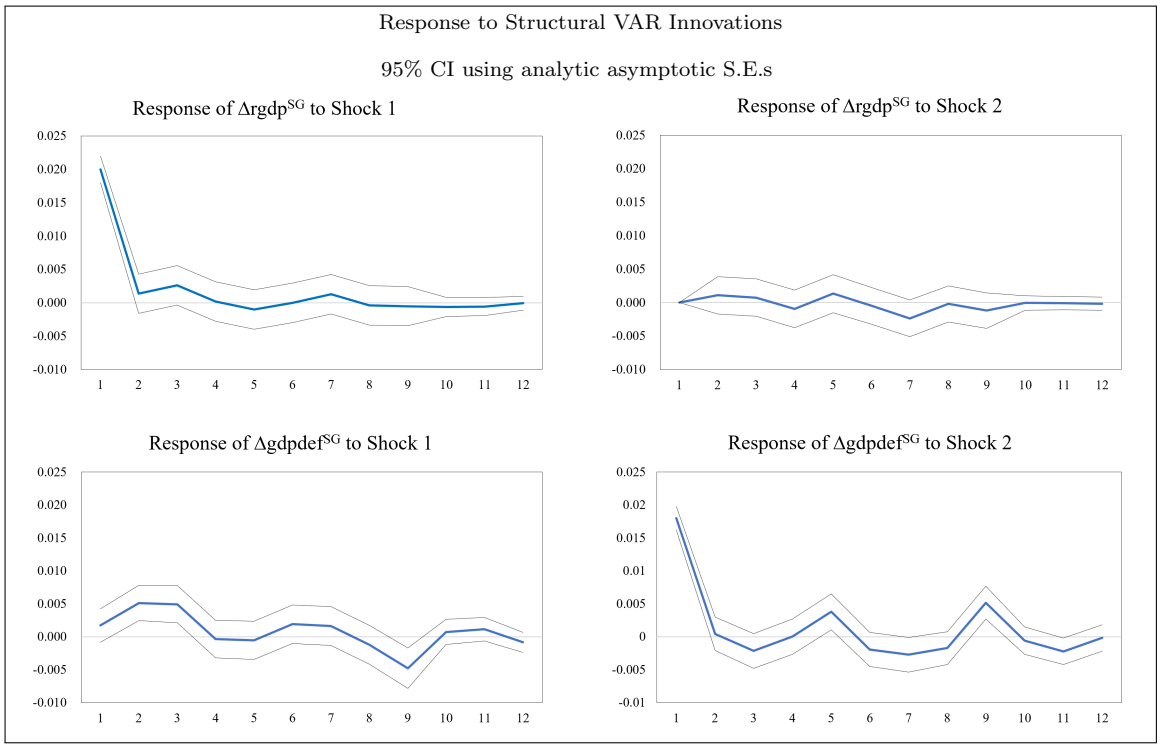


Figure 6.2. Impulse responses of $\Delta rgdp^{SG}$ and $\Delta gdpdef^{SG}$ under short-run restrictions.

Figure 6.2 shows that Singapore's real output responds positively and strongly to Shock 1 in the first period, then declines quickly, and stabilizes around period 5. Additionally, Singapore's price level responds positively to Shock 1, reaching its highest level in period 2 and remaining positive until period 4.

In contrast, Shock 2 has an insignificant impact on real output, which remains close to zero across the 12-period horizon. Consequently, real economic activity drives price changes, whereas price shocks do not lead to an expansion in real output.

Table 6.8. Variance decomposition of $\Delta rgdp^{SG}$ and $\Delta gdpdef^{SG}$.

