CAUSALITY AND BEHAVIORAL FINANCE STUDIES

Raymond Wai-man Yeung

Kai-Yin Woo

Edward Chi-Ho Tang

Jacky Ho-Man Lau

Chun-Kei Tsang

Sung-Ko Li

Tai-Yuen Hon

Wing-Kwong Au

Wing-Keung Wong

Scientific and Business World

Causality and Behavioral Finance Studies

Raymond Wai-man Yeung
Kai-Yin Woo
Edward Chi-Ho Tang
Jacky Ho-Man Lau
Chun-Kei Tsang
Sung-Ko Li
Tai-Yuen Hon
Wing-Kwong Au
Wing-Keung Wong

Author(s)

Raymond Wai-man Yeung
Department of Economics and Finance
Hong Kong Shue Yan University, Hong Kong

Kai-Yin Woo
Department of Economics and Finance
Hong Kong Shue Yan University, Hong Kong

Edward Chi-Ho Tang
Department of Economics and Finance
Hong Kong Shue Yan University, Hong Kong

Jacky Ho-Man Lau
Department of Economics and Finance
Hong Kong Shue Yan University, Hong Kong

Chun-Kei Tsang
Department of Economics and Finance
Hong Kong Shue Yan University, Hong Kong

Sung-Ko Li
Department of Economics and Finance
Hong Kong Shue Yan University, Hong Kong

Tai-Yuen Hon
Business, Economic and Public Policy Research Centre
Hong Kong Shue Yan University, Hong Kong

Wing-Kwong Au
Department of Social Work
Hong Kong Shue Yan University, Hong Kong

Wing-Keung Wong
Department of Finance, Fintech & Blockchain Research Center, and Big Data Research Center, Asia University, Taiwan
Department of Medical Research, China Medical University Hospital, Taiwan
Business, Economic and Public Policy Research Centre,
Hong Kong Shue Yan University, Hong Kong.
The Economic Growth Centre, Nanyang Technological University, Singapore

FIRST EDITION 2025
ISBN (eBook)

Acknowledgments

Raymond Wai-man Yeung

The author would like to thank Dr. Tai-Yuen Hon for inviting me to participate in their research project. I thank Dr. Wing-Kwong Au and Dr. Wing-Keung Wong for permitting me to take part in their research. Without their assistance, I could not have completed this research work and published it in this book. Additionally, I would like to express my gratitude to Dr. S.K. Lee and the Centre for the Department of Economics and Finance at Hong Kong Shue Yan University for supporting this publication project. Finally, I wish to thank Dr. K.Y. Woo and Dr. Edward C. H. Tang for their ongoing support of my research work, which has brought me numerous benefits. I would also like to thank Dr. Wing-lok Hung of the Chinese University of Hong Kong for regularly introducing individuals from diverse backgrounds to assist me in my research and career development.

Kai-Yin Woo

The author would like to acknowledge Department of Economics and Finance of the Hong Kong Shue Yan University, for financial and research support. I am also thankful for Professor MA, Yue, City University of Hong Kong, who gave me invaluable advice and guidance in my PhD thesis.

Edward Chi-Ho Tang

I would like to express my gratitude to Dr. Charles Leung for the continuous guidance and support. Also, I am always grateful to Hong Kong Shue Yan University for giving me a great opportunity to start my academic career. Finally, I sincerely thank my collaborators for making this publication successful.

Chun-Kei Tsang

The author would like to thank Prof. Li Sung-Ko and Dr. Lee Shu-Kam for their continuous guidance and support. This research is partially supported by Business, Economic and Public Policy Research Centre and Department of Economics and Finance of Hong Kong Shue Yan University.

Tai-Yuen Hon

The author would like to thank Dr. Lee Shu-Kam for his continuous encouragement. This book is partially supported by grants from the Department of Economics and Finance of Hong Kong Shue Yan University. The authors are grateful to the book editor for substantive comments that have significantly improved this book.

Wing-Kwong Au

There are so many people to whom thanks are owed that it would be impossible to list them all individually. Grateful thanks are due to Book company which commissioned this project, especially Professor Wong Wing-Keung for his invaluable support and help while the book was being prepared. My thanks go to Tai-Yuen Hon and Kai- Yin Woo for their facilitating work. Without their assistance, this work would never be published in this book. I am grateful to the Shue Yan University Library and University of Hong Kong library – all of which were instrumental in finding many documentary and other sources relating to the social mobility of youth in Hong Kong. My personal gratitude must go to my family, especially Kerrie, my wife for her persistent and unfailing support.

Wing-Keung Wong

The author would like to thank Robert B. Miller and Howard E. Thompson for their continuous guidance and encouragement. This research has been supported by Asia University, China Medical University Hospital, The Hang Seng University of Hong Kong, National University of Singapore, Research Grants Council (RGC) of Hong Kong (project numbers 12502814 and 12500915), and the Ministry of Science and Technology (MOST, Project Numbers 106-2410-H-468-002 and 107-2410-H-468-002-MY3), Taiwan. However, any remaining errors are solely ours.

Contents

PREFACE

This book has compiled with five academic papers. We do not have any copyright issue in our book. This book includes Chapter 1 Causality Relationship between Money, Income, Price, and Exchange Rates in a Small Open Economy; Chapter 2 The Effect of Global Oil Price and Macroeconomic Variables on the stock market returns for ASEAN Countries; Chapter 3 Is it Worthwhile to Study Competitiveness Indices? Evidence from the Causal Relationship between Global Competitiveness Index and Economic Growth Rate; Chapter 4 Structural Time Series Analysis of Data from Interwar European Hyperinflations of Germany, Hungary and Poland; Chapter 5 Review of the Theories of Behavioral Finance and Behavioral Economics, Financial Econometrics, and Applications. The co-authors are eager to get this book published and intend to maintain strong friendships. We are closely cooperating with each other and are more united than ever.

Chapter 1
Causality Relationship between Money, Income, Price, and Exchange Rates in a Small Open Economy

Raymond Wai-man Yeung
Tai-Yuen Hon
Wing-Kwong Au
Wing-Keung Wong

Abstract

We extend Hon's (2015) paper to investigate the direction of causation among income, price, exchange rates and money supply in Hong Kong. We use the Granger causality concept to find the existence of such a relationship. The chapter presents the results of two separate bivariate analyses: one involving money and income, and the other involving money and exchange rates. A notable result to come out of the chapter is that there is no causality relationship between them.

1.Introduction

Causality is a fundamental concept that helps us understand how events and phenomena are interconnected. It involves discovering the relationships between variables and determining how one variable influences the behavior of another. Clive W. J. Granger, a prominent scholar in this field, published the concept of "Granger Causality" in Econometrica in 1969, which has since been widely used in testing temporal causation and analyzing economic time series with common trends (Granger, 1980 and 1988). He defines causality as depending on the variance of the best least squares prediction using all information at some point in the past. The tests have been conducted using the concepts known in the literature as 'Granger-causation'. In 1987, Granger and Engle worked on the concept of cointegration, for which they were jointly awarded the Nobel Memorial Prize in Economic Sciences in 2003. In doing so, we hope to extend Hon's paper and contribute to the study of monetary policy, causality, and hedging. This chapter's tables and appendix are referred to Hon (2015) for Tables 1-4 and Appendix 1.

Researchers still rely heavily on causality to uncover meaningful causal relationships in economic studies. For instance, Gbenga and Daniel (2024) aimed to explain the relationship between money supply and inflation rate in Nigeria's economy. To deepen our understanding of the crucial economic relationship between money supply and inflation rate in the country, the study attempted to elucidate the impact of these fluctuations. The data used for this analysis consisted of annual time series data ranging from 1990 to 2022, sourced from the CBN Statistical Bulletin. The empirical findings revealed that the various components of the money supply collectively contribute to the inflation rate, while the individual indicators of the money supply exhibit distinct consequences. Broad money supply and exchange rate exhibit a negative relationship, albeit with weak significance in determining the inflation rate in Nigeria.

Conversely, the interest rate has a positive effect on the inflation rate. Based on these results, several policy implications can be derived. It is crucial for the government, while formulating monetary policy, to recognize that an increase in the money supply tends to have a positive response from the inflation rate. Additionally, the government must be mindful of the relationship between the interest and inflation rates. Therefore, this study recommends that the Central Bank of Nigeria understands the role of money supply in enhancing inflation rate adjustments and devises monetary policies that would facilitate the proper functioning of the economy, ultimately leading to a stable price level.

Paul, Inore, and Kimat (2023) conducted a study in Papua New Guinea using long-term annual data from 1977 to 2020. Their research revealed a long-term cointegrating relationship between consumer price inflation, the money supply, the Kina-USD exchange rates, and real GDP. Their error-correcting model found that consumer price inflation is Granger-caused by the money supply, the Kina-dollar exchange rates, and real GDP. As per the theory, the money supply has a positive sign, the Kina-USD depreciation has a positive sign, and the real GDP has a negative sign.

The variance decomposition results showed that high-magnitude shocks in the natural logarithm of exchange rates were generated by one-standard-deviation shocks in consumer prices, corroborating the Purchasing Power Parity theory. This theory asserts that increases in consumer prices lead to the depreciation of the currency. In addition, one standard deviation shock in the money supply produced significant shocks in the natural logarithm of the consumer price index and the natural logarithm of exchange rates, which supported the monetarist hypothesis that the money supply is an important policy variable causing inflation and exchange rate depreciation. Finally, the nominal exchange rate depreciation explains inflation in an open economy such as Papua New Guinea.

Moreover, Shi, Stan and Phillips (2020) conducted a study to re-examine the changes in the causal relationship between money and income in the United States from 1959 to 2014. They proposed three methods to discover changing points in causal relationships, all of which could be implemented without detrending the data. These methods include a forward recursive algorithm, a rolling window algorithm, and a recursive evolving algorithm. They utilized subsample tests of Granger causality within a lag-augmented vector autoregressive framework. The study also provided the limit distributions for these subsample Wald tests. They developed bootstrap methods to control family-wise size in implementing the recursive testing algorithms.

The suite of simulation experiments has shown that the recursive evolving window algorithm provides the most reliable results, followed by the rolling window method. On the other hand, the forward-expanding window procedure is found to have the worst performance. During the Volcker period in the 1980s, both the rolling window and recursive evolving approaches indicated the presence of Granger causality running

from money to income. However, the forward algorithm fails to find any evidence of causality over the entire sample period.

2.Framework

Cointegration theory is first used to test whether a long-run equilibrium relation exists between the two variables. After cointegration has been established, causality measures are constructed to quantify various types of feedback between the variables. The theory of cointegration was developed by Granger and others in a series of papers such as Engle and Granger (1987). Cointegration of a pair of variables may be defined as follows. A series, x_t which has a stationary, invertible, non-deterministic ARMA (autoregressive- moving average) representation after differencing **d** times is integrated of order **d**, denoted $x_t \approx I(d)$. Thus a series which is integrated of order zero (**I(0)**) is itself stationary, whilst the simplest example of an **I(1)** series is a random walk. For a pair of variables to be cointegrated, a necessary (but not sufficient) condition is that they be integrated of the same order. If both x_t and y_t are **I(d)** then the linear combination $z_t = x_t - \alpha y_t$ will generally also be **I(d)**. However, if there exists a constant scalar α such that $z_t \approx I(d-b)$, b > 0, x_t and y_t are said to be cointegrated of order **d**, **b** denoted $(x_t, y_t) \approx CI(d, b)$.

The cointegration model aims to explain the economic relationship between the dependent and independent variables through an econometric model based on the equilibrium theory. In simpler terms, as the independent variable changes, the dependent variable will show a related movement. This type of causal relationship represents a long-term and stable equilibrium state. Short-term effects, such as seasonal or random interference factors, should not constitute long-term severe interference, and other factors apart from independent variables should not affect the establishment of a stable equilibrium relationship between the dependent variable and the independent variable. To establish an econometric model representing a long-term equilibrium relationship, it is essential to ensure that the residual portion of the dependent variable that the independent variable cannot explain does not hinder or interfere with establishing a stable equilibrium relationship between the two variables and that the residual sequence is stationary. In summary, the cointegration model is based on the economic concept modelling of "long-term equilibrium" and verifies whether the linear combination of the cointegration model is stationary by stabilizing the model residual sequence.

In this chapter, we are most concerned that x_t and y_t are both **I(1)** and $z_t \approx I(0)$. While x_t and y_t may each have infinite variance, the linear combination z_t is stationary. We mainly use tests based on the work of Fuller (1976) and Dickey and Fuller (1979, 1981) to test for unit roots and cointegrations. First, we test for integration to find the order of integration **d**.

$$\Delta x_t = \alpha_0 + \alpha_1 x_{t-1} + \varepsilon_t$$

If x_t is random walk, it implies $\alpha_1 = 0$ ($\alpha_0 = 0$); or, if x_t is random variable, it implies $\alpha_1 < 0$. We set the hypothesis as follows.

$$H_0: x_t \approx I(1)$$
$$H_1: x_t \approx I(0)$$

We run the regression by OLS:

$$\Delta X_t = \alpha_0 + \alpha_1 X_{t-1} + \sum_{i=1}^{k} \beta_i \Delta X_{t-i} + \varepsilon_t$$

So, we can find **t** – statistic for $\hat{\alpha}_1$ and compare with Augmented Dickey-Fuller (ADF) table. If the value of **t** – statistic for $\hat{\alpha}_1$ is statistically insignificant, we accept the null hypothesis [$x_t \approx I(1)$]. On the other hand, if $\hat{\alpha}_1$ is significant, then, we reject the null hypothesis [x_t is **I(0)** and not **I(1)**].

Suppose we get all the results to accept the null hypothesis for the above equation, then, we can run the regression for the twice differenced variable as follows.

$$\Delta^2 X_t = \alpha_0 + \alpha_1 \Delta X_{t-1} + \sum_{i=1}^{k} \beta_i \, \Delta^2 X_{t-i} + \varepsilon_t$$

Similarly, we may compute the **t** – statistic and compare with ADF table. If the **t** – statistic value for $\hat{\alpha}_1$ is statistically insignificant, we conclude that $\Delta x_t \approx I(1)$ [or $x_t \approx I(2)$]. Alternatively, if the **t** – statistic for $\hat{\alpha}_1$ is significant, we propose that $\Delta x_t \approx I(0)$ [or $x_t \approx I(1)$]. Also, the present paper concentrates on two tests: Sargan – Bhargava (1983) Durbin-Watson (DW) test and the Augmented Dickey Fuller (ADF) test of residuals from the cointegration regression. The cointegrating regression for the present model has the following form:

$$X_t = INT + \alpha Y_t + \varepsilon_t$$

Note that this equation is simply the stochastic version with an intercept term (INT).

Engle and Granger (1987) report tables of critical values generated by Monte Carlo simulation for the DW statistic from the cointegrating regression; these are 0.511, 0.386 and 0.322 for test sizes of one, five and ten per cent, and 100 observations. Augmented Dickey – Fuller (ADF) test is computed by first running the cointegrating regression and find the residuals $e = x - \hat{x}$ the, we run the following regression:

$$\Delta e_t = \emptyset_0 + \emptyset_1 e_{t-1} + \sum_{i=1}^{k} \theta_i \Delta e_{t-i} + U_t$$

The test statistic is computed as the ratio of $\emptyset_1$ to its estimated standard error. The estimated residual series, U_t, is white noise. The **t** ratio is known as the ADF statistic. If it is necessary to add one or more lagged first differences into the auxiliary regression in order to induce an approximately white noise disturbance, then the '**t** – ratio' of the lagged level ('Augmented Dicky – Fuller statistic') has approximate critical values of -3.77, -3.17 and -2.84 for nominal test sizes of one, five and ten per cent and a sample size of 100 observations. Granger (1987), and Engle and Granger (1987) have proved a theorem showing that the existence of an error-correction form (ECF) between two variables is necessary and sufficient for them to be cointegrated. The definition of causality proposed by Granger (1969) essentially states that **X** causes **Y**, if the history of **X** can be utilized to more accurately predict **Y** than only the history of **Y**. This view of causality gives rise to a one-sided distributed lag approach. The test consists of estimating the following two equations:

$$Y_t = a_0 + \sum_{i=1}^{m1} \alpha_i Y_{t-i} + \sum_{i=1}^{n1} \beta_i X_{t-i} + e_{1t}\,; \tag{1}$$

$$X_t = b_0 + \sum_{i=1}^{m2} \gamma_i X_{t-i} + \sum_{i=1}^{n2} \delta_i Y_{t-i} + e_{2t}\,. \tag{2}$$

In running two equations, it is assumed that **X** and **Y** are stationary time series and that e_{1t} and e_{2t} are uncorrelated. Decisions regarding the lag length of the variables and the appropriate filter to achieve stationary must be made when employing this test procedure.

Unidirectional causality from **X** to **Y** is said to exist if the estimated coefficients on the lagged values of **X** in Equation (1) are significantly different from zero as a group, while the set of δ_i is statistically zero. Similarly, unidirectional causality from **Y** to **X** is said to exist if, as a group, δ_i is statistically different from zero but β_i is not. For bidirectional causality to happen, both the sets of β_i and δ_i are statistically non-zero. It is noted that, when X_t and Y_t are cointegrated, either unidirectional or bidirectional causality will be found.

The error correction model (ECM) and the cointegration model are two econometric models used for stationary time series analysis based on the concept of "long-term equilibrium." However, the error correction model differs from the cointegration model in that it focuses on the short-term "disequilibrium process" instead of the long-term equilibrium results and whether the model residuals are stationary. While the error correction model is a logical deduction of the "long-term equilibrium" relationship between two variables, economic operations in the real world are driven by a "non-

equilibrium process." This non-equilibrium process generates economic and financial data, so it's necessary to use the dynamic non-equilibrium process to approximate the long-term equilibrium state of economic theory. Therefore, the autoregressive distributed lag model (ADL) is the most common modelling method.

This study provides a theoretical overview of Wald tests for Granger causality in levels vector autoregressions (VAR's) and Johansen-type error correction models (ECM's). The theory is based on results in Toda and Phillips (1991) and allows for stochastic and deterministic trends as well as arbitrary degrees of cointegration. We recommend some operational procedures for conducting Granger causality tests that are based on the Gaussian maximum likelihood estimation of ECM's. These procedures are applicable in the important practical case of testing the causal effects of one variable on another group of variables and vice versa. This study also investigates the sampling properties of these testing procedures through simulation exercises. Three sequential causality tests in ECM's are compared with conventional causality tests in levels and differences VAR's.

3.Data

All data were taken from Data Stream and Hong Kong Monthly Digest of Statistics. The Tiananmen Square protests of 1989, commonly known as the June Fourth Incident or '89 Democracy Movement in Chinese, were student-led popular demonstrations in Beijing which took place in the spring of 1989 and received broad support from city residents, exposing deep splits within China's political leadership. Due to avoid the influence of June Fourth Incident in 1989, the analysis covers the period from the first quarter 1981 to fourth quarter 1988. Quarterly data were used as this was thought more appropriate. The definition of money supply is:

Money Supply definition 1. (Total)-

Notes and coins with public, plus customers' demand deposits with and licensed banks.

Money supply definition 2. (Total)-

M1 plus customers' savings and time deposits with licensed banks, plus negotiable certificates of deposit issued by licensed banks and held outside the monetary sector.

Money supply definition 3. (Total)-

M2 plus customers' deposit with licensed and registered deposit-taking companies plus negotiable certificates of deposits issued by deposit-taking companies held outside the monetary sector.

HK$M1, HK$M2 and HK$M3 are the Hong Kong dollar components of these definitions.

Gross domestic product (GDP) is an aggregate measure of the value of goods and services produced by residents within the domestic boundary of a country or a territory, net of their import contents before provision for depreciation (or capital consumption). The two consumer price index series were derived from the household expenditure survey conducted in 1984-1985. They are defined in terms of the percentage distribution of households by expenditure as follows.

INDEX	Approximate percent of households covered	Monthly expenditure range in 1984/85
CPI(A)	50	HK$2,000-HK$6,499
CPI(B)	30	HK$6,500-HK$9,999

The effective exchange rate indexes (EERI) measures movements in weighted-average of nominal exchange rates of HK Dollar against the currencies of 15 principal trading partners. Since quarterly data on GDP are not available from the first quarter 1981 to fourth quarter 1988, we have derived them indirectly. We use the total domestic export data to estimate the quarterly GDP. One plausible method is that GDP as annual data (GDP_A) is regressed on total domestic export as annual data (DX_A). We find the intercept term (INT_A) and the slope (S_A), then the whole equation is divided by four to give the estimate of GDP as quarterly data (GDP_Q) as follows.

$$GDP_A = INT_A + S_A DX_A$$

$$\frac{GDP_A}{4} = \frac{INT_A}{4} + S_A \frac{DX_A}{4}$$

$$GDP_Q = INT_Q + S_A DX_Q$$

4.Results

Cointegration techniques for examining long-run equilibrium relationships are used as the basis of our study. Quarterly data were obtained on M1, M2, M3, GDP, CPIA, CPIB and effective exchange rate indexes (EX) for the period first quarter 1981 to fourth quarter 1988 for the Hong Kong. First, we tested for a unit root in the above macroeconomic variables series, the results of which are reported in Table 1 test for a unit root in M1, M2 M3, GDP, CPIA, CPIB and EX series.

Table 1 Test for a unit root in M1, M2 M3, GDP, CPIA, CPIB and EX series

	$\hat{T}_\mu$		$\hat{T}_\mu$
$\Delta(LM\ 1)$	1.5147	$\Delta^2(LM\ 1)$	-4.2591
$\Delta(LM\ 2)$	-2.2058	$\Delta^2(LM\ 2)$	-3.1581
$\Delta(LM\ 3)$	-1.9659	$\Delta^2(LM\ 3)$	-3.3597
$\Delta(LGDP)$	-0.9689	$\Delta^2(LGDP)$	-6.4374
$\Delta(LCPIA)$	-0.6387	$\Delta^2(LCPIA)$	-2.2867
$\Delta(LCPIB)$	-0.6658	$\Delta^2(LCPIB)$	-2.2169
$\Delta(LEX)$	-2.1046	$\Delta^2(LEX)$	-3.5625

Where:
LM1 is the money supply definition 1 (Total) in logarithms;
LM2 is the money supply definition 2 (Total) in logarithms;
LM3 is the money supply definition 3 (Total) in logarithms;
LGDP is the gross domestic product in logarithms;
LCPIA is consumer price index (A) in logarithms;
LCPIB is consumer price index (B) in logarithms;
LEX is the effective exchange rate indexes in logarithms.