	$\Delta rgdp^{SG}$ fluctuations (%)		$\Delta gdpdef^{SG}$ fluctuations (%)	
Horizon	$\Delta rgdp^{SG}$	$\Delta gdpdef^{SG}$	$\Delta rgdp^{SG}$	$\Delta gdpdef^{SG}$
1	100.000	0.000	0.897	99.103
4	99.363	0.637	14.000	86.000
8	97.572	2.428	14.699	85.301
12	97.238	2.762	18.263	81.737

According to Table 6.8, Singapore's real output is overwhelmingly driven by domes-

tic shocks, accounting for 100% in period 1 and stabilizing at 97.24% by period 12. Similarly, domestic price fluctuations are mainly driven by domestic shocks at 99.1% in the first period. Conversely, real output shocks have a modest effect, contributing approximately 18.26% to price movements over the longer term.

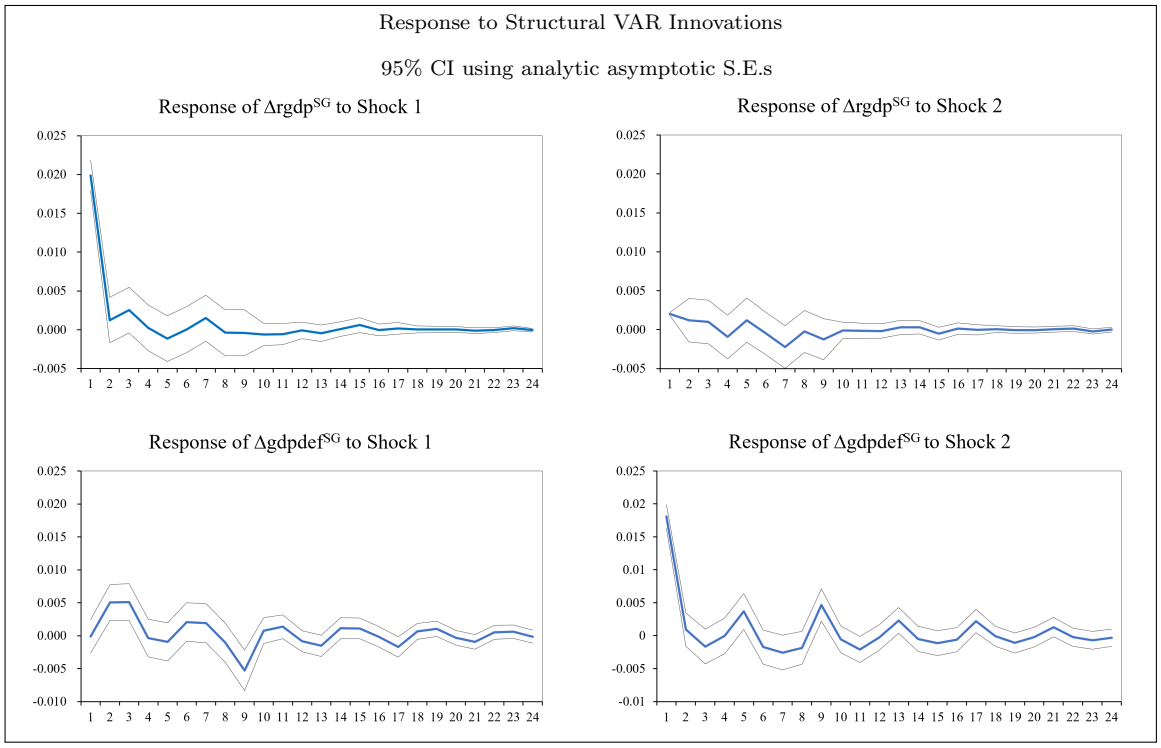


Figure 6.3. Impulse responses of $\Delta rgdp^{SG}$ and $\Delta gdpdef^{SG}$ in long – run restrictions.

Figure 6.3 shows that output shocks have a strong but transitory effect on real GDP growth, whereas inflation shocks have a negligible impact on output. Inflation responds positively to its own shocks and gradually returns to equilibrium.

Table 6.9. Variance decomposition of $\Delta rgdp^{SG}$ and $\Delta gdpdef^{SG}$ under long-run restrictions.

	$\Delta rgdp^{SG}$ fluctuations (%)		$\Delta gdpdef^{SG}$ fluctuations (%)	
Horizon	$\Delta rgdp^{SG}$	$\Delta gdpdef^{SG}$	$\Delta rgdp^{SG}$	$\Delta gdpdef^{SG}$
1	98.994	1.006	0.003	99.997
4	98.213	1.787	13.561	86.439
8	96.664	3.336	14.734	85.266
12	96.303	3.697	19.461	80.539
16	96.202	3.798	19.983	80.017
18	96.201	3.799	20.331	79.669
24	96.184	3.816	20.610	79.390

Consistent with the impulse responses, Table 6.9 shows that output fluctuations are overwhelmingly explained by output shocks, accounting for over 96.2% of the forecast error variance throughout the horizon. However, the contribution of output shocks to inflation fluctuations increases over time, reaching approximately 20.6% after 24 quarters.

The contribution of real output innovations to domestic price fluctuations is bounded under short-run restrictions, explaining 18.26% of the variance by the 12th quarter. However, this transmission does not dissipate when assessed under long-run restrictions. It steadily accumulates, reaching 20.61% by the 24th quarter. This asymmetry underscores the efficacy of Singapore's exchange-rate–centered regime in decoupling real output growth from price-level shocks.

6.5 Conclusion

This chapter provided a comprehensive empirical comparative analysis of the macroeconomic dynamics and shock transmission mechanisms in Hong Kong and Singapore over the 1975–2025 period. This objective was achieved by employing advanced time-series econometric frameworks—particularly, the VECM and the SVAR under short- and long-run restrictions.

The cointegrating relationship between real GDP and the GDP deflator suggests that

output and prices move together in the long run in Hong Kong. However, the ECT of -0.007 for real GDP indicates a very slow adjustment process toward equilibrium. Consequently, deviations from the long-run relationship between output and prices are corrected only gradually, suggesting persistent effects of shocks on the macroeconomic adjustment process.

For Singapore, the identified price innovation has only a limited estimated effect on real output in the bivariate SVAR. It should not be interpreted as evidence that monetary policy is irrelevant for real activity. The price innovation is a model-specific structural shock and does not necessarily correspond to an exogenous monetary-policy shock. Although output shocks gradually contribute to inflation, rising from 18.26% in the short run to 20.61% in the long run, inflation shocks have only a limited impact on output. The similarity of the results obtained under both short- and long-run identification schemes indicates that real output shocks overwhelmingly explain output fluctuations, whereas price shocks exert only a negligible influence on output. This pattern is broadly consistent with the classical view that real factors dominate economic fluctuations and that monetary disturbances have limited effects on real activity.

Compared with Singapore, price shocks could explain a larger proportion of output fluctuations in Hong Kong. Accordingly, price disturbances may play a more significant role in transmitting external shocks to the real economy. As a highly open economy, Hong Kong may be more vulnerable to external price movements, subsequently influencing domestic output fluctuations.

The findings indicate that the interaction between output and prices differs between Hong Kong and Singapore. Although a long-run equilibrium relationship between output and prices is observed in Hong Kong, Singapore's macroeconomic fluctuations appear to be primarily driven by output-side disturbances. Hence, the mechanisms through which output and prices interact vary across the two economies despite both being highly open economies.

The dominance of output shocks and the limited influence of price shocks on real GDP are broadly consistent with the classical proposition that real factors are the

primary determinants of output fluctuations. However, this finding should not be interpreted as evidence that monetary policy is irrelevant. Given that the present model includes only real GDP and the GDP deflator, it cannot directly evaluate the effectiveness of Singapore's monetary policy based on the exchange rate.

Compared to Singapore, a larger portion of fluctuations in Hong Kong's real GDP can be attributed to shocks to the GDP deflator. If fluctuations in Hong Kong's GDP deflator are driven by foreign price shocks, Hong Kong may be more susceptible to foreign price fluctuations than Singapore, which contradicts the findings presented in Chapter 5.