Critical values for the $\hat{T}_{\mu}$ statistic are -2.93 and -2.60 for 5% and 10% level of significance respectively (critical values are taken from Fuller, 1976). In all seven cases we are unable to reject the null hypothesis of a unit root in the framework of equation

$$\left[\Delta x_t = \alpha_0 + \alpha_1 x_{t-1} + \sum_{i=1}^{2or\,4} \beta_i \Delta x_{t-i} + \varepsilon_t\right].$$

Moreover when the data series are twice differenced the hypothesis is accepted that **LM1** (the money supply definition 1 (Total) in logarithms), **LM2** (the money supply definition 2 (Total) in logarithms), **LM3** (the money supply definition 3 (Total) in logarithms), **LGDP** (the gross domestic product in logarithms), **LEX** (the effective exchange rate indexes in logarithms) may be integrated of the order **I(1)** with rejection region $\{\theta : \theta < -2.93\}$; **LCPIA** (consumer price index (A) in logarithms) and **LCPIB** (consumer price index (B) in logarithms) may be integrated of order **I(2)** with rejection region $\{\theta : \theta < -2.93\}$. We ran the cointegrating regressions for each of the possible combinations, normalizing alternately on the **LM1**, **LM2**, **LM3**, **LGDP** and **LEX**. These regressions are reported in Table 2 cointegrating regressions (1981-1988).

Table 2 Cointegrating regressions (1981-1988)

(1)	M1-GDP	LM1=-12.1554+2.1204 LGDP	DW=1.2154
		LGDP=6.6037+0.3869 LM1	DW=1.3319
(2)	M1-EX	LM1=27.9125-3.6631 LEX	DW=0.1859
		LEX=6.1524-0.1348 LM1	DW=0.2802
(3)	M2-GDP	LM2=-20.9363+3.1256LGDP	DW=0.9488
		LGDP=7.3037+0.272 LM2	DW=1.0967
(4)	M2-EX	LM2=40.9633-6.0007 LEX	DW=0.2423
		LEX=6.0426-0.1046 LM2	DW=0.3679
(5)	M3-GDP	LM3=-15.8753-2.6727 LGDP	DW=1.1085
		LGDP=6.5321+0.328 LM3	DW=1.2585
(6)	M3-EX	LM3=36.3688-4.9858 LEX	DW=0.2143
		LEX=6.2935-0.1226 LM3	DW=0.3422

Approximate critical value for **DW** statistic at 5% level is 0.386, with rejection region $\{DW | DW > 0.386\}$; the result is largely invariant to choose of normalizing variable. Only for the M1-EX, M2-EX and M3-EX regressions do the Durbin-Watson statistic fall below the 5% critical level for the test of **I(1)** residuals. For all other regressions

(M1-GDP, M2-GDP, M3-GDP) the Durbin-Watson statistic is large enough to reject the null of **I(1)** residuals at 5% test size. This impression is confirmed by examining the Dickey-Fuller test statistics for a unit root in the residuals from the cointegrating regression, which are reported in Table 3 Augmented Dickey-Fuller test statistic for residuals from cointegrating regressions.

Table 3 Augmented Dickey-Fuller test statistic for residuals from cointegrating regressions

Normalised on	LM1	LM2	LM3	LGDP	LEX
(1)M1-GDP	-2.3741			-3.3502	
(2)M1-EX	-1.4423				-2.8429
(3)M2-GDP		-6.5804		-6.9287	
(4)M2-EX		-2.3317			-2.8652
(5)M3-GDP			-4.8429	-6.3616	
(6)M3-EX			-2.1172		-2.9077

Approximate critical value for Augmented Dickey-Fuller (ADF) statistic at the 5% level is -3.17, with rejection region $\{ADF | ADF < -3.17\}$. With the exception of the M1-EX, M2-EX and M3-EX combinations, the null hypothesis of a unit root in the residuals is rejected for all variables combinations (M1-GDP, M2-GDP, M3-GDP) at or below the 5% significance level. We can in some cases reject the null hypothesis of **I(1)** residuals using Augmented Dickey-Fuller statistics or the Durbin-Watson statistic; i.e. we find cointegration between M1-GDP, M2-GDP and M3-GDP. If co-integration exists, then causality tests may be performed with regard to the levels of the variables concerned **(X** causes **Y** or vice versa). If cointegration does not exist, one way may still difference the data and perform causality tests on the differenced (i.e. stationary) series (ΔY causes ΔX; ΔX causes ΔY). We examine M1-GDP, M2-GDP, M3-GDP, M1-EX, M2-EX, M3-EX, GDP-M1, GDP-M2, GDP-M3, EX-M1, EX-M2 and EX-M3 to find an error-correction forms which are reported in Appendix 1 estimated error correction forms. The period of estimation is 1981 quarter 2 – 1988 quarter 4. Figures in parentheses are heteroscedastic-consistent standard errors $[White(1980]$, figures in brackets are critical values. **DW** is Durbin-Watson statistic. **LM** is a Lagrange multiplier test statistic for up to fourth order serial correlation [Breusch and Pagan (1980)]; **Q** is the Ljung-Box statistic; **ARCH** is a test statistic for autoregressive conditional heteroscedasticity [Engle (1982)]; **WH** is White's (1980) test statistic for general heteroscedasticity and functional misspecification; **N** is a test statistic for normally of the residuals based on the coefficient of skewness and excess kurtosis; **CHOW** is Chow's (1960) test statistics for post sample predictive failure, obtained by estimating up to 1987 quarter 4 and forecasting twelve months out of sample. **Q**, **ARCH** and **N** are central chi-square under the appropriate null, all other statistic (except R^2 and **DW**) are central **F**. The estimated error-correction forms for (1) to (12) are quite impressive. Error correction forms re-estimated up to 1987 quarter 4, forecast well for twelve months out of sample. For models (7) to (12), the **Q** statistic are too large to accept the hypothesis of no autocorrelation and we can reject the models, since the probability that the residuals are not white notice is at least 95 percent; thus we need

not accept the hypothesis that the residuals are nonwhite, and for (1) to (6) models, would be acceptable. To determine the "best" specification, we might want to specify and estimate some models to see whether a low chi-square statistic can be obtained. For models (1) to (12), since the value of the **CHOW** statistic are smaller than the critical value of the **F** distribution at the 5 percent level, we accept the null hypothesis. It is plausible to assume equal coefficients (no structure change). Except model (4), for models (1) to (12), since the value of the White's **F** statistic is smaller than the critical value of the **F** distribution at the 5 percent level, there is no evidence of heteroscedasticity; but , if we consider the **LM** version of the statistic for normality test, for model (1) to (4), the value of the $\chi^2 N(2)$ statistic are greater than the critical value of the χ^2 distribution at 95 percent level, there is evidence of heteroscedasticity for them. For models (1) to (12), an **ARCH** test, since the value of the chi-square statistic are smaller than critical value of the χ^2 distribution at 95 percent level, there is no evidence of heteroscedasticity; but, if we consider the Lagrange Multiplier (**LM**) test statistic for up to fourth order serial correlation, in models (1), (7), (8) and (9), since the value of the **F** version statistic are greater than the value of the **F** distribution at the 5 percent level, there is evidence of autocorrelation. The **R**-squares are quite small for each model. It means that they are not quite representative. However, these results concur with our cointegration analysis for models (1) to (6). Long-run relationships go through for M1-GDP, M2-GDP, M3-GDP, M1-EX, M2-EX and M3-EX. We report next the results of 'Granger' causality testing between the above variables. There is strong evidence of no causality relationship between them.

Table 4 Granger's technique

Hypothesis	**F-stat.**	**d.f.**
GDP $\rightarrow$ M1	1.366	4, 19
M1 $\rightarrow$ GDP	0.833	4, 19
GDP $\rightarrow$ M2	0.5677	4, 19
M2 $\rightarrow$ GDP	1.482	4, 19
GDP $\rightarrow$ M3	0.446	4, 19
M3 $\rightarrow$ GDP	1.135	4, 19
$\Delta EX \rightarrow \Delta M1$	0.464	4, 18
$\Delta M1 \rightarrow \Delta EX$	0.357	4, 18
$\Delta EX \rightarrow \Delta M2$	1.186	4, 18
$\Delta M2 \rightarrow \Delta EX$	2.35	4, 18
$\Delta EX \rightarrow \Delta M3$	1.059	4, 18
$\Delta M3 \rightarrow \Delta EX$	1.347	4, 18

As seen in Table 4 Granger's technique. Critical values for the **F(4, 19)** and **F(4, 18)** are 2.9 and 2.93 for 5 percent level of significance respectively. This suggests neither variable in each of these pairs causes the other in Granger sense. Taken with the cointegration results this may suggest other factors 'cause' both variables.

5.Conclusions

In our analysis there is no evidence of a causality relationship between money supply, income, prices, and exchange rates in Hong Kong. All data covered the period from first quarter 1981 to third quarter 1983 in the floating exchange rate system and the period from fourth quarter 1983 to fourth quarter 1988 in the linked exchange rate system. The Sino-British Joint Declaration, formally known as the Joint Declaration of the Government of the United Kingdom of Great Britain and Northern Ireland and the Government of the People's Republic of China on the Question of Hong Kong, was signed by Prime Ministers Zhao Ziyang of the People's Republic of China and Margaret Thatcher of the United Kingdom on behalf of their respective governments on 19 December 1984 in Beijing. The period covers a structural break in the fourth quarter of 1983. When the linked exchange rate system was adopted. This may be a source of criticism on our finding. However, if we just consider under the linked exchange rate system, we can only obtain twenty-one observations, the validity of our tests may be jeopardized. Hence, we must extend our data coverage. GDP is annually published before 1989. Since we should take GDP as quarterly data, we use the total domestic export data to estimate the quarterly GDP. However, in Hong Kong, GDP is sometimes propelled by exports, sometimes by domestic demand. Typically, in an upswing, growth is first propelled by exports, and then by domestic demand. It is not a perfect cyclical consideration. This can be considered as a serious data limitation and may invalidate our results. The Granger approach relies on heuristic justification, i.e. 'post hoc ergo propter hoc'. Thus, they give the wrong result if an event occurs before the event which causes it. This is equivalent to the 'Christmas card' and 'Travel agent' example – people go to travel agents and book their holidays; subsequently they take their holidays. This does not mean that the act of booking causes the holiday. For instance, if it is announced that wage increases over the next pay round will be very high so that the market expects large future price increases, the exchange rate may depreciate immediately. These tests would suggest that exchange rate changes caused the subsequent price changes. Instantaneous causality (i.e. where one variable has an effect on other variable within the same period) may not be discovered by the tests. Moreover, when this test is extended to form 'triangular' causality, they may give misleading results. It **A** causes **B** and **B** causes **C** within the same period; it is possible that the effect on **A** on **C** may appear within the next period. Thus, it will appear that the only causality between the variables is from **A** to **C**. The test cannot distinguish the actions of the authorities from those of other market participants: for instance, if it is found that exchange rate movements, unexplained by past price movements, lead to price movements, the implication for policy will be different, depending on whether the exchange rate movements are caused by the authorities or by private speculators. 'Causality' may be

a misleading term in these tests since both variables may in fact respond to another variable. In Hong Kong the money supply cannot be treated as an exogenous variable with respect to change in aggregate economic activity. The linked exchange rate system provides sufficient current capital to the economy. It will not be excessive or inadequate because money is determined by the balance of payments. But, firstly, because of the depreciation of US dollars, the depreciation of HK dollars leads to 'imported inflation' which will raise the price of raw materials and production costs and will finally lower the competitiveness of Hong Kong export goods. However, 'imported inflation' was, in fact, lower than expected in the period of 1985 to 1987. It is because Japan has cut down its export prices to maintain the market share in Hong Kong. There are so many speculators who want to profit from the revaluation of the official rate. So, there was so much 'hot money' which flows into Hong Kong's money market to press the government to revalue. For this reason, the government considered the introduction of a negative interest rate policy for capital inflows. And also if HK dollars were pressed to revalue, the public holding assets valued in terms of US dollars will suffer great loss immediately and cause the public to lose confidence in the government which may trigger some kind of political impact. Furthermore, speculators would disturb the monetary system again and again to gain profits from the time after time revaluation. Interest rates do not reflect the actual need of Hong Kong economy but only the tool of maintaining the official rate. It fluctuated rapidly and frequently. And, Hong Kong economy will directly be affected by US economy, Hong Kong will suffer economic recession whenever the US economy is contracted. The linked exchange rate system is still practical and feasible, because it can stabilize the confidence of public and the automatic adjusting mechanism of this system is satisfactory to a certain extent, because it can control the money sully according to the balance of payment.

It is hoped that the present work can stimulate and arouse future research to use causality test. In this paper, we suggest using an advanced technique to confirm the assumption of the endogeneity of money supply in Hong Kong. It is highly recommended to use a vector autoregressive (VAR) test (Toda and Phillips, 1994). This study provides a theoretical overview of Wald tests for Granger causality in levels vector autoregressions (VAR's) and Johansen-type error correction models (ECM's). The theory is based on results in Toda and Phillips (1991) and allows for stochastic and deterministic trends as well as arbitrary degrees of cointegration. We recommend some operational procedures for conducting Granger causality tests that are based on the Gaussian maximum likelihood estimation of ECM's. These procedures are applicable in the important practical case of testing the causal effects of one variable on another group of variables and vice versa. This study also investigates the sampling properties of these testing procedures through simulation exercises. Three sequential causality tests in ECM's are compared with conventional causality tests in levels and differences VAR's.

This view can be put to rigorous empirical test. One relevant test would be that of causality between the money supply and factors which might have caused it or have

been caused by it. Bivariate causality tests based on Granger's (1969) conception have been very popular with econometricians and various versions have been developed. However, they suffer from the fact that only two variables could be considered despite Granger's original multivariate formulation. The vector autoregression (VAR) technique popularized by Sim (1980, 1982) and Toda and Phillips (1991, 1994) overcomes this drawback. Therefore, we recommend adopting VAR test in determining the direction of causality between the money supply and other relevant variables in Hong Kong.

References

Breusch, T. S. and Pagan, A. R. (1980). The Lagrange Multiplier Test and its Applications to Model Specification in Econometrics. The Review of Economic Studies, 47(1), Econometrics Issue, 239-253.

Dickey, D. A. and Fuller, W. A. (1981). Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root. Econometrica, 49(4), 1057-1072.

Engle, R. F. (1982). Autoregressive Conditional Heteroscedasticity with Estimates of the Variance of United Kingdom Inflation. Econometrica, 50(4) 987-1007.

Engle, R. F. and Granger, C. W. J. (1987). Co-Integration and Error Correction: Representation, Estimation, and Testing. Econometrica, 55(2), 251-276.

Gbenga, O. and Daniel J. (2024). Impact of Money Supply on Inflation Rate in Nigeria. International Journal of Business Diplomacy and Economy. Volume 03, Number 01, 204-215.

Granger, C.W.J. (1969). Investigating Causal Relations by Econometric Models and Cross-spectral Methods. Econometrica, 37(3), 424-438.

Granger, C.W.J. (1980). Testing for Causality: A Personal Viewpoint. Journal of Economic Dynamics and Control, 2, 329-352.

Hon, T.Y. (2015). Causality Relationship between Money, Income, Price and Exchange Rates in a Small Open Economy: The Case of Hong Kong. Journal of Economics Library, Vol.2, Issue 4, December, 350-363.

Paul, T. M., Inore, I. and Kimat, J. (2023). A Study of Inflation, Exchange Rates, Money Supply, and Real GDP, Employing the Cointegration, and Error Correction Models for Annual Data between 1977 to 2020 for Papua New Guinea- a Pacific Island Country. Review of Economics and Finance, 21, 1069-1081.

Sargan, J. D. and Bhargava, A. (1981). Testing Residuals from Least Squares Regression for Being Generated by the Gaussian Random Walk. Econometrica, 51(1), 153-174.

Sims, C. A. (1972). Money, Income and Causality. The American Economic Review, 62(4), 540-552.

Sims, C. A. (1980). Macroeconomics and Reality. Econometrica, 48(1), 1-48.

Sims, C. A., Goldfeld, S. M. and Sachs, J. D. (1982). Policy Analysis with Econometric Models. Brookings Papers on Economic Activity, 1982(1), 107-164.

Shi, S., Hurn, S. and Phillips, Peter C. B. (2020). Causal Change Detection in Possibly Integrated Systems: Revisiting the Money–Income Relationship. Journal of Financial Econometrics, Volume 18, Issue 1, 1–23.

Toda, Hiro Y. and Phillips, Peter C. B., (1991). The Spurious Effect of Unit Roots on Exogeneity Tests in Vector Autoregressions: An Analytical Study. Cowles Foundation Discussion Papers. 1221.

Toda, Hiro Y. and Phillips, Peter C. B., (1994). Vector autoregression and causality: a theoretical overview and simulation study. Econometric Reviews, Volume 13, 1994 - Issue 2, 259-285.

White, H. (1980). A Heteroskedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroskedasticity. Econometrica, 48(4), 817-838.

Appendix 1 Estimated error correction forms

(1) M1-GDP

$$\Delta LM1_t = 0.0515 - 0.4248\Delta LGDP_t + 0.0123\left(LM1 - LGDP\right)_{t-1}$$

(0.0179) (0.2145) (0.0584)

$R^2 = 0.1256$ DW=2.948 LM(4,24)=4.0557
[2.78]

N(2)=64.6271 WH(1,29)=1.2776 Q(10)=13.3706
[5.99] [4.17] [18.31]

ARCH(12)=11.5602 CHOW(3,25)=0.1916
[21.03] [2.99]

(2) M1-EX

$$\Delta LM1_t = -0.0352 - 0.3003\Delta LEX_t + 0.0126\left(LM1 - LEX\right)_{t-1}$$

(0.2) (0.5254) (0.0339)

$R^2 = 0.0154$ DW=2.7635 LM(2,24)=2.5631
[2.78]

N(2)=24.5252 WH(1,29)=0.000124 Q(10)=10.3977
[5.99] [4.17] [18.31]

ARCH(12)=12.4071 CHOW(3,25)=0.384
[21.03] [2.99]

(3) M2-GDP

$$\Delta LM2_t = 0.1062 - 0.0983\Delta GDP_t - 0.0197\left(LM2 - LGDP\right)_{t-1}$$

(0.0321) (0.1046) (0.0168)

$R^2 = 0.0854$ DW=1.0025 LM(4,24)=2.6914
[2.78]

N(2)= 28.4925 WH(1,29)=1.1702 Q(10)=18.2935
[5.99] [4.17] [18.31]

ARCH(12)=18.6475 CHOW(3,25)=0.0262
[21.03] [2.99]

(4) M2-EX

$$\Delta LM2_t = 0.1986 + 0.0741\Delta LEX_t - 0.0166\left(LM2 - LEX\right)_{t-1}$$

(0.0891) (0.2487) (0.0112)

$R^2 = 0.074$ DW=0.9869 LM(4,24)=2.5877
[2.78]

N(2)=11.2233 WH(1,29)=12.3122 Q(10)=17.4107

[5.99] [4.17] [18.31]

ARCH(12)=18.0208 CHOW(3,25)=0.1994

[21.03] [2.99]

(5) M3-GDP

$$\Delta LM3_t = 0.0928 - 0.0167\,\Delta GDP_t - 0.0167\left(LM3 - LGDP\right)_{t-1}$$

(0.0236) (0.0548) (0.0113)

$R^2 = 0.0813$ DW=1.637 LM(4,24)=0.8951

[2.78]

N(2)=1.7875 WH(1,29)=2.8958 Q(10)=10.8333

[5.99] [4.17] [18.31]

ARCH(12)=15.2786 CHOW(3,25)=0.1524

[21.03] [2.99]

(6) M3-EX

$$\Delta LM3_t = 0.1431 - 0.001788\,\Delta LEX_t - 0.0106\left(LM3 - LEX\right)_{t-1}$$

(0.0558) (0.1298) (0.0068768)

$R^2 = 0.0783$ DW=1.6335 LM(4,24)=0.8755

[2.78]

N(2)=1.4655 WH(1,29)=3.9336 Q(10)=10.1015

[5.99] [4.17] [18.31]

ARCH(12)=15.0926 CHOW(3,25)=0.6945

[21.03] [2.99]

(7) GDP-M1

$$\Delta LGDP_t = 0.0415 - 0.2893\,\Delta LM1_t - 0.0653\left(LGDP - LM1\right)_{t-1}$$

(0.0149) (0.146) (0.0466)

$R^2 = 0.1815$ DW=2.3639 LM(4,24)=9.0454

[2.78]

N(2)=0.6078 WH(1,29)=0.2662 Q(10)=42.4173

[5.99] [4.17] [18.31]

ARCH(12)=15.5253 CHOW(3,25)=1.8773

[21.03] [2.99]

(8) GDP-M2

$$\Delta LGDP_t = 0.0135 - 0.3112\,\Delta LM2_t - 0.0151\left(LGDP - LM2\right)_{t-1}$$

(0.0673) (0.3311) (0.0304)

$R^2 = 0.0487$ DW=2.1075 LM(4,24)=19.0017
[2.78]
N(2)=2.7929 WH(1,29)=0.038 Q(10)=70.5774
[5.99] [4.17] [18.31]
ARCH(12)=16.5572 CHOW(3,25)=1.8398
[21.03] [2.99]

(9) GDP-M3

$$\Delta LGDP_t = 0.0855 - 0.2003\Delta LM3_t - 0.02\left(LGDP - LM3\right)_{t-1}$$
(0.0881) (0.6541) (0.0342)

$R^2 = 0.0209$ DW=2.0803 LM(4,24)=16.8168
[2.78]
N(2)=3.1524 WH(1,29)=1.4128 Q(10)=71.5513
[5.99] [4.17] [18.31]
ARCH(12)=17.0743 CHOW(3,25)=1.9752
[21.03] [2.99]

(10) EX-M1

$$\Delta LEX_t = -0.0346 - 0.0384\Delta LM1_t - 0.0048198\left(LEX - LM1\right)_{t-1}$$
(0.0713) (0.0672) (0.0121)

$R^2 = 0.0161$ DW=1.2365 LM(4,24)=1.192
[2.99]
N(2)=0.1324 WH(1,29)=0.7047 Q(10)=21.7623
[5.99] [4.17] [18.31]
ARCH(12)=16.2709 CHOW(3,25)=0.0272
[21.03] [2.99]

(11) GDP-M2

$$\Delta LEX_t = -0.0307 + 0.0426\Delta LM2_t - 0.0025365\left(LEX - LM2\right)_{t-1}$$
(0.0731) (0.1432) (0.008845)

$R^2 = 0.0047984$ DW=1.2158 LM(4,24)=1.2038
[2.78]
N(2)=0.2025 WH(1,29)=0.7696 Q(10)=22.3458
[5.99] [4.17] [18.31]
ARCH(12)=13.9485 CHOW(3,25)=0.37
[21.03] [2.99]

(12) EX-M3

$$\Delta LEX_t = -0.0237 + 0.0067243\,\Delta LM3_t - 0.0046128\left(LEX - LM3\right)_{t-1}$$

(0.0393) (0.2753) (0.0092964)

$R^2 = 0.0092543$ DW=1.2333 LM(4,24)=1.1774
[2.78]

N(2)=0.2612 WH(1,29)=1.5922 Q(10)=22.5568
[5.99] [4.17] [18.31]

ARCH(12)=14.2073 CHOW(3,25)=0.3889
[21.03] [2.99]

Biography of author(s)

Raymond Wai-man Yeung (Assistant Professor) Department of Economics and Finance, Hong Kong Shue Yan University. He holds a Doctor of Philosophy (PhD) in Economics and completed his education from the diploma program of Hong Kong Shue Yan College (the predecessor of Shue Yan University), the master's degree program of The University of Birmingham in the UK, and the doctoral degree program of Shanghai University of Finance and Economics in China. Dr. Yeung has conducted economic research on China, Hong Kong, and Asia at various universities in Hong Kong, including Hong Kong Baptist University, Hong Kong University of Science and Technology, and Lingnan University. He has published more than 30 research papers on China, Hong Kong, and Asian economic issues in various academic publications and has received the "First-Class Research Award" from the expert group of the Beijing Philosophy and Social Sciences Planning Office in 2000. His research interests include the Chinese Economic Area (CEA), Asia Pacific Economies, Urban and Regional Economics, International Political Economics, and Monetary Economics.