Chapter 7

Final Chapter

This chapter summarizes key findings and unresolved issues for further study. Hong Kong SAR and Singapore are two successful small economies in Asia, yet they use different macroeconomic approaches: Hong Kong has a currency board (Linked Exchange Rate System), while Singapore employs a managed float (Basket-Band-Crawl). These differences influence their adjustment mechanisms, performance, and resilience to shocks. The thesis aims to compare their macroeconomic structures, institutional frameworks, and adjustment mechanisms, providing insights into the trade-offs of various exchange-rate regimes and offering lessons for policymakers in small open economies.

Summary of Findings and Future Research

Chapter 1 compared the macroeconomic structures, performance, and institutional frameworks of Hong Kong SAR and Singapore from 1975 to 2025. It found both economies are highly open and resource constrained. Hong Kong has become increasingly specialized in financial services (approximately 25% of GDP), and Singapore has maintained a diversified economy with manufacturing contributing approximately one-fifth of GDP. Hong Kong's currency board offers a stable nominal anchor but requires internal adjustments like prices and wages. Singapore's managed float lets the exchange rate absorb shocks, lessening domestic pain. Evidence from past crises confirms these differences. The empirical analysis showed that Singapore consistently outperformed Hong Kong in most macroeconomic dimensions during 2008–2025: higher growth (3.95% vs. 1.81%), lower inflation (2.19% vs. 2.54%), lower unemployment (2.19% vs. 3.72%), and lower volatility across all major indicators. Hong Kong's investment exhibited extreme volatility (CV = 11.98), indicating substantially greater fluctuations in investment activity than in Singapore. The evidence suggests a funda-

mental trade-off between credibility and flexibility (Gerlach & Gerlach-Kristen, 2006; Ma et al., 2007). Hong Kong's currency board provides exchange rate credibility, which is essential to its role as an international financial gateway. Although Singapore's managed float offers greater macroeconomic stability, it requires substantial reserve buffers and institutional capacity.

Chapter 2 analyzed the cyclicality of real wages within Hong Kong SAR and Singapore, with a focus on their relationship with real GDP. The analysis examined the sensitivity of this relationship to different detrending methods: the HP-filter and LT. In addition, the persistence of the cyclical components was assessed using autocorrelation analysis. This chapter's findings showed that the cyclical behavior of real wages relative to real GDP depended heavily on the detrending technique. When the HP filter was applied, real wages in Hong Kong showed virtually no cyclical relationship with real GDP, as the coefficients were small and lacked statistical significance. In contrast, when a linear trend was used, the relationship between real GDP and real wages was countercyclical in Singapore and Hong Kong. These contrasting outcomes confirmed the sensitivity of real wage cyclicality to methodological choices, as emphasized by Abraham and Haltiwanger (1995). Our findings broadly align with those of Abraham and Haltiwanger (1995), who reported that real wages do not exhibit a systematic procyclical or countercyclical pattern once measurement and detrending issues are addressed. However, this chapter revealed a notable difference between the two economies: Singapore displayed some evidence of procyclicality, whereas Hong Kong showed no clear cyclical relationship. This contrast may reflect the differing exchange rate regimes and labor market structures of the two economies.

Chapter 3 conducted four types of analysis—sample autocorrelation, the Augmented Dickey-Fuller (ADF) test, the F-test, and the Zivot-Andrews (ZA) test—to examine the stationarity of key macroeconomic variables in Hong Kong and Singapore. The autocorrelation analysis provides preliminary insights into the time-series properties of the variables. The autocorrelations of the natural logarithms remain close to unity and decay slowly across all lags for most series, suggesting the presence of a unit root.