Tai-Yuen Hon (Research Affiliate) Business, Economic and Public Policy Research Centre, Hong Kong Shue Yan University, Hong Kong. He was an Academic Assistant, Lecturer, Senior Lecturer, and Assistant Professor in the Department of Economics and Finance (formerly known as the Department of Economics) of Hong Kong Shue Yan University from 1993 to 2016. He obtained his PhD in Business Administration from Bulacan State University, and a Master of Arts in Money, Banking and Finance from the University of Sheffield. He has published papers in the Journal of Risk and Financial Management, Journal of Family and Economic Issues, International Journal of Revenue Management, Advances in Decision Sciences, and others.

Wing-Kwong Au has been a member of the Department of Social Work at Hong Kong Shue Yan University since the 1990s, retiring in August 2024. He served as an Associate Professor and Director of the China Liaison Office at the university. Additionally, he was a Fellow of the University of Liverpool and a Registered Social Worker with the Social Workers Registration Board in Hong Kong. Dr. Au obtained his MPhil and PhD from the University of Liverpool and a Master of Arts in Social Work from the University of Wales, Bangor (now Bangor University) in the United Kingdom. His research interests include elderly services, community development, social services in China (PRC), children and marginalized youth, youth work, and behavioral finance. He has published reports on various topics, including hidden youth drug abusers, labor compensation in Hong Kong, interventions for marginalized youth behavioral patterns, and the positive life experiences of young people in Hong Kong's Eastern District. His publications also feature two books: Eastern District Positive Life Project 15th Anniversary: A Book of Reflections and The Interventions of the Marginal Youth Behavioral Pattern. Dr. Au has worked on a book chapter titled “Review on Market Efficiency and Anomalies” and is exploring “The Dilemma of Investment Decisions for Small Investors in the Hong Kong Stock Market” with fellow colleagues. Additionally, he has an upcoming article, “Children’s Lives in Sub-Divided Flats Under COVID-19,” co-authored with contributors from diverse multidisciplinary backgrounds.

Wing-Keung Wong (Chair Professor) Department of Finance, Fintech & Blockchain Research Center, and Big Data Research Center, Asia University, Taiwan. Department of Medical Research, China Medical University Hospital Business, Taiwan. Economic and Public Policy Research Centre, Hong Kong Shue Yan University, Hong Kong. He obtained his Ph.D. from the University of Wisconsin-Madison, the USA with a major in Business Statistics (Statistics and Finance) and obtained his Bachelor’s degree from the Chinese University of Hong Kong, Hong Kong, with a major in Mathematics and a double minor in Economics and Statistics. Currently, he is a Chair Professor at the Department of Finance, at Asia University. He was a Full Professor at the Department

of Economics, Hong Kong Baptist University, and Deputy Director at the Risk Management Institute, National University of Singapore. He appears in “Who's Who in the World” and gets the Albert Nelson Marquis Lifetime Achievement Award. 2017, Marquis Who's Who, and is on the list of the "2023 World's top 2% of researchers/scientists", on the list of the "Best Economics and Finance Scientists”, ranked 788th in the world and ranked first in Taiwan with a D-index of 52, and on the list of the 2023 Asia Scientists Economics & Econometrics Rankings, ranked first in Taiwan with an H index of 66, i10 index of 281, and citations of 14925. His Erdos number is 3. He is ranked top 1% by the Social Science Research Network and in the list of top Taiwan economists, top Asian economists, and top world economists by RePEc. He has published more than four hundred papers including papers published in some top journals. He has more than 17000 citations in Google Scholar, more than 15000 citations in Researchgate, and more than 16000 citations in Scopus. His hindex is 69, (46 since 2019) and his i10-index is 314, (278 since 2019) by Google Scholar citation in March 2024. He is on the list of top (1st, 0.384%) Taiwan economists, top (1st, 0.384%) Taiwan economists (counted publications last 10 years), top (39th, 0.48%) Asian economists (counted publications last 10 years), top (39th, 0.48%) Asian economists, (417th, 0.62%) [World] authors [in Economics in last 10 years] and (614th, 0.913%) [World] authors [in Economics], top (199th, 0.296%) in Number of Works, top (117th, 0.174%) in Number of Distinct Works, top (682nd, 1.01%) in Number of Distinct Works, Weighted by Number of Authors, top (37th, 0.055%) in Number of Journal Pages, top (201st, 0.299%) in Number of Journal Pages, Weighted by Number of Authors, top (900th, 1.34%) in Record of graduates, top (47th, 0.0699%) in Closeness measure in the co-authorship network, top (10th, 0.0149%) in Betweenness measure in the co-authorship network by, etc. by RePEc in December 2023. I have 37 items ranked within 15%, 32 items ranked within 10%, 22 items ranked within 5%, 18 items ranked within 3%, 18 items ranked within 2%, and 14 items within 1% among all Economists registered in RePEc in December 2023, etc. He has been serving international academies, Government, society, and universities, providing consultancy to several Government departments and corporations, and giving lectures and seminars to several universities. For example, he has been serving as editor, guest leading editor, advisor, associate editor for some international journals, appointed as an advisor/member of various international associations/institutes, serving as a referee for many journals/conferences, supervising solely or jointly several overseas graduate students, appointed as an external reviewer and external examiner by other universities, and invited by many universities/institutions to present papers or conduct seminars, for example, he is the Editor-in-Chief of Annals of Financial Economics, a Senior Co-Editor-in-Chief and Managing Editor for Advances in Decision Sciences, an Editor for Risk Management, Cogent Economics and Finance, Journal of Risk and Financial Management, Mathematical Problems in Engineering; Advisor for Asian Academy of Management Journal of Accounting and Finance; Associate Editor for International Journal of Emerging Markets, Financial Innovation, International Journal of Energy Research, Heliyon, Communications in Statistics: Theory and Methods, Communications in Statistics: Simulation and Computation, Asia-Pacific Journal of

Operational Research, Studies in Economics and Finance, Bubbles and Behavioral Finance Investment Behaviour for Small Investors in the Hong Kong Stock Market 89 Economies, Journal of Infrastructure, Policy and Development, Communications in Statistics: Case Studies, Data Analysis and Applications, etc. He has published more than four hundred papers including papers published in journals ranked as A* in ABDC, Q1 in SJR Quartile, Q1 in JCR, and 4 in AJG and including papers published in Journal of Finance, Contemporary Accounting Research, Annals of Applied Probability, Scientific Report, Mathematical Finance, European Journal of Operational Research, Journal of Business and Economic Statistics, Economic Theory, Journal of Empirical Finance, Journal of Financial Markets, Journal of Economic Behavior and Organization, Economics Letters, Econometrics Journal, Quantitative Finance, Economic Inquiry, Energy Economics, Statistics and Probability Letters, Journal of Risk, Journal of Operational Research Society, Journal of Financial Econometrics, Journal of Forecasting, Journal of International Financial Markets, Institutions & Money, Transport Policy, Personality and Individual Differences, Journal of Time Series Analysis, Applied Economics, Journal of Multinational Financial Management, Journal of Behavioral Finance, Pacific-Basin Finance Journal, Global Finance Journal, Annals of Finance, Mathematics and Computers in Simulation, IMA Journal of Management Mathematics, Review of Quantitative Finance and Accounting, North American Journal of Economics and Finance, Accounting & Finance, Economic Modelling, Energy Policy, Applied Mathematics Letters, Journal of International Consumer Marketing, Statistical Papers, Japanese Economic Review, Global Economic Review, Multinational Finance Journal, Central European Journal of Mathematics, Journal of Asian Economics, Mathematical Scientist, Journal of Retailing and Consumer Services, International Review of Financial Analysis, Current Issues in Method and Practice, Sustainability, Risk Management, Scientific Reports, International Review of Economics & Finance, Studies in Nonlinear Dynamics and Econometrics, Current Issues in Tourism, Finance Research Letters, Journal of the Korean Statistical Society, PLOS ONE, Journal of Testing and Evaluation, Estudios de Economía, Physica A: Statistical Mechanics and its Applications, International Journal of Production Research, Resources Policy, International Journal of Environmental Research and Public Health, World Economy, Emerging Markets Review, Energies, Economies, Asia Pacific Journal of Operational Research, Review of Pacific Basin Financial Markets and Policies, International Journal of Financial Engineering, Emerging Markets Review, Journal of Theoretical and Applied Electronic Commerce Research, Asian Academy of Management Journal of Accounting & Finance, Annals of Financial Economics, Asia-Pacific Journal of Business Administration, Econometrics and Statistics, Communications in Statistics: Case Studies, Data Analysis and Applications, Communications in Statistics: Theory and Methods, Communications in Statistics: Simulation and Computation, Research in International Business and Finance, Journal of Risk and Financial Management, Energy Reports, Frontiers in Public Health, Environmental Science and Pollution Research, Kybernetes, Journal of Asian Business and Economic Studies, International Journal of Emerging Markets, Emerging Markets Finance and Trade, Fuel, Mathematical and Computational Applications, Cogent

Economics and Finance, Asia-Pacific Journal of Operational Research, Chaos, Solitons & Fractals, Frontiers in Public Health-Health Economics, Fractals, Computers and Operations Research, Economic Research-Ekonomska Istraživanj, Democracy and Security, Heliyon, Journal of International Commerce, Economics and Policy, etc.

Chapter 2
The Effect of Global Oil Price and Macroeconomic Variables on the stock market returns for ASEAN Countries

Jacky Ho-Man Lau
Edward Chi-Ho Tang

Abstract

This research examines the inter-relationships among the macro-economic variables in Thailand and Philippines. Through VAR analysis, it is found that their relationships are substantially different. Typically, in Thailand, the change of global oil futures price has a positive significant effect on the change of stock price, and the lagged stock return and inflation rate are positive significant to the change of policy interest rate. However, such relationship does not exist in Philippines. Such results are also confirmed by different robustness checks.

1. Introduction

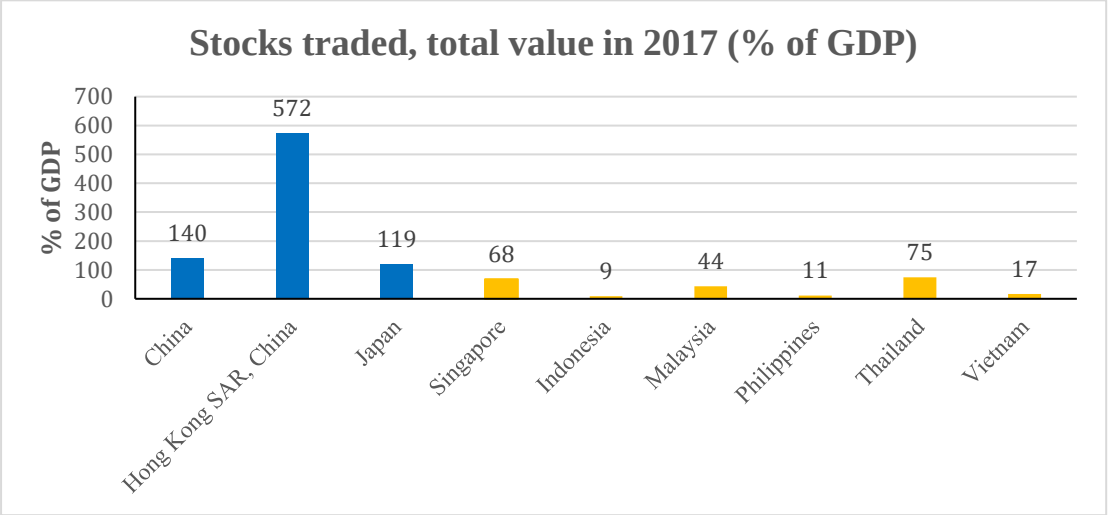
In the past decade, Asian countries have developed rapidly, including the development in science, technology, trading, production and other aspects. The average living standard of the countries in Asia and the per capita income have increased significantly. Among all the countries located in Asia, ASEAN is a new impetus for business development affecting the whole world. ASEAN is an association of Southeast Asian nations formed in 1967, which currently includes 10 countries in Southeast Asia and they are Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam. It is aiming at solving various economic, security, political, and social problems. According to HKTDC Research, ASEAN has over 640 million populations, and its aggregate economic size (GDP) raised from US$1.63 trillion in 2008 to already exceed US$2.7 trillion in 2017. Some experts even predict the ASEAN would become the fourth-largest economy in the world by 2030. All these information and statistics show the importance of understanding the economic and financial characteristics of the ASEAN countries for the future.

Various factors would affect the performance of the ASEAN countries' capital market. First, the capital market size of the ASEAN countries is different. On one hand, some national capital markets have a larger capital market size as they started earlier, such as Malaysia, Singapore, Thailand, Vietnam, Philippines and Indonesia. On the other hand, some national capital markets were relatively smaller, such as Laos, Cambodia and Myanmar. The Lao Securities Exchange and Cambodian Securities Exchange founded and started to operate in January 2011, and the Yangon Stock Exchange is opened in October 2015. Some of the ASEAN countries even have not yet established a national

stock exchange like Brunei, it shows the distinctive between the ASEAN countries' capital market size.

However, even the size capital markets of Malaysia, Singapore and Indonesia are relatively larger with ASEAN countries; they are still far behind than other countries in Asia, such as China, Hong Kong and Japan. As shown in the Figure 1, there is a great gap between the total values of stocks traded of each Asian countries in 2017. The values of stocks traded in China was nearly twice as much as the total values of Singapore, Malaysia and Thailand. In addition, Figure 2 shows the numbers of listed domestic companies of ASEAN countries are only one seventh while comparing to China, Hong Kong and Japan. Moreover, as highlighted in Figure 3, the market capitalization of listed domestic companies of China in 2017 was decuple than the companies in each country. These figures show the disparity of stock market between mature countries in Asia and ASEAN countries.

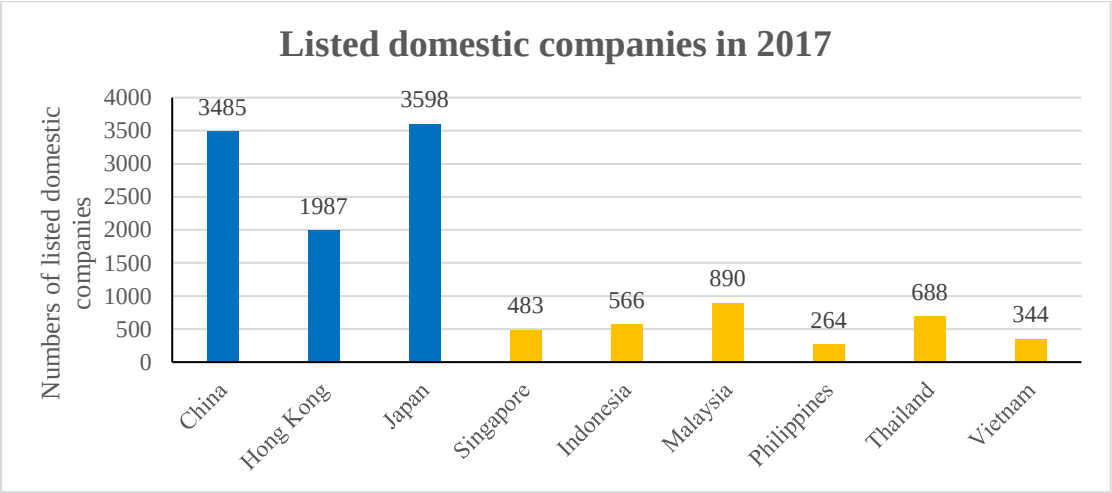
Figure 1 – Total value of stocks traded of Asia countries in 2017 (% of GDP)



Source: World Bank Group

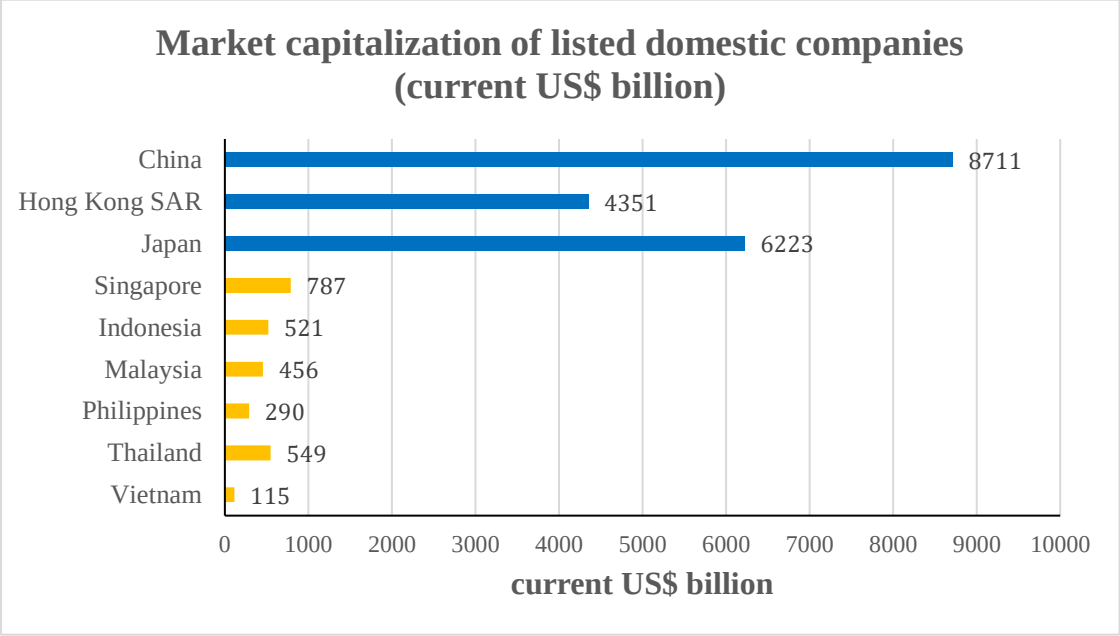
Besides the size of stock market, the economic structure and policy orientation would also affect the performance of the ASEAN countries' capital market. For example, the market of Malaysia is relatively open, and being with a relatively high financial reform speed. Indonesia and the Philippines market are relatively competitive, as they have implemented strict trade protection and financial regulation for a long period, so that the financial reform is relatively lagging behind.

Figure 2 – Listed domestic companies in 2017



Source: World Bank Group

Figure 3 – Market capitalization of listed domestic companies of Asia countries in 2017 (current US$ billion)

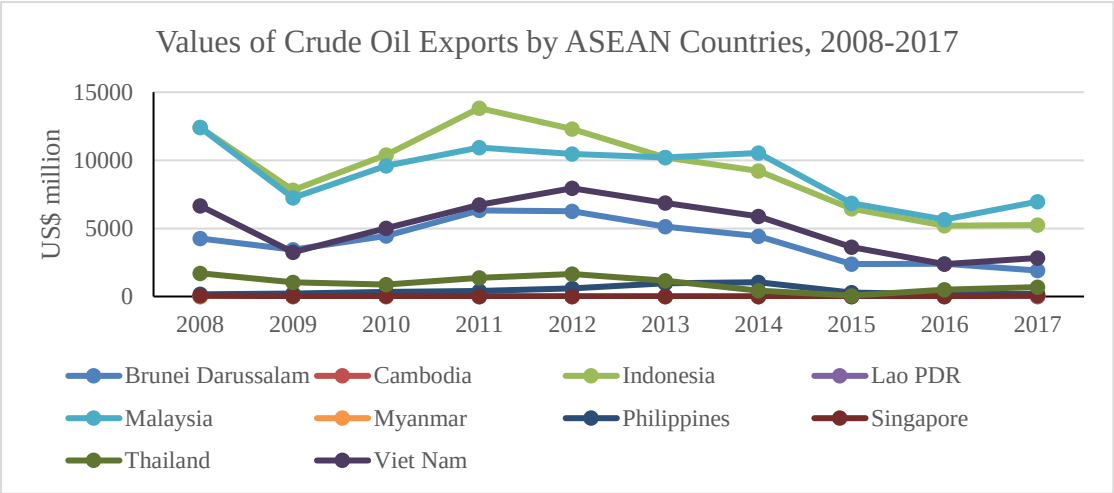


Source: World Bank Group

For a rapid expansion of the economy, besides the capital market structure and size, the price of crude oil should be an important determinant which affects the capital market. Along with the findings of Miller, J. I., & Ratti, R. A. (2009), a clear long-run relationship is found that stock market indices would respond negatively to the rise in price of oil. Consequently, it is reasonable to say when the price of crude oil imports raised, the cost of production would be raised eventually, which slowed down the growth of economy and negatively affected the performance of the local stock market. For ASEAN countries, the unsteady price of crude oil is one of the most important factors which affects the cost of production. According to the report announced by ASEAN Centre for Energy (ACE), since 2016, ASEAN did not discover any new giant oil. It forced most of the ASEAN countries became a net oil importer and vulnerable to

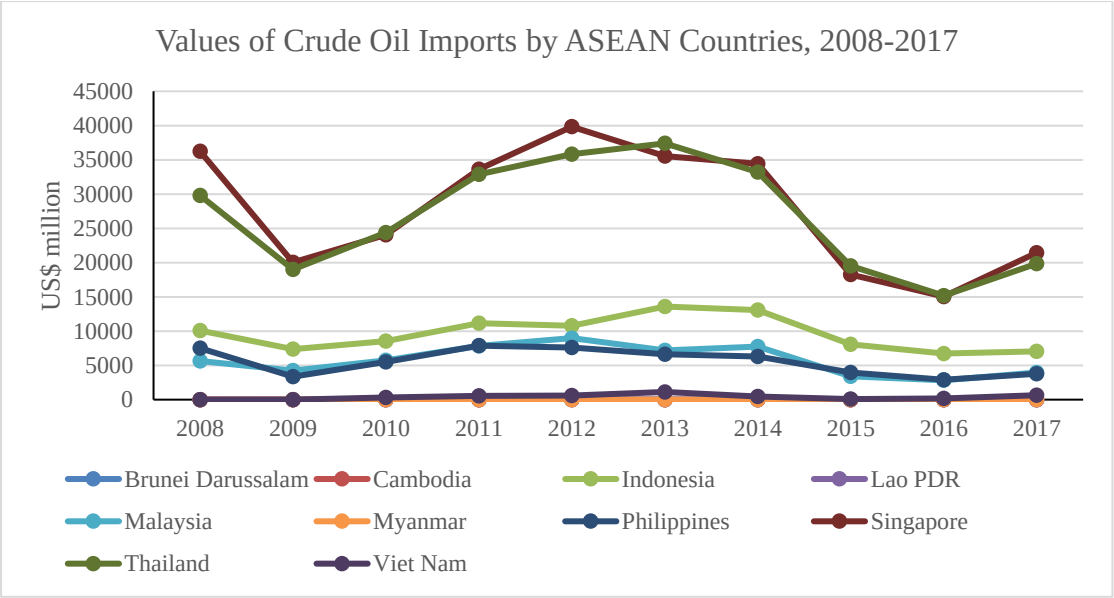
the supply disruption and oil price fluctuation. As shown in the Figures 4, 5 and 6, the number of crude oil importation far beyond the exportation by ASEAN countries from 2008 to 2017, especially Thailand. It is obviously reflecting the fact that ASEAN members are still relying on the importation of crude oil.

Figure 4 – Values of Crude Oil Exports by ASEAN Countries, 2008-2017



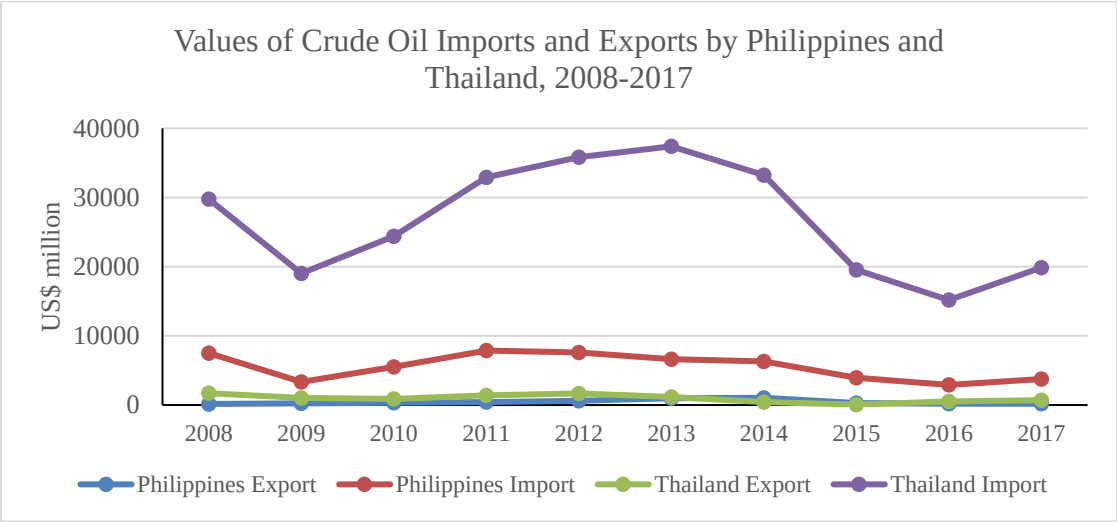
Source: Association Southeast Asian Nations

Figure 5 – Values of Crude Oil Imports by ASEAN Countries, 2008-2017



Source: Association Southeast Asian Nations

Figure 6 – Values of Crude Oil Imports and Exports by Philippines and Thailand, 2008-2017



Source: Association Southeast Asian Nations

However, according to our observation, even the oil price raised sharply in the past decade, the development speed of the ASEAN members seems not harmed or slowed significantly. This interesting phenomenon inspired us to analyze how oil price and others local economic variables would affect the stock market of ASEAN countries from 2000 to now.

2. Literature Review

Being in a rapidly developing era, investing in the stock market is always a great way to maintain the purchasing power of money under inflation, and also enlarging the wealth for a better living standard. However, it's not easy to earn money in developed countries' stock market due to information asymmetry and most of the markets are lacking rooms for improvement. But in some developing countries, like ASEAN, the stock markets are still full of expanding potential. Therefore, it would be a great idea to invest in developing countries' stock market as in the long-run, the stock value of superior listed companies must enhance a couples of times during the market development.

Most of the members of ASEAN are developing countries and the stock markets are full of expanding potential. ASEAN is composed of a miscellaneous group of ten fast-growing countries at different stages of economic and financial development. The demand of investment is vast as those countries are advancing urbanization, also increasing both hard and soft infrastructures. After the Asian financial crisis, ASEAN has sharply improved their internal and external trade and capital flows. Besides, the direct investment has risen and foreign participation in ASEAN capital markets has increased. (Almekinders, Mourmouras, Zhou & Fukuda, 2015). As being with more than 600 million populations in ASEAN, it is considered to be one of the most diverse regions in the world and also the world's fastest growing regions (Bhattacharya, 2009). Although the financial crisis in 1998 generated a profound impact on the ASEAN

region, they sustained to grow robustly after the disturbance. Therefore, according to the dynamic business environment with stable and high growth rate, ASEAN has become a promising target for international investors (Rao-Nicholson, Salaber & Cao, 2016).

In order to be well-prepared before investing the money into the stock market of ASEAN, it's necessary to understand the relationship between stock market returns and multiple macroeconomic variables. First, the price of crude oil should be involved as the price change of oil might have a great relationship with the stock market return. Alvarez-Ramirez, Soriano, Cisneros& Suarez (2003) pointed out that crude oil has become one of the most important factors in the world economy as there are nearly 67% of energy demands in the world are fulfilled by the crude oil. Basher and Sadorsky's (2006) also found out a strong evidence that the change of oil price would most likely to affect the stock market returns of 21 emerging economies; and oil price is a positive and 10% significant variable to explain the stock market returns for most of the countries studied in the paper. By using vector autoregressive model, oil price and its volatility are both important roles in affecting real stock returns (Sadorsky, 1999). Moreover, Filis, Degiannakis, & Floros (2011) raised that the lagged time-varying correlation results show oil prices always exercise a negative effect in all stock markets, no matter what the sources of the oil price shock are. The relationship should be quite important for ASEAN countries as most of them are relying on importing crude oil, such as Singapore, Philippines and Thailand. The energy of Singapore is 100% imported from other countries; for Philippines, more than half of energy supply is imported, especially coal and crude oil; Thailand is also relying on imported crude oil (Kanchana & Unesaki, 2014). Therefore, the price of crude oil would be used in the following part of paper. In particular, we use the data of Brent crude oil and West Texas Intermediate (WTI) crude oil as they are the most famous benchmark prices, which are used widely as the basis of many crude oil price formulae (Yu, Wang & Lai, 2008).

Second, interest rate, inflation rate and GDP should be included in the following testing as they would bring various effect on the stock market return. For the relationship of interest rate and stock market, Alam & Uddin (2009) pointed out that interest rate should have a significant negative relationship with share price. In some countries, the changes in interest rate would also have significant negative relationship with changes in share price. In addition, Ahmad, Rehman, & Raoof (2010) pointed out that the change in interest rate would significantly affect the stock returns by using Pakistani as an example. Besides the interest rate, inflation rate would also affect the stock market. The stock market reacts negatively to the inflation in the Consumer Price Index, especially for unexpected change of inflation rate (Schwert, 1981). Furthermore, Gultekin (1983) said that the increase in inflation raises the tax burden of corporation. In the long-run, the inflation may have a very large impact on the compositions of the capital stock as it declines in the price of corporate capital and raises the price of its substitute-housing capital. In addition, GDP should not be excluded in the following testing process as it is widely believed that along with great economic growth (Great

growth rate of GDP), the business environment would be great for the stockholders. The stock prices are very high relative to gross domestic product (Diamond, 2000). By analyzing the newspaper stories, Birz and Lott (2011) found out that the news about GDP does affect stock returns between 1991 and 2004. However, it needs to be reminded that GDP might not affecting the stock price positively in all situations, Ritter (2005) raised that the real stock returns is having a negative relationship with the per capita GDP growth over 1900–2002 as some of the examined countries with great GDP do not offer good equity investment opportunities.

In the testing process, referencing to the testing method used in "Oil price shocks and stock market activity" wrote by Sadorsky (1999) and "Energy shocks and financial markets" wrote by Huang, Masulis and Stoll (1996), vector autoregressive model (Sims, 1980) would be used to test the relationship between the price change in crude oil, change in interest rate, change in inflation rate, change in GDP and the stock return in ASEAN countries. It's important to find out the data is stationary while using the VAR model. Most of the time, the data generated from a financial market is inherently non-stationary, and therefore, we have to force the data to become stationary (Huang, Wu, Qu, Long & Shen, 2003).

3. Methodology

In this research paper, the idea of finding out the relationship between global oil price, national economic factors and local stock market reaction is based on the paper wrote by J. Isaac Millera and Ronald A. Rattib in 2009. In that paper, they analyzed the long-run relationship between the world price of crude oil and international stock markets from 1971 to 2008, by using the integrated Vector Error Correction model and they found out that stock market indices would respond negatively to the price raise of oil. However, would it apply to the rapidly developing countries in ASEAN? To find out the answer, this research paper would aim at revealing the relationship between the global price of crude oil, local interest rate, local inflation rate, national GDP and the stock performance in ASEAN countries, particularly Thailand and Philippines.

3.1 Unit Root Test

For analyzing the data, Vector Autoregressive model (VAR) model will be used for capturing the linear interdependencies of a set of endogenous variables (Stock price, Interest rate, Inflation rate, GDP in USD) over the same sample period (t=72). In general, unit root test should be used before using VAR model. Spurious relationship may arise when the variables in dataset are containing unit roots and this analyzed result is unreliable, as the variables are not causally related.

Dickey-Fuller Test and Augmented Dickey-Fuller Test are often used for Unit Root Testing process (Dickey and Fuller, 1979). Both of them are possible and appropriate

to use in this paper but the Dickey-Fuller Test would be more suitable. First, the equation of Dickey-Fuller Test is:

$$Y_t = \emptyset Y_{t-1} + u_t$$

where Y_t is the testing variable at time t, $\emptyset$ is a coefficient which demonstrating the relationship between the testing variables at time t-1 and time t. u_t is the error term. By subtracting Y_{t-1} from both sides, the equation was further developed to be:

$$\Delta Y_t = \theta Y_{t-1} + u_t \qquad [where\ \theta = \emptyset - 1]$$

where ΔY_t is equal to is the first difference of the testing variable at time t and the coefficient θ is equal to $(\emptyset - 1)$ and now representing the relationship between the testing variables at time t-1 and the first differenced testing variable at time t. Moreover, if the Dickey-Fuller Test involved drift and deterministic time trend, the equation would be:

$$\Delta Y_t = \propto + \beta t + \theta Y_{t-1} + u_t$$

where $\propto$ represents the drift and βt represents the deterministic time trend. With this equation, hypothesis are set as: Null hypothesis (H_0): $\theta = 0$ and the alternative hypothesis (H_1) is: $\theta \neq 0$. If the result of Dickey-Fuller Test reject Null hypothesis, which means the testing variable ΔY_t is stationary and no unit root arise. However, structural effects including autocorrelation are still involved while testing with Dickey Fuller Test, therefore, Augmented Dickey-Fuller Test method emerged by changing the equation into (Dickey and Fuller, 1979):

$$\Delta Y_t = \theta Y_{t-1} + \sum_{i=1}^{r} \propto_i \Delta Y_{t-i} + u_t$$

After all this, Augmented Dickey-Fuller (ADF) test would be used in this paper for examining the existence of non-stationary variables in our model without any structural effects and the hypothesis are set as: Null hypothesis (H_0): $\theta = 0$ and the alternative hypothesis(H_1) is: $\theta \neq 0$. It is noteworthy that standard T-Distribution is not able to provide critical values for the Augmented Dickey-Fuller Test, the T-distribution would be replaced by the Dickey–Fuller Distribution and which is defined as:

$$test\ stat = \frac{\hat{\varphi}}{\widehat{SE(\varphi)}}$$

If the final version of the model does include a deterministic trend, at 5% significance level, the Dickey-Fuller critical value is approximately –3.45. If the t-stat on θ is more

negative than –3.45, we reject the unit root hypothesis and conclude that the series is stationary. Otherwise, we conclude that the series has a unit root in 5% significant level.

3.2 Vector Autoregressive model

After testing whether the variables are having unit-root or not, VAR model would find out the linear relationship among multiple time series. All variables within the VAR model would be explained by its lagged values and the lagged values of other variables, and an error term. The equation of a VAR model is:

$$Y_t = \beta_0 + \beta_i Y_{t-1} + u_t$$

where Y_t, β_0, Y_{t-1} *and* u_t are vectors with the format of $m \times 1$, and β_i is a vector representing the format of $m \times m$,which is equal to$\begin{bmatrix} Y_{11} & \cdots & Y_{1m} \\ \vdots & \ddots & \vdots \\ Y_{m1} & \cdots & Y_{mm} \end{bmatrix}$. In this equation, all the variables are endogenous and it enables us to find out the relationship between its lagged values and the lagged values of other variables, including the error term. However, sometimes the VAR model would be affected immediately by other observable variables (Exogenous / independent variables) which are determined outside the system. In this case, the equation would be changed into:

$$Y_t = \beta_0 + \beta_i Y_{t-1} + \alpha_i X_t + u_t$$

where X represent exogenous variable and the α_i is a vector with the format of $m \times 1$, which is equal to $\begin{bmatrix} \alpha_1 \\ \vdots \\ \alpha_m \end{bmatrix}$.

3.3 Robustness Check

In order to confirm the accuracy of the data analysis in this paper, two controlling experiments would be involved in the last part of the analysis. First, doing the VAR model with changing the exogenous variable – the price of oil into the endogenous variables. Second, the VAR model would use another oil price dataset for testing in order to dismiss the opportunity of unreliable results generated by only testing one oil price benchmark.

4. Data and Variable Descriptions

This section is going to describe the variables involved in the research model. In this paper, it attempts to find out the effects of global oil price and national economic factors on local stock market of ASEAN Countries. According to the literature review part, the experts pointed out the relationship between various macroeconomic variables and stock market. As shown in Table 1, within the model, endogenous variables would be included: 1. Price of Stock Market, 2. Local Interest Rate, 3. Local Inflation Rate, and 4. Local Gross Domestic Product. Besides, 5. Price of Global Oil Price would be the exogenous variable. However, due to data availability, only Thailand and Philippines are selected for analysis, the details of stock market of Thailand and Philippines are showing in Table 2. All quarterly data covers the period from September 2000 to September 2018.

As shown in the Table 3, the price of Thailand's stock market, would be represented by the quarterly index price of Thailand SET Index; and the price of Philippines' stock market would be represented by the quarterly price of Philippines PSEi Index. Using the Thailand SET Index as the variable because SET Index is one of the most significant stock market benchmarks in Thailand, which currently separating into 6 different series[i] and including 150 listed companies. About the Philippines PSEI.PS index, which is also a most famous benchmark index in Philippines and it composed of the top 30 companies selected by the Philippine Stock Exchange.

[i] *There are Large Cap, Mid Cap, Small Cap, All-Share, Mid/Small Cap, Fledging

Table 1 – Summary table of the Thailand and Philippines data comparison

	Thailand	Philippines
Sampling Period	01/09/2000 to 01/09/2018	
Data Frequency	Quarterly	
National Level Data	Stock price, Interest rate, Inflation rate, GDP in USD	
Global Level Data	Brent Crude Oil Price WIT Oil Price (use for robustness check)	

Table 2 – Stock Market information summary table of the Thailand and Philippines

	Thailand	Philippines
Stock Exchange History	The Bangkok Stock Exchange (SET) was established in 1962, currently located in Bangkok.	The Philippine Stock Exchange (PSE) was established in 1927, currently located in Taguig City.
Number of Stock Listed	317	270
Trading Hours	Conducted on all bank business days, normally Monday through Friday. There are two trading sessions per day, morning and afternoon. (9:30 - 17:00)	Continuous session from 9:30AM to 3:30PM daily with a recess from 12:00PM to 1:30PM.

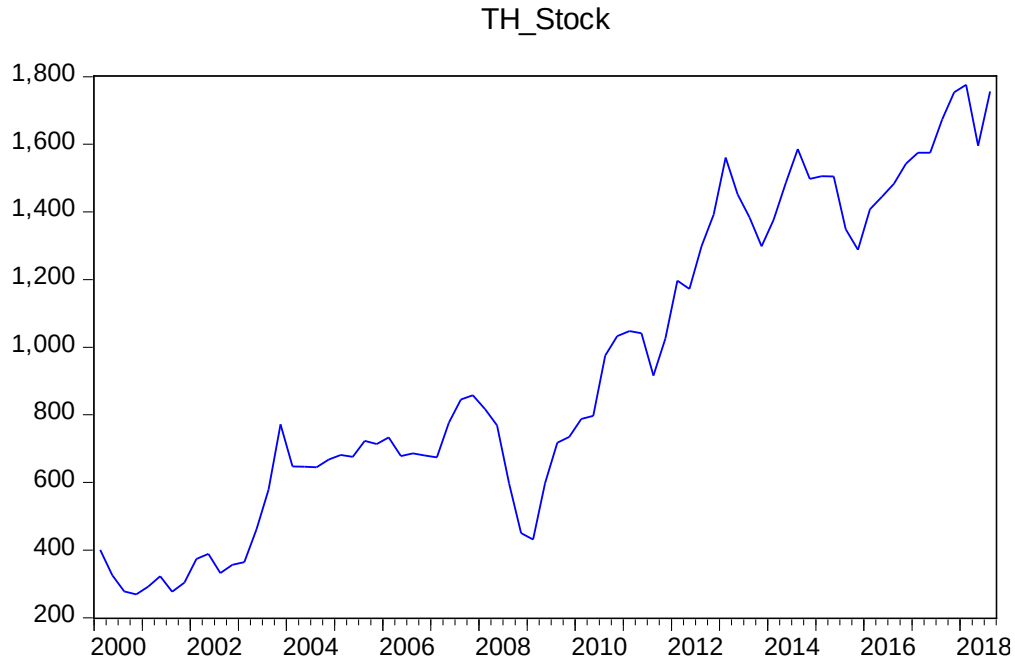
Table 3 – Variables Description

Variables	Abbrev.	Order
Quarterly ending price of Thailand SET Index	TH_STOCK	I(1)
Quarterly Policy interest rate of Thailand	TH_INT	I(1)
Change of Consumer Price Index of Thailand	TH_INF	I(1)
Quarterly GDP of Thailand	TH_USDGDP	I(1)
Quarterly ending price of Philippines PSEi Index	PH_STOCK	I(1)
Quarterly Philippines policy interest rate	PH_INT	I(1)
Change of Consumer Price Index of Philippines	PH_INF	I(1)
Quarterly GDP of Philippines	PH_USDGDP	I(1)
Quarterly Future price of Brent Crude Oil	BRENT_CRUDE_OIL	I(1)
Quarterly Future price of WTI Oil	WTI_OIL	I(1)

Figure 7 shows the trend of quarterly price of Thailand SET Index from 2000 to 2018 and Figure 8 shows the trend of quarterly price of Philippines PSEi Index. Obviously, both the quarterly price of Thailand SET Index and Philippines PSEi Index are being in a rising trend. After the global financial crisis, both indexes accelerate significantly. By 2018, the Indexes were two times higher than the historical peak in 2008.