When the first differences are examined, the autocorrelations decline substantially, supporting the view that most series are difference-stationary. However, the detrended series still exhibit high persistence for real GDP, nominal GDP, and prices, while the persistence of real wages is markedly lower, especially in Singapore. The ADF test results indicated that most macroeconomic variables in both economies are DS. However, notable exceptions emerged: the UR in Singapore appeared to be TS. The F-test results provided evidence against the random walk hypothesis. Real GDP and nominal GDP in both Hong Kong and Singapore strongly reject the random walk specification, while employment and real wages generally failed to reject the null hypothesis. For the UR, the evidence differed across economies: the null hypothesis could not be rejected for Hong Kong, whereas it was strongly rejected for Singapore. Overall, nominal variables exhibited stronger departures from a random walk process than labor market variables. The ZA test confirms the ADF findings for most variables, allowing for a one-time structural break. In Hong Kong, nominal GDP showed stationarity around a break. In Singapore, nominal GDP and CPI rejected the unit root when a break was allowed. All other variables remained DS even after accounting for a structural break. Overall, our findings are broadly consistent with those of Nelson and Plosser (1982), who argued that most macroeconomic variables in the US are DS. For Hong Kong and Singapore, the evidence strongly supported the DS representation of macroeconomic time series, except for Singapore's UR, which appeared to be TS.

Chapter 4 provided mixed evidence regarding the long-run price relationship between Hong Kong and Mainland China. The VECM estimation results reveal that adjustment toward long-run equilibrium occurs primarily through the Hong Kong–US exchange rate. In contrast, price levels in Hong Kong and Mainland China exhibit little response to deviations from equilibrium. This outcome reflects Hong Kong's currency board system, where the HKD–USD rate primarily burden of adjustment. The chapter's findings reveal that some price transmission from Mainland China to Hong Kong; however, strict PPP does not hold. These results highlight the role of exchange rate arrangements in shaping the adjustment process and suggest that further research in-

corporating structural breaks, alternative price indices, and robustness checks would be valuable for a more comprehensive assessment of the long-run validity of PPP between Hong Kong and Mainland China.

Chapter 5 estimated an SVAR model with short-run restrictions for the consumer price inflation rates of China–Hong Kong, China–Singapore, the US–Hong Kong, and the US–Singapore. Compared with Singapore, Hong Kong's inflation rate is more responsive to US price shocks (Cheung & Yuen, 2002). The findings of this study contradict Cheung and Yuen's conclusion: the present results suggest that Singapore's inflation is more responsive to external price shocks than Hong Kong's. The findings differ from those reported in previous studies, possibly due to differences in empirical methodology and sample period. The Johansen cointegration test was applied to two pairs to analyze a three-country framework: US–China–Hong Kong and US–China–Singapore. A key difference was noted: only US–China–Hong Kong showed a single cointegrating vector, indicating a stable long-term relationship; no cointegration was found for Singapore. Given cointegration among the US–China–Hong Kong, this section estimated a VECM for this framework. The error-correction terms for the US and China are statistically significant, indicating that both are converging toward, rather than diverging from, the long-run equilibrium. In Hong Kong, the coefficient is statistically insignificant, indicating weak adjustment dynamics. Inflation in a small country (not a large one) adjusts to deviations from the cointegration relationship between the CPIs (Cheung & Yuen, 2002). Our estimates have shown contradictory results. The IRF and FEVD results show that inflation is primarily driven by domestic factors, accounting for more than 90% of its forecast error variance over the long run. China exerts the strongest and most persistent influence on Hong Kong's CPI, reflecting the close economic integration between Hong Kong and Mainland China. Conversely, the contribution of US inflation shocks remain relatively limited. Consequently, while Hong Kong is exposed to external inflationary pressures, the transmission of inflation from China is considerably more important than that from the US. Overall, the evidence from the bivariate SVAR models indicates that external inflation spillovers to

Hong Kong are relatively limited compared with Singapore. Hong Kong's inflation remains predominantly driven by domestic factors, China has become the dominant external source of inflation transmission over the long run.

Chapter 6 analyzed macroeconomic dynamics and shock transmission in Hong Kong and Singapore from 1975–2025, using advanced econometric models like VECM and SVAR, under short- and long-run restrictions. Hong Kong's VECM confirms a long-term link among macroeconomic variables. The ECT of -0.007 for real GDP indicates a very slow adjustment process toward equilibrium. Consequently, deviations from the long-run relationship between output and prices are corrected only gradually, suggesting persistent effects of shocks on the macroeconomic adjustment process. For Singapore, the identified price innovation has only a limited estimated effect on real output in the bivariate SVAR. it should not be interpreted as evidence that monetary policy is irrelevant for real activity. The price innovation is a model-specific structural shock and does not necessarily correspond to an exogenous monetary-policy shock. Output shocks slowly raise inflation from 18.26% in the short run to 20.61% in the long run, inflation shocks have only a limited impact on output. The similarity of the results obtained under both short- and long-run identification schemes indicates that real output shocks overwhelmingly explain output fluctuations, whereas price shocks exert only a negligible influence on output. This pattern is broadly consistent with the classical view that real factors dominate economic fluctuations and that monetary disturbances have limited effects on real activity. Compared with Singapore, price shocks could explain a larger proportion of output fluctuations in Hong Kong. Accordingly, price disturbances may play a more significant role in transmitting external shocks to the real economy. As a highly open economy, Hong Kong may be more vulnerable to external price movements, subsequently influencing domestic output fluctuations. The findings indicate that the interaction between output and prices differs between Hong Kong and Singapore. However, this finding should not be interpreted as evidence that monetary policy is irrelevant. Given that the present model includes only real GDP and the GDP deflator, it cannot directly evaluate the effectiveness of Singapore's mon-

etary policy based on the exchange rate. Compared to Singapore, a larger portion of fluctuations in Hong Kong's real GDP can be attributed to shocks to the GDP deflator. If fluctuations in Hong Kong's GDP deflator are driven by foreign price shocks, Hong Kong may be more susceptible to foreign price fluctuations than Singapore, which contradicts the findings presented in Chapter 5.

Unresolved Issues and Future Research

Despite the comprehensive nature of this study, several unresolved issues remain. Addressing these issues in future research would contribute to a more complete understanding of macroeconomic dynamics in small open economies.

Structural Breaks and Regime Changes

This study identified major economic events—Asian Financial Crisis (1997–1998), Global Financial Crisis (2008), and COVID-19—as potential sources of structural change. While the Zivot-Andrews test in Chapter 3 constrained to one structural break, multiple breaks were not explored. Future research could use the Bai-Perron test for multiple breaks to see if relationships from Chapters 4, 5, and 6 have shifted, especially as the institutional environment and economic integration changed across the sample period.

External Variables in the Output-Price Framework

The analysis in Chapter 6 was based on a bivariate framework. As Genberg (2003) demonstrated, external factors dominate domestic factors in explaining macroeconomic fluctuations in Hong Kong. Future research could extend the analysis by incorporating key external variables such as U.S. output, interest rates, and oil prices in a multivariate VAR framework. This would allow for a more complete understanding of how external shocks are transmitted to domestic output and prices in the two economies.

The Role of Asset Prices and Financial Variables

This study did not examine the role of financial variables such as asset prices, credit growth, or capital flows in shaping macroeconomic outcomes. Given the importance of these variables in small open economies—particularly Hong Kong, where asset price volatility is a defining feature of the business cycle (Leung & Suen, 2001)—future

research could incorporate them to provide a more comprehensive analysis of macroeconomic dynamics. The role of property prices, stock market fluctuations, and credit cycles in amplifying output fluctuations under different exchange rate regimes would be a valuable extension.

The Transmission of China's Inflation to Hong Kong and Singapore

Chapter 5 revealed that China exerts a significant influence on Hong Kong's inflation, but the mechanisms of this transmission remain unclear. Future research could investigate the channels through which Chinese price shocks are transmitted to Hong Kong—whether through trade, financial linkages, or expectations. The role of the Renminbi exchange rate and capital controls in shaping this transmission would also merit exploration.

Exchange Rate Flexibility and External Shock

As discussed in Chapter 1, the policy trilemma framework (Krugman & Obstfeld, 2006, Chapter 22), (Mankiw, 2010) highlights the inherent trade-offs in exchange rate regime choice. However, several questions remain unresolved. First, the extent to which Singapore's managed float has effectively insulated its economy from external shocks—the so-called "insulation effect"—has not been rigorously quantified. Second, the experience of the Eurozone suggests that fixed exchange rates can be viable under certain conditions, particularly when accompanied by deep financial integration and factor mobility. Whether Hong Kong's currency board could similarly benefit from closer economic integration with Mainland China remains an open question. These issues warrant further investigation in future research.