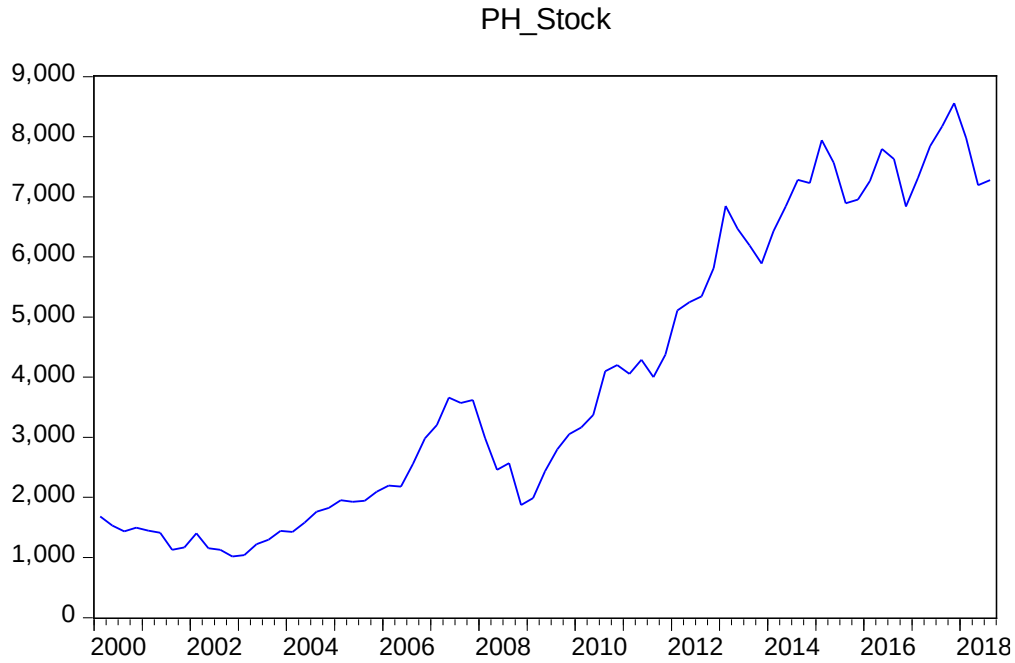
The second variable is the local quarterly policy interest rates, which are decided by the local central banks. Its change will exert an effect on saving and investment decisions. For the third variable, it uses the local inflation rate. It is constructed as the quarterly change of Consumer Price Index (CPI). In addition, local Gross Domestic Product (GDP) is used to represent the living standards of a nation, as it calculated the market value of all the final goods and services produced of a nation within a period of time.

Figure 7 – Quarterly price of Thailand SET Index



Source: Thomson Reuters Eikon

Figure 8 – Quarterly price of Philippines PSEi Index

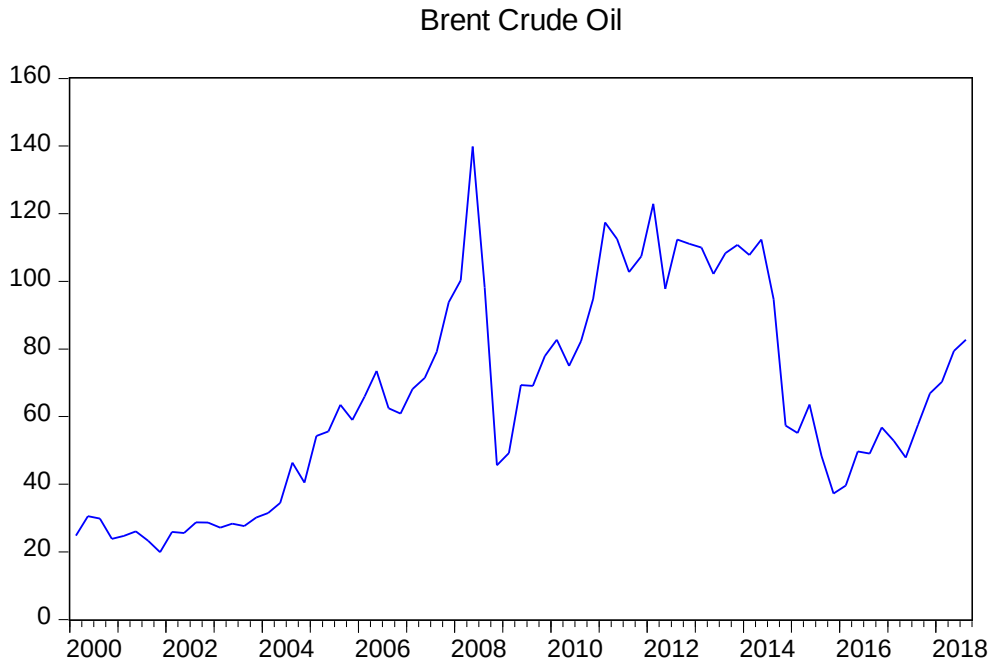


Source: Thomson Reuters Eikon

The final variable is the Price of Global Oil, which would be represented by the quarterly futures price of Brent Crude Oil. It is the most famous and globalized trading sweet light crude oil and it is extracted from the North Sea. The Brent Crude Oil is

largely adopted by the producers in Asia in the early 2000s. Besides, the outstanding crude oil benchmark - WTI Oil would be used as a part of robustness check. Figures 9 and 10 show the trend of quarterly price of Brent Crude Oil futures and the quarterly price of WTI Oil futures. They are moving analogously with glance over the figures. Both of them were having a great upward trend from 2004 to 2008 but turned around during the global financial crisis of 2007–2008. The historical highest level were both between 2006-2008 and it seems that there were a new upward trend after 2017.

Figure 9 – Quarterly price of Brent Crude Oil future



Source: Thomson Reuters Eikon

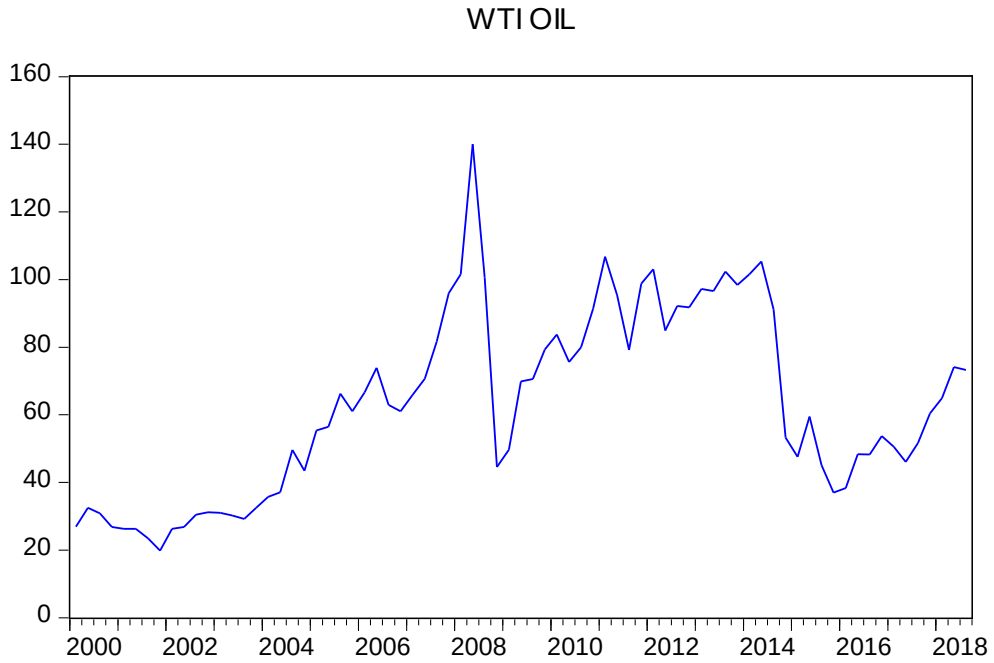
Table 4 – Correlations among selected variables of Thailand

	D(TH_STOCK)	D(TH_INT)	D(TH_INF)	D(TH_USDGDP)
D(TH_STOCK)	1			
D(TH_INT)	-0.1047	1		
D(TH_INF)	-0.2091	0.0726	1	
D(TH_USDGDP)	0.5085	0.0390	-0.2976	1

Table 5 – Correlations among selected variables of Philippines

	D(PH_STOCK)	D(PH_INT)	D(PH_INF)	D(PH_USDGDP)
D(PH_STOCK)	1			
D(PH_INT)	0.0184	1		
D(PH_INF)	-0.1749	0.3437	1	
D(PH_USDGDP)	0.4643	-0.1619	-0.3540	1

Figure 10 – Quarterly price of WTI Oil future



Source: Thomson Reuters Eikon

Before going into the analysis part, stationary test – unit root test must be done in order to avoid the spurious result. It sets Null hypothesis (H_0): $\theta = 0$ and the alternative hypothesis (H_1) is: $\theta \neq 0$. According to Table 6, as all the variable tested t-statistics are larger than the critical t-statistics; thus we do not reject the Null hypothesis and therefore these variables are non-stationary. In this case, we would take a first difference for the non-stationary data and test again. Obviously, all the variables tested t-statistics become smaller than -3.476 and thus rejected the Null hypothesis (H_0), meaning that all variables have no unit root and become stationary. Thus, all the data used in the analysis part would be first-differenced variables.

Table 6 – Augmented Dickey-Fuller (ADF) Test Results

Abbrev.	Level (Trend and intercept)	1st difference (Trend and intercept)
TH_STOCK	-2.75953	-7.08182*
TH_INT	-2.66574	-5.07991*
TH_INF	-0.783367	-7.90920*
TH_USDGDP	-2.30744	-8.48307*
PH_STOCK	-2.93586	-6.98995*
PH_INT	-2.77571	-8.09391*
PH_INF	-2.11299	-5.32942*
PH_USDGDP	-3.21717	-7.20974*
BRENT_CRUDE_OIL	-2.14809	-7.51325*
WTI_OIL	-1.81092	-8.15990*

The optimal lag is determined by SIC criteria at a maximum lag of 11 quarters.
* significant at 5% level;

5. Empirical Results

5.1 VAR model

Table 7 – VAR Lag Order Selection Criteria of Thailand

Lag	LR	FPE	AIC	SC	HQ
0	-2156.35	NA	1.51e+21	60.1209	60.3739
1	-2121.62	63.6795*	9.01e+20*	59.6005*	60.3594*
2	-2116.44	8.92219	1.22e+21	59.9011	61.1659
* indicates lag order selected by the criterion					
LR: sequential modified LR test statistic (each test at 5% level)					
FPE: Final prediction error					
AIC: Akaike information criterion					
SC: Schwarz information criterion					

Table 8 – VAR Lag Order Selection Criteria of Philippines

Lag	LR	FPE	AIC	SC	HQ
0	-2222.15	NA	9.42e+21	61.9486	62.0493
1	-2203.23	34.6857*	8.70e+21*	61.8675*	62.1696
2	-2191.015	21.0378	9.72e+21	61.9726	62.4762
* indicates lag order selected by the criterion					
LR: sequential modified LR test statistic (each test at 5% level)					
FPE: Final prediction error					
AIC: Akaike information criterion					
SC: Schwarz information criterion					

According to the result of Table 6, VAR model in this paper will include first difference variables. After solving the unit root test problem, the lag length of the VAR model would be the following question as the analysis result would be affected by different lag length. From Tables 7 and 8, the testing result of Thailand and Philippines are also showing the sequential modified LR test statistic (LR), final prediction error (FPE) and Akaike information criterion (AIC) suggest that the optimal lag is one. Therefore, for both VAR model of Thailand and Philippines, they should both constructed as:

$$Y_t = \beta_0 + \beta_i Y_{t-1} + \alpha_i X_t + u_t$$

where $Y_t, \beta_0, \beta_i, Y_{t-1}, \alpha_i$ and u_t are a vector in 4×1, X_t is a variable which representing the D(BRENT_CRUDE_OIL) at time t-1. Therefore, the VAR (1) model of Thailand is established as:

$$\begin{bmatrix} D(TH\_STOCK) \\ D(TH\_INT) \\ D(TH\_INF) \\ D(TH\_USDGDP) \end{bmatrix}_t = \begin{bmatrix} C_1 \\ C_2 \\ C_3 \\ C_4 \end{bmatrix} + \begin{pmatrix} \beta_{1,1} & \cdots & \beta_{4,1} \\ \vdots & \ddots & \vdots \\ \beta_{1,4} & \cdots & \beta_{4,4} \end{pmatrix} \begin{bmatrix} D(TH\_STOCK) \\ D(TH\_INT) \\ D(TH\_INF) \\ D(TH\_USDGDP) \end{bmatrix}_{t-1} +$$

$$\begin{bmatrix}\alpha_1\\ \alpha_2\\ \alpha_3\\ \alpha_4\end{bmatrix}\text{D(BRENT\_CRUDE\_OIL)}_t + \begin{bmatrix}u_1\\ u_2\\ u_3\\ u_4\end{bmatrix}_t$$

And the VAR(1) model of Philippines is established as:

$$\begin{bmatrix} D(PH\_STOCK)\\ D(PH\_INT)\\ D(PH\_INF)\\ D(PH\_USDGDP)\end{bmatrix}_{\text{t}} = \begin{bmatrix}C_1\\ C_2\\ C_3\\ C_4\end{bmatrix} + \begin{pmatrix}\beta_{1,1} & \cdots & \beta_{4,1}\\ \vdots & \ddots & \vdots\\ \beta_{1,4} & \cdots & \beta_{4,4}\end{pmatrix}\begin{bmatrix} D(PH\_STOCK)\\ D(PH\_INT)\\ D(PH\_INF)\\ D(PH\_USDGDP)\end{bmatrix}_{\text{t}-1} +$$

$$\begin{bmatrix}\alpha_1\\ \alpha_2\\ \alpha_3\\ \alpha_4\end{bmatrix}\text{D(BRENT\_CRUDE\_OIL)}_t + \begin{bmatrix}u_1\\ u_2\\ u_3\\ u_4\end{bmatrix}_t$$

Table 9 – Parameter Estimation for the Thailand VAR (1) Model with Brent Crude Oil

	D(TH_STOCK)	D(TH_INT)	D(TH_INF)	D(TH_USDGDP)
D(TH_STOCK(-1))	0.90419	2.89880**	0.21494	2.56672**
D(TH_INT(-1))	-1.30629	5.40793**	-0.04311	-0.03888
D(TH_INF(-1))	-0.12156	5.06247**	1.25001	-0.16557
D(TH_USDGDP(-1))	-0.21476	-2.46666^^	0.74353	-1.53234
C	1.59593	-2.28515^^	3.94506**	1.93868*
D(BRENT_CRUDE_OIL)	3.36626**	1.78873*	9.26141**	1.39140

** positive significant at 5% level; * positive significant at 10% level;
^^ negative significant at 5% level; ^ negative significant at 10% level

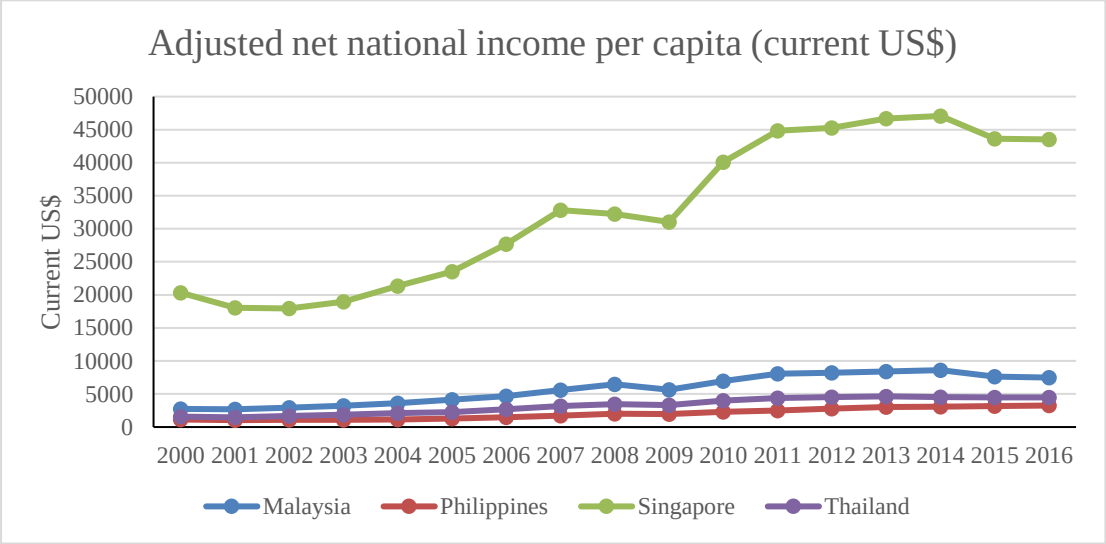
Table 9 shows the results of VAR (1) Model with Brent Crude Oil of Thailand. As t-test was used in the VAR (1) model, the critical t-statistics would be 1.67 in 10% significant level and 2.00 in 5% significant level. The followings are the result of Thailand VAR (1) Model with Brent Crude Oil:

First, D(TH_STOCK (-1)) and D(TH_INF(-1)) are significant variables to explain D(TH_INT) at 5% level. It's well known that while the market is being over-heated or over-calmed, most of the central banks in the world would change the interest rate in order to turn the market into an ideal direction. It is because one of the major duty of each central bank is dismissing the pressure of over-inflation or over-deflation situation of the society, which generated by local asset and stock price movements. Changing the interest rate is a great significant monetary policy to stimulate or cool down the

market as it would change the cost of production and investment. For example, when the interest rate decrease, the desire by households and businessmen would raise their spending and investment and thus stimulate the financial market and also the inflation rate. Therefore, central banks would raise the interest rate during over-inflation (asset price and stock market boom sharply) or reduce the interest rate during over-deflation (asset price and stock market bust sharply). A paper about Monetary Policy And Asset Price Volatility has been published by Bernanke, B., & Gertler, M. (2000), the paper pointed "Because inflation targeting both helps to provide stable macroeconomic conditions and also implies that interest rates will tend to rise during (inflationary) asset price booms and fall during (deflationary) asset price busts, this approach may reduce the potential for financial panics to arise in the first place." Similarly, for Thailand, when the stock market and inflation rate were raising and going to be higher than the inflation target set by the central bank, the interest rate would therefore react positively under the control of central bank, vice versa.

Second, according to the Table 9, it unexpectedly shows that D(TH_INT(-1)) is not a variable that significantly affects D(TH_STOCK) and even D(TH_INF), which means the change in interest rate does not bring a significant effect on the economy market. A step further, this relationship can also show that controlling interest rate might not be a great method for affecting the financial market and controlling the inflation in Thailand. One of the available reasons to explain this rarely circumstance is that Thailand is a developing country with low national income per capita and low interest rate pass-through. According to Figure 11, Thailand has low national income per capita while comparing with Singapore and Malaysia, where the annual national income per capita of Thailand was only USD 6,595. In the paper "Monetary policy and the transmission mechanism in Thailand", it pointed out a that when interest rates fall, the desire by households to raise their spending is limited by their low current earnings (Disyatat & Vongsinsiriku. 2003). This might be a possible reason to explain why the D(TH_INT(-1)) is not a significant variable affecting the D(TH_STOCK) and the D(TH_INF) as the motivation generated by interest rate cannot affect the citizens with low current earning and wealth.

Figure 11 – Adjusted net national income per capita (current US$)



Source: World Bank Group

Besides the reason of low current income and wealth, the low interest rate pass-through is a reasonable explanation for why the interest rate cannot significantly affect the stock market and inflation rate. Interest rate pass-through means how the changes in interest rate would directly affect the retail rates. This factor is important to Thailand as it has limited financial sources and thus the retail rates are equal to the opportunity cost of funds. According to Cottarelli & Kourelis, they tested the degree of pass-through and discovered the interest rate pass-through of Thailand is smaller and slower than most of the other countries, including Indonesia, Singapore and Philippines in the long-run (Cottarelli & Kourelis. 1994). It raised the problem that interest rate movement in Thailand cannot directly affect the opportunity cost of funds and might be a reason of why D(TH_INT(-1)) is not a variable which significantly affecting the D(TH_STOCK) and the D(TH_INF). From the insignificant relationship between the D(TH_INT(-1)), D(TH_STOCK) and the D(TH_INF), we can also say that, the monetary policy (especially the part of interest rate control) currently is not the best option for controlling the economy of Thailand, but the channels of credit, exchange rate or asset price might be better.

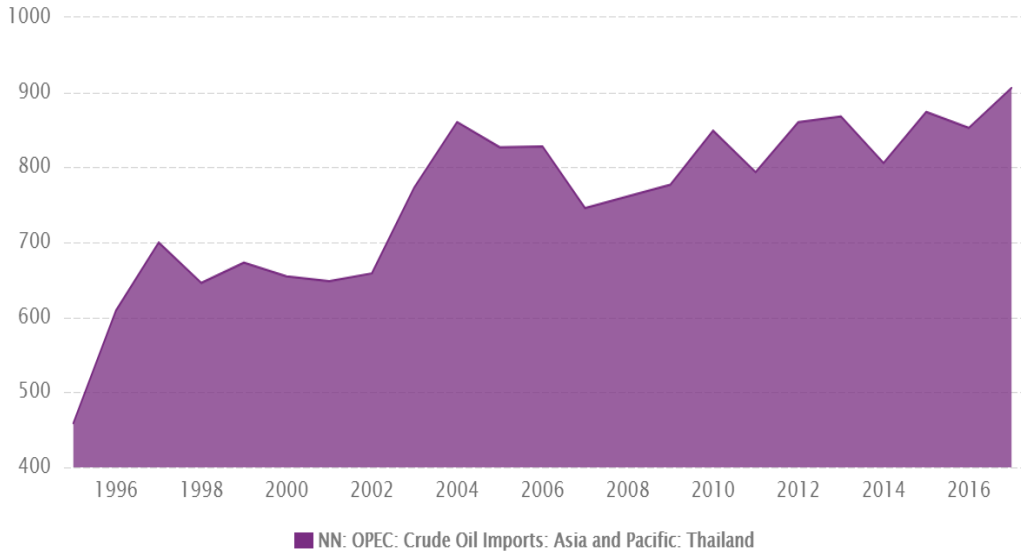
Third, D(TH_INF(-1)) is not a variable which significantly affects the D(TH_STOCK), it can be explained as inflation belongs to lagging data, which usually announced by the government monthly or quarterly. According to Tangjitprom (2011). “Inflation rate are insignificant to determine the stock return. The data about stock return, interest rate

or exchange rate can be known in daily basis but inflation rate or unemployment rate need to be waited until the responsible agency will report the calculated number." Therefore, it is commonly believed that inflation rate is not a significant estimator for explaining the stock market return due to lagged problem.

Fourth, it is not surprised that the D(TH_STOCK(-1)) is the 5% positive significant variables to explain the D(TH_USDGDP). It is because the stock market activities are part of Investment and thus the lagged stock market return would most likely to have a positive significant effect on the Gross Domestic Product.

More importantly, the D(BRENT_CRUDE_OIL) is a 5% positive significant variable to explain the D(TH_STOCK). Normally, when the global oil price is rising, the cost of production would increase and thus negatively affect the stock market, which means there should be a negative relationship between the change of oil price and the change of stock market return. However, it's not absolutely true for some developing countries and here are the reasons: First, the content of Thailand's stock benchmark index would affect the relationship between the oil and stock performance. According to the companies listed on the Thailand SET Index, there are more than 1/5 of companies are directly related to the in industry of Energy & Utilities and most of them are companies for oil generation or power generation with sustainable energy, such as Energy Absolute Pcl. (Providing Liquid fuel, Solar and wind power), Glow Group (Electricity Generating via gas and coal-fired and solar power) and Electricity Generating Pcl. (Generating electricity using several fuel sources such as natural gas, liquefied natural gas, coal, biomass, hydro, solar, wind, and geothermal) etc. Therefore, when the oil price rose, the revenue and the stock price of these companies would also increased, thus affecting the change of stock index positively. Moreover, from 2000 to now, Thailand is still classified as a developing country. The oil import number might be a great evidence to show even the price of oil rises, the companies would keep on import more for production. The oil import numbers of Thailand kept raising from 2000 to now. According to Figure 12, we can easily see that the imports of crude oil by Thailand kept raising, from 458.900 barrel per day in 1995 to 906 barrel per day in 2017.

Figure 12 – Thailand's Crude Oil: Imports from 1995 to 2017



Source: Organization of the Petroleum Exporting Countries

Furthermore, according to Table 9, the D(BRENT_CRUDE_OIL) is a 5% positive significant variable to explain the D(TH_INF) but only 10% positive significant to explain the D(TH_INT). According to the paper wrote by Cologni, A., & Manera, M. (2008), they raised that most of the countries, the impact of unexpected oil price movement would bring shocks on interest rates and also linking with the Fisher effect, the interest rates shocks would finally affect the inflation rate. Therefore, the effect of change in Brent crude oil price on the change in interest rate should be as significant as the change in inflation rate, but it's not shown in the test's result. For this situation, one of the possible reason might be the inflation of Thailand is mainly dominated by the cost-push factors but not by the demand-pull factors. Cost-push inflation means the inflation happened mainly due to the increases in the cost of wages and raw materials. According to Jongwanich, J., & Park, D. (2009), the empirical analysis result shows developing Asia's countries current inflation surge is related to external oil, food price shocks, but more related to excess aggregate demand and inflationary expectations. In this case, the change in price of Brent oil might also gave an inflationary expectation to the Thailand citizens and thus affecting the inflation more significantly than the interest rate.

Table 10 – Parameter Estimation For the Philippines VAR(1) Model with Brent Crude Oil

	D(PH_STOCK)	D(PH_INT)	D(PH_INF)	D(PH_USDGDP)
D(PH_STOCK(-1))	0.89945	-0.86541	-2.96879^^	1.79780*
D(PH_INT(-1))	0.34351	0.17533	0.74823	-0.27211
D(PH_INF(-1))	-1.50046	0.69875	4.86637**	-0.52552
D(PH_USDGDP(-1))	0.35598	0.16048	2.55873**	-0.01139
C	1.96423*	-0.95443	4.29194**	1.73765*
D(BRENT_CRUDE_OIL)	0.37917	-0.76089	5.90285**	0.77216

** positive significant at 5% level; * positive significant at 10% level;

^^ negetive significant at 5% level; ^ negetive significant at 10% level

Table 10 shows the results of VAR(1) Model with Brent Crude Oil of Philippines. Obviously, the VAR(1) result for Philippines is different from the Thailand counterpart. As mentioned before, when the stock market and the economy situation are going to be over-heated, most of the countries' central bank would control the situation through adjusting the interest rate via monetary policy. However, as shown in the Table 10, the D(PH_STOCK(-1)) and the D(PH_INF(-1)) are not significant to explain the D(PH_INT), which are totally contrary to the result found in Thailand. This circumstance matched the result raised by Bautista (2003), who pointed out that "Except Philippines all other countries show significant negative relationship either Interest Rates with Share price or Changes of Interest Rate with Changes of Share Price or both." One of the possible reasons for explaining this insignificant relationship is that Philippines' monetary policy failed to control the stock market and inflation rate, but only the exchange rate. According to the paper wrote by Yap (1996), it showed that starting from 1970 to 1995, the Philippines government was kept controlling the domestic economy and financial market through tight monetary and fiscal policy; however, according to the viewpoint raised by Gochoco-Bautista and Bautista (2005), Philippines attempted to maintain a stable and strong currency and control the inflation rate at the same time, but given the difficulties of attaining simultaneous monetary and exchange rate targets when capital is internationally mobile, it resulted in a relatively higher and more variable rates of inflation. Therefore, the empirical results in Table 10 support the viewpoint above.

Furthermore, as shown in Table 10, it shown that, D(PH_USDGDP(-1)) and D(BRENT_CRUDE_OIL) are 5% positive significant variables to explain the D(PH_INF). It means when the change of crude oil and lagged change of GDP raised, the change of inflation rate would follow positively. It might be explained by the viewpoint mentioned by Jongwanich and Park (2009) in paper "Inflation in developing Asia", Philippines is a country with limited fuel subsidies and thus the degree of oil price pass-through to consumer prices is higher. It means that when the oil price shock increased the cost of production, the companies would relatively transfer more the cost to the consumer and finally push-up the inflation rate.

More importantly, opposite result is found in Philippines, where the D(BRENT_CRUDE_OIL) is not a significant variable to explain the D(PH_STOCK). For Thailand, there are lots of sustainable energy list companies being in the Thailand's stock benchmark index; thus, when the change of Brent Crude Oil raised, the price of substitute – sustainable energy would raise at the same time and finally lead to a positive effect on the D(TH_STOCK). However, as shown in Table 11, there are only 4 energy related companies listed on the Philippines PSEi Index, the ratio is far less than the Thailand and supports the fact that D(BRENT_CRUDE_OIL) is not a significant variable to explain the D(PH_STOCK).

Table 11 – Energy related companies listed on PSEi Index (2019)

Name	Business
Aboitiz Power Corp (https://aboitizpower.com/)	Generating Run-of-river hydroelectric, Large hydroelectric power
First Gen Corporation (https://www.firstgen.com.ph/)	Clean and renewable energy
Manila Electric Company (https://www.meralco.com.ph/#toggle-children)	Electric
Semirara Mining And Power Corporation (http://www.semiraramining.com/)	Coal produce

Furthermore, as shown in the Figure 6, although the imports of crude oil exceed the exports of crude oil in Philippines, the gap is much smaller than the Thailand's gap. It reflects the fact about the Philippines dependency on the crude oil is much lower than

Thailand and thus the shock of crude oil cannot significantly affect the stock market return in Philippines.

5.2 Robustness Check Model

As mentioned in Methodology, robustness check would be performed for confirming the accuracy of VAR(1) model of Philippines above. First, generate a VAR(1) model with the price of oil as an endogenous variable. As shown in Table 12, the result double confirmed most of the relationship within the VAR(1) model of Philippines in Table 10. The change of interest rate is still affecting significantly by the lagged stock return, lagged change of local interest rate, the lagged change of local GDP. The only meaningful difference between Tables 12 and 10 is the return of Brent crude oil futures no longer being a 5% significant variable to affect the change of local interest rate.

Table 12 – Parameter Estimation for the Philippines *VAR(1)* Model with using the price of oil as an endogenous variable

	D(PH_STOCK)	D(PH_INT)	D(PH_INF)	D(PH_USDGDP)	D(BRENT_CRUDE_OIL)
D(PH_STOCK(-1))	0.78862	-0.95907	-3.29201^^	1.70277*	-1.31129
D(PH_INT(-1))	0.41182	0.63545	0.23880	-0.39627	-0.85637
D(PH_INF(-1))	-1.61061	-0.45258	2.04142**	-0.39747	-1.32632
D(PH_USDGDP(-1))	0.31565	-0.32214	2.78705**	0.16232	1.37406
D(BRENT_CRUDE_OIL)	0.61796	1.82460*	1.34720	-0.14230	1.13597
C	2.03890**	0.03148	4.04403**	1.47372	1.10449

** positive significant at 5% level; * positive significant at 10% level;

^^ negative significant at 5% level; ^ negative significant at 10% level

Second, by using another benchmark crude oil futures – WTI crude oil futures, for confirming the accuracy of VAR(1) models of Thailand and Philippines. As shown in Tables 13 and 14, all 5% significant relationship demonstrated in Tables 9 and 10 are confirmed to be correct. Therefore, the relationship between variables shown in Tables 9 and 10 are highly reliable.

Table 13 – Parameter Estimation For the Thailand VAR(1) Model with WTI Crude Oil

	D(TH_STOCK)	D(TH_INT)	D(TH_INF)	D(TH_USDGDP)
D(TH_STOCK(-1))	0.95403	2.92714**	0.35217	2.61081**
D(TH_INT(-1))	-1.10651	5.40790**	0.43313	-0.07422
D(TH_INF(-1))	-0.19249	5.00252**	1.01667	-0.19506
D(TH_USDGDP(-1))	-0.39584	-2.54598^^	0.23627	-1.56936
C	1.69897	-2.21839^^	4.09596**	1.97155*
D(BRENT_CRUDE_OIL)	3.29350**	1.59982	8.67834**	0.72361

** positive significant at 5% level; * positive significant at 10% level;

^^ negative significant at 5% level; ^ negative significant at 10% level

Table 14 – Parameter Estimation For the Philippines VAR(1) Model with WTI Crude Oil

	D(PH_STOCK)	D(PH_INT)	D(PH_INF)	D(PH_USDGDP)
D(PH_STOCK(-1))	0.91246	-0.83482	-3.04761^^	1.73922*
D(PH_INT(-1))	0.37011	0.18109	0.87238	-0.30675
D(PH_INF(-1))	-1.46468	0.68721	5.03967**	-0.53990
D(PH_USDGDP(-1))	0.34050	0.12264	2.63900**	0.06139
C	1.94245*	-0.94975	4.14382**	1.74596*
D(BRENT_CRUDE_OIL)	0.49986	-0.60256	5.83177**	0.41881

** positive significant at 5% level; * positive significant at 10% level;

^^ negetive significant at 5% level; ^ negetive significant at 10% level

6. Conclusions

In this research, it investigates how the benchmark of global oil price and several macro-economic variables potentially affect the price of benchmark index in Thailand and Philippines stock markets. VAR model is applied in the research, the result shows that in Thailand, the change in oil future price has a significant effect to the benchmark index return, the change in inflation rate and change in interest rate. In Philippines, the change in oil future price is having a significant effect to the change in inflation rate but not to the benchmark index return. It is believed to be related to the index structure and dependency on crude oil.

To conclude, our paper takes the first step to probe the stock market reaction to the global oil price in ASEAN, which is a huge financial market with expanding potential. For future research, it will be meaningful and fascinating to further investigate how the price of energy products would affect ASEAN countries.

References

Ahmad, M. I., Rehman, R. U., & Raoof, A. (2010). Do interest rate, exchange rate effect stock returns? A Pakistani perspective. International Research Journal of Finance and Economics, 50, 146-150.

Alam, M. D., & Uddin, G. (2009). Relationship between interest rate and stock price: empirical evidence from developed and developing countries.

Almekinders, G., Mourmouras, M. A., Zhou, M. J. P., & Fukuda, S. (2015). ASEAN financial integration (No. 15-34). International Monetary Fund.

Alvarez-Ramirez, J., Soriano, A., Cisneros, M., & Suarez, R. (2003). Symmetry/anti-symmetry phase transitions in crude oil markets. Physica A: Statistical Mechanics and its Applications, 322, 583-596.

ASEAN Centre for Energy. (2018). How ASEAN Should Respond to Oil Price Hike. Retrieved from http://www.aseanenergy.org/blog/how-asean-should-respond-to-oil-price-hike/

Association of Southeast Asian Nations (ASEAN). (2018), OPEC Annual Statistical Bulletin 2017. Retrieved from https://www.opec.org/opec_web/static_files_project/media/downloads/publications/ASB2017_13062017.pdf

Basher, S. A. & Sadorsky, P. (2006). Oil price risk and emerging stock markets. Global Finance Journal, 17, 224-251.

Bautista, C. C. (2003). Interest rate-exchange rate dynamics in the Philippines: a DCC analysis. Applied Economics Letters, 10(2), 107-111.

Bernanke, B., & Gertler, M. (2000). Monetary policy and asset price volatility (No. w7559). National bureau of economic research.

Bhattacharyay, B. N. (2009). Infrastructure development for ASEAN economic integration.

Birz, G., & Lott Jr, J. R. (2011). The effect of macroeconomic news on stock returns: New evidence from newspaper coverage. Journal of Banking & Finance, 35(11), 2791-2800.

Ceicdata. (2018) Thailand Crude Oil: Imports. Retrieved from https://www.ceicdata.com/en/indicator/thailand/crude-oil-imports

Cottarelli, C., & Kourelis, A. (1994). Financial structure, bank lending rates, and the transmission mechanism of monetary policy (International Monetary Fund, Working Paper Number 94/39).

Diamond, P. A. (2000). What stock market returns to expect for the future. Soc. Sec. Bull., 63, 38.

Dickey, D. A., & Fuller, W. A. (1979). Distribution of the estimators for autoregressive time series with a unit root. Journal of the American statistical association, 74(366a), 427-431.

Disyatat, P., & Vongsinsirikul, P. (2003). Monetary policy and the transmission mechanism in Thailand. Journal of Asian Economics, 14(3), 389-418.

Filis, G., Degiannakis, S., & Floros, C. (2011). Dynamic correlation between stock market and oil prices: The case of oil-importing and oil-exporting countries. International Review of Financial Analysis, 20(3), 152-164.

Gochoco-Bautista, M. S., & Bautista, C. C. (2005). Monetary policy and exchange market pressure: The case of the Philippines. Journal of Macroeconomics, 27(1), 153-168.

Gultekin, N. B. (1983). Stock market returns and inflation forecasts. The Journal of Finance, 38(3), 663-673.

Huang, N. E., Wu, M. L., Qu, W., Long, S. R., & Shen, S. S. (2003). Applications of Hilbert–Huang transform to non-stationary financial time series analysis. Applied stochastic models in business and industry, 19(3), 245-268.

Huang, R. D., Masulis, R. W., & Stoll, H. R. (1996). Energy shocks and financial markets. Journal of Futures Markets: Futures, Options, and Other Derivative Products, 16(1), 1-27.

Jongwanich, J., & Park, D. (2009). Inflation in developing Asia. Journal of Asian Economics, 20(5), 507-518.

Kanchana, K., & Unesaki, H. (2014). ASEAN Energy Security: An indicator-based assessment. Energy Procedia, 56, 163-171.

Organization of the Petroleum Exporting Countries. (2017) OPEC Annual Statistical Bulletin Retrieved from https://www.opec.org/opec_web/static_files_project/media/downloads/publications/ASB2017_13062017.pdf

Rao-Nicholson, R., Salaber, J., & Cao, T. H. (2016). Long-term performance of mergers and acquisitions in ASEAN countries. Research in International Business and Finance, 36, 373-387.

Ritter, J. R. (2005). Economic growth and equity returns. Pacific-Basin Finance Journal, 13(5), 489-503.

Sadorsky, P. (1999). Oil price shocks and stock market activity. Energy economics, 21(5), 449-469.

Schwert, G. W. (1981). The adjustment of stock prices to information about inflation. The Journal of Finance, 36(1), 15-29.

Sims, C. A. (1980). Macroeconomics and reality. Econometrica: Journal of the Econometric Society, 1-48.

Tangjitprom, N. (2011). Macroeconomic factors of emerging stock market: the evidence from Thailand. International Journal of Financial Research, 3(2), 105-114.

The Philippine Stock Exchange, Inc. (2011) Policy On Index Management. Retrieved from https://www.pse.com.ph/resource/filetemplate/file/pseindexguide.pdf

The Stock Exchange of Thailand. (2018) History & Roles. Retrieved from https://www.set.or.th/en/about/overview/history_p1.html

The Stock Exchange of Thailand. (2018) Set50 & Set100 Index Constituents. Retrieved from https://www.set.or.th/th/market/files/constituents/SET50_100_H1_2019.pdf

World Bank, World Development Indicators. (2017). Adjusted net national income per capita (current US$). Retrieved from https://data.worldbank.org/indicator/NY.ADJ.NNTY.PC.CD?view=chart

World Bank, World Development Indicators. (2017). Listed domestic companies, total. Retrieved from https://data.worldbank.org/indicator/CM.MKT.LDOM.NO?view=chart

World Bank, World Development Indicators. (2017). Market capitalization of listed domestic companies (current US$). Retrieved from https://data.worldbank.org/indicator/CM.MKT.LCAP.CD?view=chart

World Bank, World Development Indicators. (2017). Stocks traded, total value (% of GDP). Retrieved from https://data.worldbank.org/indicator/CM.MKT.TRAD.GD.ZS?view=chart

Yap, J. T. (1996). Inflation and economic growth in the Philippines (No. 1996-11). PIDS Discussion Paper Series.

Yu, L., Wang, S., & Lai, K. K. (2008). Forecasting crude oil price with an EMD-based neural network ensemble learning paradigm. Energy Economics, 30(5), 2623-2635.

Biography of author(s)

Edward Chi-Ho Tang
Department of Economics and Finance, Hong Kong Shue Yan University, Hong Kong

Edward Tang is an Associate Professor at the Department of Economics and Finance of Hong Kong Shue Yan University. He obtained PhD at the City University of Hong Kong. His research interests include real estate economics and empirical asset pricing. He has published many articles in Contemporary Economic Policy, International Real Estate Review, Journal of Macroeconomics, Pacific Economic Review, Regional Science and Urban Economics, and Singapore Economic Review. Also, he was invited to be one of the guest editors of the Singapore Economic Review (Special Issue on Asian Consumer Economics). In 2020-2021, he was the Principal Investigator of a project funded under RGC's Faculty Development Scheme.

Jacky Ho-Man Lau

Jacky Lau, who graduated with First Class Honours in Economics and Finance from HKSYU, currently holds the position of Senior Change Specialist in a Hong Kong-listed company. He focuses on internal digital transformation within the organization.

Chapter 3
Is it Worthwhile to Study Competitiveness Indices? Evidence from the Causal Relationship between Global Competitiveness Index and Economic Growth Rate

Chun-Kei Tsang
Sung-Ko Li

Abstract
This paper justifies the use of competitiveness indices in empirical studies by examining the causal relationship between the Global Competitiveness Index (GCI) and economic growth rate. A competitiveness map is introduced to identify outperformers of competitiveness and thus investment opportunities. Adopting panel Granger-causality test to examine the causal relationship between GCI and economic growth rate in the period 2006-2015, this paper finds evidence of two-way causality between GCI and economic growth rate of most countries in the world. Such causal relationship breaks down in developing countries. It is explained by the effectiveness of resource allocation mechanism to generate competitiveness. The paper further presents a competitiveness map based on data envelopment analysis to analyze the effectiveness in generating competitiveness. This information is used to identify best performing countries based on competitiveness. The study supports the use of GCI to analyze the business environment in different countries for making investment decisions. This approach can be extended to test other existing competitiveness indices. The competitiveness map illustrated in the paper provides an easy and effective screening tool to identify outperformers in terms of competitiveness.

1. Introduction

Porter's (1990) framework of competitiveness and its extensions have been widely applied to the field of business and economics. Researchers believe that there are positive impacts of competitiveness on economic growth and firm performance (see, for example, Cho and Moon, 2013; Martins, 2013; Manzur et al., 1999). Specifically, China and India are two similar countries in that they are large, populous, continental economies that have gone through similar stages of transition and development over the past several decades. Yet China's economy significantly outperformed India's economy, especially in terms of foreign direct investment and economic growth. Schwab (2014, pp. 29 - 31) argued that the competitiveness divide between China and India could explain such differences in economic performance between these two countries. [ii]

[ii] While China's GDP per capita was lower than India's in 1991, China was four times richer in 2014. India and China ranked 48 and 34 in 2007, respectively. The rank differential has increased from 14 places to 43 with India and China ranked 71 and 28 in the Global Competitiveness Index 2014 - 2015 (Schwab 2014, p. 29), respectively.

The framework of competitiveness has been operationalized by constructing competitiveness indices. Some examples are: the global competitiveness index of the World Economic Forum, the world competitiveness ranking of IMD, the competitiveness index of Southeast Asian countries (Kao et al. 2008). Such indices explore more aspects of a country than a narrow focus on inputs and outputs (Peneder, 2016; Krugman, 1996). At the industry level, competitiveness usually refers to a set of indicators that may lead to the success of industry in the international market (see, for example, Braddorn and Hartley, 2007; Mitchell and Stewart, 2007). At the national level, although there are different kinds of measurements, competitiveness usually refers to a set of indicators that will create more prosperity for an economy, which results in a higher economic growth (Bris et al., 2014, p. 489-491; Frontier Economics Limited, 2013, p. 23; Ni, 2012, p. 21-23).

The positive effects of competitiveness on economic performance are supported by some empirical studies such as Li and Tsang (2018), Farinha et al. (2018a), Waheeduzzaman (2011), Fagerberg et al. (2007), and others. Individual aspects of competitiveness also can influence a country's economic growth. For examples, 'location and timing' could explain the difference of economic development between China and India (Prime, Subrahmanyam, and Lin, 2012); institutional environment is important for firm growth (Hadjikhani, Lee, & Ghauri, 2008); endowment of resources helps to exploit business opportunities (Grosse and Trevino, 2005); quality labor promote the development of innovative ideas (Barro, 1991).

The underlying assumption of the previous applications is: National competitiveness contributes to firm performance in the country, which in return drives economic performance of the whole economy. However, the usefulness of competitiveness indices is still under debate (see, for examples, Peneder, 2016; Hay, 2012; Lall, 2001). A less mentioned but important view is that the relationship between competitiveness and economic performance may go in the reverse direction in which competitiveness can be a result of economic performance. This has been noted by Bris et al. (2014, p. 493) in IMD World Competitiveness Yearbook. In the construction of the competitiveness indices, some determinants of economic performance are also included. [iii] On the other hand, each competitiveness index also consists of many components not directly related to economic performance.