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Appendix

Table A-1. VAR lag order selection criteria for cointegration test

Lag	AIC	SIC
1	-37.0889	-36.8656
2	-42.1548	-41.7528
3	-45.1636	-44.5831
4	-45.6480	-44.8888
5	-45.6574	-44.7195
6	-45.9160	-44.7996
7	-46.5855	-45.2904
8	-46.8417	-45.3680
9	-47.0583	-45.4059
10	-47.4104	-45.5794
11	-47.6686	-45.659*
12	-47.7771	-45.5889
13	-47.7779	-45.4110
14	-47.8279	-45.2823
15	-47.9411	-45.2169
16	-48.0024*	-45.0996

Note. AIC denotes the Akaike Information Criterion; SIC denotes the Schwarz Information Criterion (also known as the Bayesian Information Criterion, BIC). The lag order corresponding to the minimum value of each criterion is marked with an asterisk (*).

Table A-2. VAR lag order selection criteria: China and Hong Kong CPIs (log levels).

Lag	Log likelihood	AIC	SIC
0	675.3191	−6.9774	−6.9435
1	1,457.536	−15.0418	−14.9404
2	1,471.526	−15.1453*	−14.9762*
3	1,472.533	−15.1143	−14.8777
4	1,474.098	−15.0891	−14.7848
5	1,475.728	−15.0645	−14.6926
6	1,479.377	−15.0609	−14.6214
7	1,480.345	−15.0295	−14.5223
8	1,484.350	−15.0295	−14.4548
9	1,487.239	−15.0180	−14.3756
10	1,490.361	−15.0089	−14.2989
11	1,494.735	−15.0128	−14.2352
12	1,504.988	−15.0776	−14.2323

Note: * indicates the lag order selected by the criterion.

Table A-3. VAR lag order selection criteria: China and Singapore CPIs (log levels)

Lag	Log likelihood	AIC	SIC
0	545.698	−5.6287	−5.5948
1	1,563.801	−16.1430	−16.0416
2	1,569.070	−16.1562	−15.9871
3	1,570.916	−16.1338	−15.8972
4	1,600.996	−16.4041	−16.0998*
5	1,602.426	−16.3775	−16.0056
6	1,604.176	−16.3542	−15.9146
7	1,620.163	−16.4784	−15.9712
8	1,622.604	−16.4622	−15.8874
9	1,623.544	−16.4305	−15.7881
10	1,631.995	−16.4766	−15.7666
11	1,638.389	−16.5014	−15.7238
12	1,649.180	−16.5718*	−15.7266

Note: * indicates the lag order selected by the criterion.

Table A-4. VAR lag order selection criteria: US and Hong Kong CPIs (log levels)

Lag	Log likelihood	AIC	SIC
0	435.4713	−4.4919	−4.4581
1	1,539.426	−15.8904	−15.7890
2	1,576.979	−16.2381	−16.0691*
3	1,581.059	−16.2390*	−16.0023
4	1,583.528	−16.2231	−15.9188
5	1,586.364	−16.2110	−15.8391
6	1,590.324	−16.2106	−15.7711
7	1,591.138	−16.1776	−15.6704
8	1,597.493	−16.2020	−15.6272
9	1,598.627	−16.1723	−15.5299
10	1,603.381	−16.1801	−15.4701
11	1,610.652	−16.2140	−15.4364
12	1,611.662	−16.1830	−15.3378

Note: * indicates lag order selected by the criterion.