Whether competitiveness can empirically forecast economic performance or vice versa has not been studied seriously in the literature. This paper uses the Global Competitiveness Index as a proxy of competitiveness to investigate the causality between competitiveness and economic performance. This study is significant because if a competitiveness index is able to forecast long-term economic performance, then it provides an effective tool for researchers and practitioners to study and identify

[iii] Appendix I lists examples of such determinants as components in several indices.

business opportunities across countries. Otherwise, the usefulness of constructing competitiveness indices is greatly reduced. Conversely, if better economic performance causes higher competitiveness, then the endogeneity of competitiveness must be considered in empirical studies. This paper further indicates that the causality pattern is different for developing and developed countries. Such a difference can be explained by the different abilities of developing and developed countries in transforming resources into competitiveness in. Finally, the information of studying competitiveness indices is useful to draw a competitiveness map for identifying investment opportunities.

2. Empirical design and Hypotheses

As mentioned previously, our primary objectives are to test whether competitiveness index empirically causes economic performance or vice versa. Thus, our hypotheses are:
Hypothesis 1 (H1): Competitiveness causes economic performance.
Hypothesis 2 (H2): Economic performance causes competitiveness.

If H1 is supported, it means economic performance is an outcome of competitiveness. Then researchers and practitioners may apply the concept of competitiveness to forecast the economic performance of a country and identify valuable business opportunities. On the other hand, if H2 is supported, it means economic performance is a cause of competitiveness. Then this relationship should be noticed in empirical studies when competitiveness indices are involved.

3. Data

This paper uses data from two sources: The competitiveness (C) in the analysis is represented by the Global Competitiveness Index (GCI) from the Global Competitiveness Report of the World Economic Forum. The economic performance (g) is reflected by the growth rate of the GDP per capita (constant 2005 US$) adopted from World Development Indicators of the World Bank. For data consistency and availability, the studied period is from 2006 to 2015 [iv] and 109 countries in the Global Competitiveness Report are covered.

In addition to testing the causality between economic performance and competitiveness for all countries as a group, we also study such relationship with respect to development stages. All countries in the data set are partitioned into three different subgroups. The GCI data already pre-defined three country groups, factor-driven economies (S1), efficiency-driven economies (S2), and innovation-driven economies (S3) and two

[iv] The values of GCI in the Global Competitiveness Report 2015 - 2016, for example, are treated as data in 2015. Since the methodology of GCI has been revised in recent years and the length of new GCI data is insufficient to carry out the study, only the original version of GCI data is included for data consistency.

transitional groups between S1 and S2, S2 and S3. [v] Since transitional groups have relatively small samples for conducting group individual tests, we combined them with their "higher" groups. Thus, in the follows, group S2 includes countries in transition from S1 to S2 and group S3 includes countries in transition from S2 to S3. The descriptive statistics of the variables are listed in Table 1:

Table 1: Descriptive Statistics

All (n = 1090)	Max	Min	Mean	Std
C	5.80	2.58	4.29	0.66
g	0.3303	-0.1887	0.0232	0.0404
S1 (n = 390)	Max	Min	Mean	Std
C	4.90	2.58	3.72	0.41
g	0.3303	-0.1887	0.0349	0.0416
S2 (n = 320)	Max	Min	Mean	Std
C	5.23	3.48	4.21	0.28
g	0.1292	-0.1386	0.0284	0.0364
S3 (n = 380)	Max	Min	Mean	Std
C	5.80	3.85	4.96	0.48
g	0.2564	-0.1515	0.0068	0.0368

4. Method

The test of causal relationship between two variables in time series data has been well-developed since it was introduced by Granger (1969). Starting in the 2000s, researchers have been testing Granger causality in panel data, see Habibullah and Eng (2006), Hartwig (2010, 2014), among others. To test hypothesis H1 of "Competitiveness (C) causes economic performance (g)", the null hypothesis of the relevant Granger causality test is "C does not Granger cause g". Given that both series are stationary, the null hypothesis can be rejected if the inclusion of lagged values of C significantly reduces the predictive error variance of g (Hamilton, 1994). In this case, competitiveness C is said to Granger-cause economic performance g and hypothesis H1 is supported by the data. The causality from g to C can be studied likewise and hypothesis H2 can be tested.

Although there are many modified versions of Granger-causality test, applying Granger-causality test in short panel data still relies on the classical Granger model. This paper adopts the approach proposed by Hartwig (2014), which was initiated by Holtz-Eakin et al. (1988). In the testing model, all regression coefficients of lagged g and C are assumed to be the same across various time periods and across different countries. All countries are classified into N different groups to represent their

[v] We note that the World Economic Forum has changed the methodology of GCI in recent years.

development stages. Also, the catching-up effect is further controlled by the initial output level of each country. [vi]

In order to test for pairwise Granger-causality between the two series C and g, it is necessary that they are stationary. We follow Hartwig's (2014) steps to test for unit root. The results of panel unit root tests are reported in Table 2.

Table 2: Test for unit root

H_0: Unit root in level	C		g	
	Stat.	Prob.	Stat.	Prob.
Levin, Lin & Chu t*	-13.08	0.0000	-24.40	0.0000
Im, Pesaran and Shin W-stat	-2.94	0.0000	-12.66	0.0000
ADF - Fisher Chi-square	292.28	0.0000	586.90	0.0000
PP - Fisher Chi-square	284.59	0.0000	624.30	0.0000

Table 2 shows that the null hypothesis of non-stationarity for C and g can be rejected. Thus C and g are stationary time series and the estimations of Granger causality using C and g are valid.

5. Results

5.1 Initial estimations

Pairwise Granger Causality is then tested for all countries, allowing for group-specific effects for the three groups (S1, S2, and S3), and including one time lag to five time lags in the regression equation. The results are presented in Table 3.

Table 3: Pairwise Granger Causality Tests of all countries with group specific effects (S1 cross-section=39, S2 cross-section=32, S3 cross-section=38, time: 2006-2015)

$C \nrightarrow g$		$g \nrightarrow C$		Lags	Obs.
9.3728	*	4.6886	*	1	987
6.8246	*	9.1693	*	2	872
7.9903	*	6.4458	*	3	763
2.2806		4.4541	*	4	654
3.8621	*	9.5909	*	5	545

Note: F-Statistic is displayed. * denote significance at the 5% level.
$A \nrightarrow B$: A not Granger Cause B

The first column of Table 3 is for testing hypothesis H1. The null hypothesis is that "C does not Granger cause g", which is rejected at 5% level of significance in four out of the five lag structures. This means that the null hypothesis can be rejected and the claim of H1 ("C causes g") is supported by the data. On the other hand, the results of testing the converse causal relation are shown in the second column. The null hypothesis that

[vi] See Appendix II for the detailed model setting.

"g does not Granger cause C" is rejected at 5% level of significance for all lags. Hypothesis H2 that "g causes C" can also be supported by the data.
In conclusion, both hypotheses H1 and H2 can be confirmed by the data. There is a two-way causal relationship between competitiveness and economic growth. Thus, forecasting economic performance using competitiveness index (GCI) is valid. Conversely, it is also valid that better economic performance leads to higher value of competitiveness index.

The rationale behind the first causal relationship is simple. If the competitiveness index reflects the potential capability of a country which contributes to firm performance in the country, then a higher economic growth rate is a natural consequence of a higher value of competitiveness index.

The impacts of economic growth on competitiveness index are more complicated. Higher economic growth rate can provide additional resources. On the one hand, such new resources can be used to produce more consumption goods. On the other hand, new resources can be devoted to promote the competitiveness of the country by nurturing a better society and creating new technologies. Whether additional resources brought by economic growth are used to enhance competitiveness is an investment issue. It depends on the mechanism of resource allocation in the society. Thus, theoretically higher economic growth rate may or may not bring forth higher competitiveness. Such a relationship deserves further investigation.

5.2 Estimations on developing and developed countries

We note that the factor-driven economies (group S1) and efficiency-driven economies (group S2) mainly focus on traditional production of manufactured goods and services. In contrast, implementing new technologies from research and development is emphasized in innovation-driven economies (group S3). This difference in economic structure may be critical for the relationship between economic performance and competitiveness as mentioned by Farinha et al. (2018b). Accordingly, all countries in the dataset are classified into two broad categories: developing countries (S1 and S2) and developed countries (S3). We believe that the ability to transform additional resources into competitiveness is relatively weak in developing countries. We further test for Pairwise Granger Causality for these two groups, and the results are reported in Tables 4.

The upper panel of Table 4 lists test results for developing countries. The null hypothesis of "C does not Granger cause g" in the first column can be rejected at 5% level of significance for all lag structures. On the other hand, there is no overwhelming evidence to reject the hypothesis of "g does not Granger cause C" in the second column. This hypothesis can be rejected only for the regression equations with two lags and five lags. We can conclude for developing countries that H1 is supported by the data while H2 is not. In other words, competitiveness Granger causes economic growth

rate in developing countries but not vice versa.

Table 4: Pairwise Granger Causality Tests for Institutions and Economic Growth

Developing Countries[#]					
$C \nrightarrow g$		$g \nrightarrow C$		Lags	Obs.
3.9296	*	2.4865		1	639
3.9669	*	4.0657	*	2	568
5.4814	*	2.4346		3	497
2.4676	*	2.3168		4	426
4.5314	*	4.3564	*	5	355
Developed Countries					
$C \nrightarrow g$		$g \nrightarrow C$		Lags	Obs.
9.4327	*	5.5821	*	1	342
6.4578	*	11.7095	*	2	304
5.1597	*	8.9136	*	3	266
2.7487	*	6.0935	*	4	228
0.9911		8.8381	*	5	190

Note: F-Statistic is displayed. * denote significance at the 5% level.
$A \nrightarrow B$: A not Granger Cause B
#Since two groups are involved, one dummy is included Pairwise Granger Causality Tests to capture group specific effects

The lower panel of Table 4 lists test results for developed countries. Both null hypotheses "C does not Granger cause g" and "g does not Granger cause C" can be rejected at 5% level of significance except for the regression equation with 5 time lags in the first column. The two-way causal relation in the previous section maintains for the developed countries.

Therefore, forecasting economic performance using competitiveness index is valid in both developing countries and developed countries. However, better economic performance only leads to a higher value of competitiveness index in developed countries but not developing countries. These results support the use of competitiveness indices in predicting economic performance and identifying business opportunities in both developing countries and developed countries. However, different results for H2 in developing countries and developed countries suggest there is a fundamental difference in economic structure between them. This difference should be noticed when using competitiveness indices. We will further study this difference and its implications in the following section.

5.3 Estimations on sub-indices

In order to have a clear picture of the relationship between competitiveness index and economic performance, we further estimate the results for different sub-indices of competitiveness. The GCI is constructed from three sub-indices, namely, "basic

requirements", "efficiency enhancers" and "innovation and sophistication factors". [vii] It is well-known from Porter (1990) that the needs in development shifts as a country develops. That means developing countries should focus more on basic requirements or efficiency enhancers while developed countries should focus more on efficiency enhancers or innovation and sophistication factors. We expect different results could be obtained from different sub-indices of competitiveness in different countries groups. Thus, we test for Pairwise Granger Causality for different sub-indices of GCI in developing and developed countries. The results are reported in Table 5:

Table 5: Pairwise Granger Causality Tests for Different Types of Institutions

Developing Countries#												
$C_A \nrightarrow g$		$g \nrightarrow C_A$		$C_B \nrightarrow g$		$g \nrightarrow C_B$		$C_C \nrightarrow g$		$g \nrightarrow C_C$		Lags	Obs.
3.8018		0.5389		1.9525		36.9541	*	0.2046		8.8595	*	1	639
3.4884	*	2.6810		2.2968		27.6713	*	0.6568		4.3568	*	2	568
6.1068	*	1.8835		3.3635	*	13.5865	*	0.7568		4.9293	*	3	497
3.4196	*	3.5049	*	1.1569		9.8461	*	0.4754		3.3658	*	4	426
5.1092	*	5.5012	*	1.5666		7.0209	*	1.1234		0.1748		5	355
Developed Countries													
$C_A \nrightarrow g$		$g \nrightarrow C_A$		$C_B \nrightarrow g$		$g \nrightarrow C_B$		$C_C \nrightarrow g$		$g \nrightarrow C_C$		Lags	Obs.
3.6575		0.0753		10.2608	*	17.2692	*	8.0459	*	14.2350	*	1	342
4.0908	*	8.5807	*	6.7339	*	14.3167	*	5.6987	*	13.7471	*	2	304
6.3519	*	5.1485	*	6.1057	*	10.9371	*	3.3286	*	9.7822	*	3	266
1.1315		2.7317	*	2.6363	*	8.9075	*	3.0509	*	7.0639	*	4	228
0.4209		7.3686	*	1.2457		6.6441	*	0.9655		3.1702	*	5	190

Note: F-Statistic is displayed. * denote significance at the 5% level.
C_A: Basic Requirements
C_B: Efficiency Enhancers
C_C: Innovation and Sophistication Factors
$A \nrightarrow B$: A not Granger Cause B
#Since two groups are involved, one dummy is included Pairwise Granger Causality Tests to capture group specific effects

The first and second columns in Table 5 show the relationship between basic requirements and economic growth rate in developing countries and developed countries. It shows that "basic requirements cause economic growth" only appears in developing countries, whereas "economic growth causes basic requirements" only appears in developed countries. The third and fourth columns show the relationship between efficiency enhancers and economic growth rate in developing countries and developed countries. Although economic growth Granger causing efficiency enhancers appears in both developing and developed countries, efficiency enhancers causing economic growth only appears in developed countries. The fifth and sixth columns show the relationship between innovation and sophistication factors and economic growth rate in developing countries and developed countries. Similar to the efficiency

[vii] See Appendix III for the details of sub-indices of GCI.

enhancers, the causality from innovation and sophistication factors to economic growth only appears in developed countries, whereas the causality from economic growth to innovation and sophistication factors appears in both developing and developed countries. Thus, forecasting economic performance by the basic requirements sub-index is only valid in developing countries, while forecasting economic performance by the sub-indices of efficiency enhancers and innovation and sophistication factors are only valid in developed countries. As completely different results are obtained for the three sub-indices, these results provide further information to predict economic performance and identifying business opportunities in developing countries and developed countries. For example, in considering investment in a developing country, one could pay special attention to the basic requirements sub-index besides the GCI.

5.4 Searching Investment Opportunities through Data Envelopment Analysis on Competitiveness

In the previous section, GCI and its sub-indices have been shown to be able to predict economic performance. The converse relation is said to be an empirical issue. The fundamental argument behind the causality from economic growth to competitiveness is that transforming economic growth to competitiveness requires a mechanism to allocate resources efficiently and appropriately. This refers to the effectiveness of the government of a country to enhance competitiveness. When competitiveness can cause economic growth as shown by the Granger causality tests in the previous section, enhancing competitiveness by mobilizing additional resources from economic growth can stimulate further growth in the future. Thus, the ability of putting resources in the right place to enhance competitiveness is also crucial for long-run sustainable growth. This has two implications: (i) Effective resources allocation is a condition of the causality from economic performance to competitiveness. (ii) Since efficient allocation of resources affects future economic growth, a good mechanism of resource allocation can be used as an additional criterion to supplement investment decisions.

This section investigates the reason behind the causal relation from economic growth to competitiveness in more details by applying the method of Data Envelopment Analysis (DEA). It also explores further the difference between developing and developed countries from the angle of resource allocation. A new tool is then introduced to supplement investment decisions.

5.5 The mechanism of transforming resources into competitiveness

Given some new resources generated from economic growth, such resources can be allocated in two different ways. On the one hand, new resources can be utilized to sectors not related to competitiveness. This will has minimal effect on future economic growth. On the other hand, the competitiveness of an economy can be reflected by various dimensions. Each dimension is a sector of the economy. New resources can be devoted to different sectors of the economy. This may increase competitiveness and can

generate future economic growth. Whether there is higher competitiveness and growth depends on the efficiency of allocating such resources and the appropriateness of such allocation.

Each pattern of competitiveness dimensions is called an economic structure. Behind each economic structure there is an allocation of resources. As competitiveness causes economic performance, there should exist an optimal economic structure that maximizes competitiveness and thus economic growth. For example, the resource allocation in an economy with a large manufacturing sector and a small service sector is very different from an economy with a small manufacturing sector and a large service sector. Thus, these two economies should have completely different optimal economic structures. Allocating resources according to the optimal economic structure is the best for future economic growth. A suboptimal structure indicates that there is room for higher economic growth by improving competitiveness through reallocating resources. Thus, allocating resources towards the optimal economic structure should be a major focus of economic policy (Skoorka, 2000).

Our view of the importance of resource allocation is consistent with conventional views in the literature. For example, Wong (2008) examined provinces of China and concluded that allocation of resources is also an important factor of growth. Another example is the hot debate of "curse of natural resources" on economic development. Daniele (2011) concluded that the effect of resources on economic growth strictly depends on national institutional characteristics. The economies of some oil-exporting countries are influenced by the fluctuations of the oil market. This reflects their inability to build up competitive industries using their oil money. The mechanism from allocation of resources to economic growth is explained in mainstream studies of economic growth by effective allocation of resources into appropriate sectors. For example, Lucas (1988) and Grossman and Helpman (1994) suggested that some resources should be allocated to physical capital and human capital accumulation, research and development and innovation, etc. In the framework of this paper and GCI, that is equivalent to directing resources to the pillar such as “higher education and training” and “innovation”. This increases the competitiveness of a country and then boosts economic growth.

There are twelve dimensions in the GCI (called pillars in the Global Competitiveness Report) represent various aspects of a country, such as infrastructure, macroeconomy, goods and labor markets, financial market, and others. The composition of these dimensions can be a good proxy to the economic structure of a country and can be used to study the effectiveness of resources allocation. By retrieving the information of subindexes from GCI, we will be able to compare the resource allocation of different countries under the competitiveness aspect.

5.6 Data envelopment analysis for competitiveness index

Base on the results in previous subsections, we suspect that the impacts of economic growth on competitiveness are different for countries under different mechanisms of resource allocation. Specifically, we question the ability of developing countries to direct additional resources to strengthen their competiveness. To confirm this, we adopt a new approach to study the GCI.

Borrowing the idea of Li and Tsang (2018), Li and Zhao (2015), and Bowen and Moesen (2011), we hypothesize that each country utilize resources to generate competitiveness. Each dimension of the GCI is treated as an output. Each weight used in the computation of the competitiveness index is regarded as the "price" of each dimension. Accordingly, the competitiveness index is like the "revenue" of a firm and can be evaluated by Data Envelopment Analysis (see, for example, Laureti and Viviani, 2011). To make developing and developed countries comparable, we further modify their model by incorporating a resource constrain, a country's GDP per capita (in natural log form) as an input. Using the variable returns to scale (VRS) frontier, we can compute an index of the *efficiency of overall competitiveness* (O_c) which measures the loss in competitiveness compare to the best performer.

As shown in Li and Tsang (2018) and Li and Zhao (2015), this efficiency of overall competitiveness can be eliminated by expanding all dimensions proportionally or by changing dimension mix. The first component is measured by the *efficiency of proportional competitiveness* (E_p) and the second component is measured by the *efficiency of dimension mix* (E_d). Thus, the potential of improving overall competitiveness as indicated by the efficiency of overall competitiveness (O_c) can be decomposed into the efficiency of proportional competitiveness (E_p) and the efficiency of dimension mix (E_d), i.e. $O_c = E_d E_p$. [viii] By definition, O_c, E_d, and E_p are greater than or equal to one, in which a larger value represents higher inefficiency. Given existing resources, $O_c > 1$ means that a country is possible to increase her competitiveness. This can be achieved in two ways: expanding all dimensions proportionally (if $E_p > 1$) or changing the relative proportions among dimensions (if $E_d > 1$). Specifically, E_p represents the efficiency of utilizing resources to achieve competitiveness whereas E_d represents the ability of allocating resources according to the optimal dimension mix. Thus, to generate competitiveness, a high value of E_p means a low efficiency of utilizing resources and a high value of E_d means a low efficiency of allocating resources correctly.

The annual geometric means of the efficiency scores for developing countries and

[viii] See Appendix IV for the derivation of O_c, E_d, and E_p.

developed countries in year 2011-2015 are reported in Table 6. [ix] The average efficiency of proportional competitiveness in the developing group (around 1.06) is significantly higher than that of the developed group (around 1.02). This means developing countries are farther away from the competitiveness frontier and have more rooms to catch-up the frontier countries. On the other hand, the average efficiency of dimension mix of the developing group (around 1.15) is also significantly higher than that of the developed group (around 1.10). This means the developing group also has more room for improvement in adjusting the dimension mix, which means a different economic structure is required for improving competitiveness. If the pattern of competitiveness dimensions reflects economic structure, our results confirm that developing countries are weak in directing additional resources to the right sectors to enhance competitiveness.

Table 6: Efficiency Scores for Two Country Groups

Year	2011	2012	2013	2014	2015
Efficiency of proportional competitiveness (E_p)	*	*	*	*	*
Developing countries	1.06	1.06	1.05	1.05	1.06
Developed countries	1.02	1.02	1.02	1.02	1.02
Efficiency of dimension mix (E_d)		*	*	*	*
Developing countries	1.13	1.14	1.14	1.14	1.17
Developed countries	1.10	1.10	1.10	1.10	1.10

Note: Geometric means are shown.
* denote significance difference between two groups at the 5% level in independent samples T-test.

5.7 The competitiveness map

As argued before, the efficiency of dimension mix reflect the ability of allocating resources to the right places. In the presence of economic growth, a country with high efficiency of dimension mix should be able to allocate any additional resources correctly. This implies higher competitiveness and more future economic growth. Therefore a country with higher efficiency of dimension mix is expected to have a sustainable economic growth in the long-run than another country with low efficiency of dimension mix. Seeking for global investment opportunities, a company can add higher efficiency of dimension mix as a complementary criterion.

Based on the decomposition of the GCI by DEA, we further map the two components of different countries for comparison. As the level of development (real GDP per capita) is already controlled in the process of decomposition, the E_p and E_d obtained are directly comparable. For illustration, the value of E_p and E_d are presented as 5-year average of 2011-2015 and inversed indices (i.e., ranged 0 to 1, where 1 is the best). We then map the $1/E_p$ and $1/E_d$ to identify investment opportunities (See Figure 1 and

[ix] Different dimension weights are used in different groups following the GCI report. Since dimension weights of transitional groups in older years are missing, only results for 2011 - 2015 are computed.