Table A-5. VAR lag order selection criteria: US and Singapore CPIs (log levels)

Lag	Log likelihood	AIC	SIC
0	585.7268	−6.0490	−6.0152
1	1,671.122	−17.2552	−17.1537
2	1,698.476	−17.4972	−17.3281
3	1,706.377	−17.5376	−17.3009
4	1,727.769	−17.7178	−17.4135*
5	1,730.009	−17.6996	−17.3277
6	1,732.604	−17.6850	−17.2455
7	1,745.533	−17.7775	−17.2704
8	1,748.270	−17.7645	−17.1897
9	1,750.467	−17.7458	−17.1034
10	1,761.700	−17.8207	−17.1107
11	1,769.255	−17.8576*	−17.0799
12	1,772.098	−17.8456	−17.0003

Note: * indicates lag order selected by the criterion.

Table A-6. VAR lag order selection criteria: US, China, and Hong Kong CPIs (log levels)

Lag	Log likelihood	AIC	SIC
0	979.1734	−10.1158	−10.0651
1	2,347.4079	−24.2011	−23.9983
2	2,382.7990	−24.4746*	−24.1196*
3	2,388.8319	−24.4439	−23.9367
4	2,391.7385	−24.3807	−23.7214
5	2,395.6882	−24.3284	−23.5169
6	2,402.4824	−24.3055	−23.3419
7	2,406.2316	−24.2511	−23.1354
8	2,414.6163	−24.2447	−22.9768
9	2,418.2801	−24.1894	−22.7694
10	2,426.8849	−24.1853	−22.6132
11	2,436.7751	−24.1946	−22.4702
12	2,449.9575	−24.2379	−22.3614

Note: * indicates lag order selected by the criterion.

Table A-7. VAR lag order selection criteria: US, China, and Singapore CPIs (log levels)

Lag	Log likelihood	AIC	SIC
0	938.779675	−9.6972	−9.6465
1	2,469.748725	−25.4689	−25.2660
2	2,501.466616	−25.7043	−25.3493*
3	2,515.426155	−25.7557	−25.2486
4	2,536.428241	−25.8801	−25.2208
5	2,541.534965	−25.8397	−25.0283
6	2,546.175716	−25.7946	−24.8310
7	2,562.350057	−25.8689	−24.7532
8	2,568.532964	−25.8397	−24.5718
9	2,,572.028575	−25.7827	−24.3627
10	2,585.813045	−25.8323	−24.2601
11	2,597.626213	−25.8614	−24.1371
12	2,609.912347	−25.8955*	−24.0190

Note: * indicates lag order selected by the criterion.

Table A-8. VAR lag order selection criteria for the real GDP and GDP deflator of Hong Kong (log levels).

Lag	Log Likelihood	AIC	SIC
0	-94.707	1.028798	1.063228
1	932.411	-9.85544	-9.75215
2	934.0132	-9.82993	-9.65778
3	974.4179	-10.2172	-9.9762
4	983.9902	-10.2765	-9.96662
5	1026.509	-10.6863	-10.30753^{*}
6	1028.476	-10.6646	-10.2171
7	1035.478	-10.6966	-10.1801
8	1043.947	-10.7441	-10.1588
9	1050.224	-10.76834^{*}	-10.1142
10	1051.872	-10.7433	-10.0203
11	1052.008	-10.7022	-9.91032
12	1061.121	-10.7566	-9.89585

Note. (*) indicates the lag order selected by the corresponding information criterion.

Table A-9. VAR lag order selection criteria for the real GDP and GDP deflator of Singapore (log levels).

Lag	Log Likelihood	AIC	SIC
0	30.09885	-0.29892	-0.26449
1	932.4183	-9.85551	−9.752223*
2	937.7569	-9.86975	-9.69760
3	947.8736	-9.93483	-9.69381
4	948.3471	-9.89731	-9.58744
5	961.3607	-9.99320	-9.61447
6	962.5122	-9.96290	-9.51530
7	966.3867	-9.96156	-9.44511
8	967.8184	-9.93424	-9.34892
9	978.6392	−10.00680*	-9.35263
10	980.0665	-9.97943	-9.25640
11	980.7966	-9.94465	-9.15275
12	984.3576	-9.93997	-9.07922

Note. (*) indicates the lag order selected by the corresponding information criterion.