Appendix V). This diagram is called the *competitiveness map*.

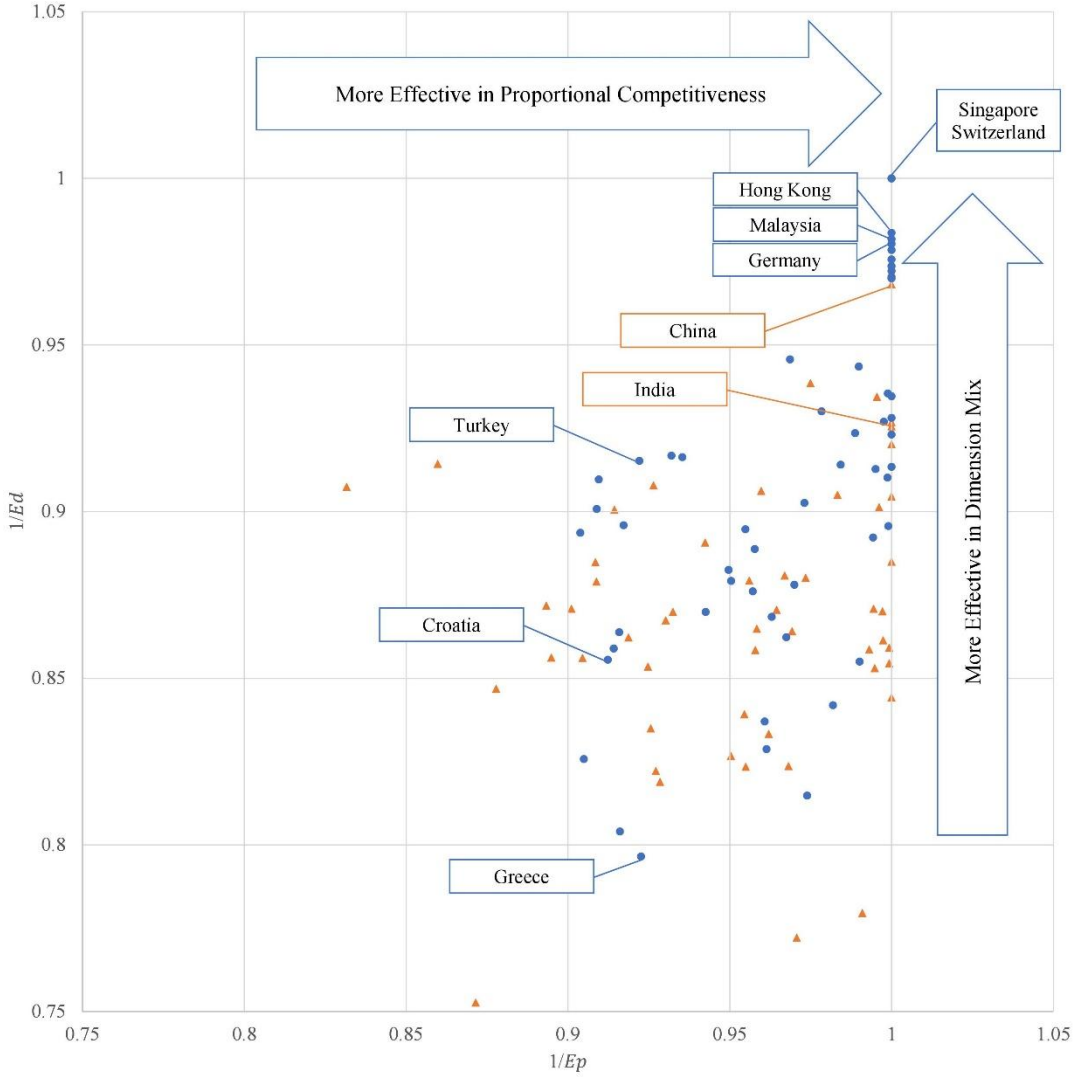
The competitiveness map, which based on decomposing the competitiveness index, can be used to identify outperformers in terms of proportional competitiveness and dimension mix. In Figure 1, moving rightward means improving the efficiency of proportional competitiveness whereas moving upward means improving the efficiency of dimension mix. For a country on the map, it is outperformed by any country in its upper-right region. Therefore, the best performing countries are in the upper-right corner of the competitiveness map whereas the worse performing countries are in the lower-left corner. The five best performing countries in terms of the efficiency of overall competitiveness (O_c) are identified in Figure 1: Singapore, Switzerland, Hong Kong SAR, Malaysia, and Germany. These countries are also identified by other rankings as good business opportunity. For example Forbes Best Countries for Business 2018 ranked Hong Kong SAR and Singapore as 3rd and 8th out of 161 countries [x], U.S.News & World Report Best Countries Ranking 2019 ranked Switzerland and Germany as 1st and 4th out of 80 countries [xi]. Moreover, we further incorporate an adjustment on resource constrain to overcome part of the drawback in which previous competitiveness rankings tend to overrate high income countries and underrate low income countries. Thus, our result also identifies Malaysia as good investment opportunity.

In practical applications, one may use the competitiveness map to compare some selected countries' investment opportunity. For instance, consider Greece, Croatia, and Turkey. They are all located in the Balkan region with a similar value of $1/E_p$ (0.92, 0.91, 0.92). However, for $1/E_d$, we have Greece (0.80) < Croatia (0.86) < Turkey (0.92). Hence Turkey is a better country to be invested in these three countries. Another example is the comparison between China and India. They have the same value of $1/E_p$ (1.00, 1.00) but different $1/E_d$ (0.97, 0.93). It shows that China has better investment opportunity compare with India. Similarly, one may conduct comparison using $1/E_p$. The competitiveness map gives us an easy and effective screening tool to identify outperformers in terms of competitiveness for further investigation.

[x] Forbes Best Countries for Business 2018, retrieved on 16/08/2019 from https://www.forbes.com/best-countries-for-business/list/#tab:overall

[xi] U.S.News & World Report Best Countries Ranking 2019, retrieved on 16/08/2019 from https://www.usnews.com/news/best-countries/overall-rankings

Figure 1: The Competitiveness Map



Note: ▲: Developing countries; ●: Developed countries; See Appendix V for the data

5.8 Robustness check

Finally, we estimate the effects of E_p and E_d on economic growth as a robustness check. If the value of E_p and E_d truly reflect the performance of a country, E_p and E_d should have a negative effect on economic growth. The panel regression results for E_p and E_d on economic growth is shown in Table 7:

Table 7: Panel Regression Results for E_p and E_d

	Dependent variable: g	
	Model A	Model B
E_p	-0.1034*	-0.1132*
	(0.0499)	(0.0492)
E_d	-0.1033*	-0.1260*
	(0.0425)	(0.0422)
Y_{t-1}	-	-7.02E-06*
		(1.82E-06)

Constant	0.2463* (0.0832)	0.4058* (0.0918)
Adj R-squared	0.3856	0.4047
n	545	545

Note: Cross-section and Period fixed effect included. * denote significance at the 5% level. Numbers in brackets represent standard error of the coefficient.

In Table 7, Model A estimates that effect of E_p and E_d on economic growth. Model B further controls for the real GDP per capita in the previous year as a comparison. As shown in Table 7, all coefficients in both models are significant. In particular, the negative sign of the coefficient of E_p and E_d suggests 1 percentage point increase $(+0.01)$ in inefficient proportional competitiveness and inefficient dimension mix will result in at least a 0.1 percentage point decrease (-0.001) in the economic growth rate. These results confirm our claim that inefficiency in directing additional resources to enhance competitiveness has a negative effect on economic growth. As in previous sections, we already concluded that competitiveness index could be used to forecast economic performance. Thus, decomposing the competitiveness index can further facilitate in identifying investment opportunities easily.

6. Conclusions

Researchers of competitiveness tend to believe that higher competitiveness will lead to better economic performance in the long run. This paper, using the Global Competitiveness Index as a proxy for competitiveness, provides evidence to support this conjecture. Further, we discuss the relation between using the competitiveness index and investment. Thus, a well-constructed competitiveness index is helpful to forecast the economic performance of a country and can be used to identify investment opportunities for multinational corporations. In fact, when there are sufficient data, testing whether a competitiveness index can Granger-cause economic growth rate can be regarded as a test of the appropriateness of that index to reflect the competitiveness of a country. Since one major purpose of studying competitiveness is to find ways to promote economic growth, failure to Granger-cause economic growth by a competitiveness index can be seen as disqualifying such index to reflect the competitiveness of a country.

On the other hand, whether better economic performance can enhance the competitiveness of a country is less straight forward. We believe that strong economic growth can provide resources and environment to nurture a better society and create new technologies, which in turn promote the competitiveness of the country. However, this requires a mechanism to allocate resources efficiently and appropriately.

Developed countries are more advanced in production technologies, market system, and public management. Thus, they are more efficient in resources allocation. It is not surprising that, as found in this paper, they become more competitive through economic

growth. In contrast, it is found that economic growth does not Granger-cause competitiveness in developing countries. These countries are lagging behind in social institutions, market mechanism, and others. Thus, they are less efficient in resources allocation.

The information of efficiency scores of competitiveness are used to draw the competitiveness map, which identifies outperformers in terms of proportional competitiveness and dimension mix. The map is especially useful screening tool for studies of competitiveness and international business. This method can be applied to other competitiveness indices and that deserves further study.

References

Barro, R. (1991), "Economic growth in a cross-section of countries", *Quarterly Journal of Economics*, Vol. 106 No. 2, pp. 407-444.

Braddorn, D. and Hartley, K. (2007), "The competitiveness of the UK aerospace industry", *Applied Economics*, Vol. 39 No. 6, pp. 715-726.

Bris, A., Garelli, S., Pierazzi, A., Grydbeck, C., Jobin, C., Beer-Espinosa, K., Hediger, M. and Milner, W. (2014), *IMD World Competitiveness Yearbook*, IMD World Competitiveness Center, Lausanne.

Bowen, H. and Moesen, W. (2011), "Composite competitiveness indicators with endogenous versus predetermined weights: An application to the World Economic Forum's global competitiveness index", *Competitiveness Review*, Vol. 21 No. 2, pp. 129-151.

Cho, D. and Moon, H. (2013), *From Adam Smith to Michael Porter: Evolution of Competitiveness Theory (Extended Edition)*, New Jersey: World Scientific Publishing.

Daniele, V. (2011), "Natural resources and economic growth: A curse or a blessing?", *Rivista Italiana Degli Economisti*, Vol. 16 No. 3, pp. 507-528.

Fagerberg, J., Srholec, M. and Knell, M. (2007), "The Competitiveness of Nations: Why some Countries Prosper while Others Fall Behind", *World Development*, Vol. 35 No. 10, pp. 1595-1620.

Farinha, L., Ferreira, J. and Nunes, S. (2018a), "Linking innovation and entrepreneurship to economic growth", *Competitiveness Review*, Vol. 28 No. 4, pp. 451-475.

Farinha, L., Nunes, S., Ferreira, J. and Fernandes, A. (2018b), "Understanding the foundations of global competitive advantage of nations", *Competitiveness Review*, Vol. 28 No. 5, pp. 503-517.

Frontier Economics Limited (2013), *Exploring the Impact of Private Equity on Economic Growth in Europe*, Frontier Economics Europe, London.

Granger, C.W.J. (1969), "Investigating Causal Relations by Econometric Models and Cross-spectral Methods", *Econometrica*, Vol. 37 No. 3, pp. 424-438.

Grosse, R. and Trevino, J.L. (2005), "New institutional economics and FDI location in central and eastern Europe", *Management International Review*, Vol. 45 No. 2, pp. 123-145.

Grossman, G.M. and Helpman, E. (1994), "Protection for sale", *American Economic Review*, Vol. 84 No. 4, pp. 833-850.

Habibullah, M.S. and Eng, Y.K. (2006), "Does financial development cause economic growth? A panel data dynamic analysis for the Asian developing countries", *Journal of the Asia Pacific Economy*, Vol. 11 No. 4, pp. 377-393.

Hadjikhani, A., Lee, J. and Ghauri, P.N. (2008), "Network view of MNCs' socio-political behavior", *Journal of Business Research*, Vol. 61 No. 9, pp. 912–924.

Hamilton, R. (1994), *Time Series Analysis*, Princeton University Press, Princeton.

Hartwig, J. (2014), "Testing the Uzawa-Lucas model with OECD Data", *Research in Economics*, Vol. 68 No.2, pp. 144-156.

Hartwig, J. (2010), “Is health capital formation good for long-term economic growth? Panel Granger-Causality evidence for OECD countries”, *Journal of Macroeconomics*, Vol. 32 No. 1, pp. 314-325.

Hay, C. (2012), “The 'Dangerous Obsession' with cost competitiveness ... and the not so dangerous obsession with competitiveness”, *Cambridge Journal of Economics*, Vol. 36 No. 2, pp. 463-479.

Holtz-Eakin, D., Newey, W. and Rosen, H.S. (1988), “Estimating vector autoregressions with panel data”, *Econometrica*, Vol. 56 No. 6, pp. 1371-1395.

Kao, C., Wu, W.Y., Hsieh, W.J., Wang, T.Y., Lin, C. and Chen, L.H. (2008), “Measuring the national competitiveness of Southeast Asian countries”, *European Journal of Operational Research*, Vol. 187 No. 2, pp. 613-628.

Krugman, P.R. (1996), “Making sense of the competitiveness debate”, *Oxford Review of Economic Policy*, Vol. 12 No. 3, pp. 17-25.

Lall, S. (2001), “Competitiveness indices and developing countries: An economic evaluation of the Global Competitiveness Report”. *World Development*, Vol. 29 No. 9, pp. 1501-1525.

Laureti, T. and Viviani, A. (2011), “Competitiveness and productivity: A case study of Italian firms”, *Applied Economics*, Vol. 43 No. 20, pp. 2615-2625.

Li, S.K. and Tsang, C.K. (2018), “The impacts of biased resource allocation on the effectiveness of official development assistance”, *Singapore Economic Review*, https://doi.org/10.1142/S0217590818500285

Li, S.K. and Zhao, L. (2015), “The competitiveness and development strategies of provinces in China: a data envelopment analysis approach”, *Journal of Productivity Analysis*, Vol. 44 No. 3, pp. 293-307.

Lucas, R.E. (1988), “On the mechanics of economic development”, *Journal of Monetary Economics*, Vol. 22 No. 1, pp. 3-42.

Manzur, M., Wong, W.K. and Chee, I.C. (1999), “Measuring international competitiveness: experience from east Asia”, *Applied Economics*, Vol. 31 No. 11, pp. 1383-1391.

Martins, P.M.G. (2013), “Do large capital inflows hinder competitiveness? The Dutch disease in Ethiopia”, *Applied Economics*, Vol. 45 No. 8, pp. 1075-1088.

Mitchell, H. and Stewarta M.F. (2007), “A competitive index for international sport”, *Applied Economics*, Vol. 39 No. 5, pp. 587-603.

Ni, P. (2012), *The Global Urban Competitiveness Report 2011*, Cheltenham: Edward Elgar.

Peneder, M. (2016), “Competitiveness and industrial policy: From rationalities of failure towards the ability to evolve”, *Cambridge Journal of Economics*, Vol. 41 No. 3, pp. 829-858.

Porter, M.E. (1990), *The Competitive Advantage of Nations*, New York: Free Press.

Prime, P.B., Subrahmanyam, V. and Lin, C.M. (2012), “Competitiveness in India and China: the FDI puzzle”, *Asia Pacific Business Review*, Vol. 18 No. 3, pp. 303-333.

Schwab, K. ed. (2014), *The Global Competitiveness Report*, World Economic Forum,

Geneva.
Skoorka, B.M. (2000), “Measuring market distortion: International comparisons, policy and competitiveness”, *Applied Economics*, Vol. 32 No.3, pp. 253-264.
Waheeduzzaman, A.N.M. (2011), “Competitiveness and convergence in G7 and emerging markets”, *Competitiveness Review*, Vol. 21 No. 2, pp. 110-128.
Wong, K. (2008), “Economic growth and resource allocation: The case of China”, *Journal of Chinese Economic and Foreign Trade Studies*, Vol. 1 No. 2, pp. 105-121.

Appendix I: Growth Determining Factors Included in the Definition of Competitiveness Index

Competitiveness index	**Variables that reflect economic growth**	**Source**
Global Competitiveness Index	GDP (PPP $billions) (Market size)	World Economic Forum
World Competitiveness Yearbook	Real GDP growth per capita (Economic performance)	IMD World Competitiveness Center
EU Regional Competitiveness Index	Potential GDP in PPS (Potential market size expressed in GDP (pps), index EU28 = 100)	European Commission Joint Research Centre Institute for Security and Protection of the Citizens
European competitiveness index	GDP per capita (economic performance)	Centre for International Competitiveness
Overall competitiveness of China's provincial economy	Provincial GDP, GDP growth rate	The Chinese Academy of Social Sciences

Appendix II: The Panel Granger-causality Test

The data involves the value of a competitiveness index and economic growth rate of country i at time t: C_{it} and g_{it}, $i = 1, \dots, I$, $t = 0,1, \dots, T$. Given that both variables are stationary, competitiveness index C is said failing to Granger-cause g if the inclusion of lagged values of C does not significantly reduce the predictive error variance of g. That is, the mean squared error (MSE) of a forecast of g_{t+1} based on the information set of $(g_t, g_{t-1}, \dots)$ is the same as the one which uses both $(g_t, g_{t-1}, \dots)$ and $(C_t, C_{t-1}, \dots)$. In particular (Hamilton, 1994),

$$\mathrm{MSE}[\mathrm{E}(g_{t+1}|g_t, g_{t-1}, \dots)] = \mathrm{MSE}[\mathrm{E}(g_{t+1}|g_t, g_{t-1}, \dots; C_t, C_{t-1}, \dots)]. \qquad (A1)$$

Conversely, competitiveness index C Granger-cause economic growth g if the right-hand side of (A1) is larger. The causality from g to C can be studied likewise.
The bivariate vector autoregressive (VAR) model with MA(K) describing C and g is:

$$\begin{bmatrix} g_{it} \\ C_{it} \end{bmatrix} = \begin{bmatrix} \alpha_1 \\ \alpha_2 \end{bmatrix} + \sum_{k=1}^{T} \begin{bmatrix} \gamma_{11}^{(k)} & \gamma_{12}^{(k)} \\ \gamma_{21}^{(k)} & \gamma_{22}^{(k)} \end{bmatrix} \begin{bmatrix} g_{i,t-k} \\ C_{i,t-k} \end{bmatrix} + \sum_{n=1}^{N} \begin{bmatrix} \tau_n^{(1)} \\ \tau_n^{(2)} \end{bmatrix} D_{nit} + \begin{bmatrix} y_{i0} \\ y_{i0} \end{bmatrix} + \begin{bmatrix} \varepsilon_{it}^{(1)} \\ \varepsilon_{it}^{(2)} \end{bmatrix}.$$

In the above model, all regression coefficients of lagged g and C are assumed to be the same across various time periods and across different countries. All countries are classified into N different groups to represent their development stages. The group-specific effects are captured by $\tau_n^{(1)}$ and $\tau_n^{(2)}$ (Holtz-Eakin et al. (1988) included country-specific effects in their regression equations). The catching-up effect is further controlled by y_{i0}, the natural logarithm of initial output level of country i. If country i is in group j, then $D_{jit} = 1$ for all t and $D_{nit} = 0$ for all t which $n \neq j$. C does not Granger-cause g if the coefficient matrices Γ_k are lower triangular for all k, where $\Gamma_k = \begin{bmatrix} \gamma_{11}^{(k)} & \gamma_{12}^{(k)} \\ \gamma_{21}^{(k)} & \gamma_{22}^{(k)} \end{bmatrix}$ (That is, Γ_k is lower triangular if and only if $\gamma_{12}^{(1)} = \gamma_{12}^{(2)} = \cdots = \gamma_{12}^{(T)} = 0$.). If Γ_k are rejected to be lower triangular for some k, then C will be said to Granger-cause g and hypothesis H1 is confirmed by empirical data. Similarly, H2 can be tested.

Appendix III: The Global Competitiveness Index Framework (Schwab, 2014, p.9)

Global Competitiveness Index		
Basic requirements sub-index	Efficiency enhancers sub-index	Innovation and sophistication factor sub-index
Pillar 1. Institutions Pillar 2. Infrastructure Pillar 3. Macroeconomic environment Pillar 4. Health and primary education	Pillar 5. Higher education and training Pillar 6. Goods market efficiency Pillar 7. Labour market efficiency Pillar 8. Financial market development Pillar 9. Technological readiness Pillar 10. Market size	Pillar 11. Business sophistication Pillar 12. Innovation

Appendix IV: Data Envelopment Analysis for Competitiveness Index

Suppose there are K observed countries. Let y_{mk} be the mth dimension and w_{mk} the corresponding weight of that dimension in the competitiveness index for country k, $m = 1, \dots, \mathrm{M}$ and $k = 1, \dots, \mathrm{K}$. Denote the overall competitiveness index by C. Then the observed overall competitiveness index of country j is

$$C^j = \sum_{m=1}^{M} w_{mj} y_{mj}.$$

Previous empirical studies of competitiveness implicitly assume constant tradeoffs among dimensions. Li and Zhao (2015) modeled nonlinear tradeoffs among different dimensions. To make developing and developed countries comparable, we further modify their model by controlling a country's GDP per capita (in natural log form, x) as an input. Using the variable returns to scale (VRS) frontier, the corresponding maximum value of the competitiveness index for country j is

$$C^{j*} = \max_{y,z} \sum_{m=1}^{M} w_{mj} y_{mj}$$

subject to

$$\sum_{k=1}^{K} z_k y_{mk} \geqq \theta y_{mj}, m = 1, \cdots, M$$

$$\sum_{k=1}^{K} z_k x_k \leqq x_j$$

$$\sum_{k=1}^{K} z_k = 1$$

$$z_k \geqq 0, k = 1, \dots \mathrm{K}$$

where the solution y_k^* is an optimal dimension vector. The current loss in competitiveness for country j is indicated by the following measure:

$$O_c{}^j = \left(\sum_{m=1}^{M} w_{mj} y_{mj}^* \right) / \left(\sum_{m=1}^{M} w_{mj} y_{mj}^0 \right).$$

Li and Zhao (2015) called this the *efficiency of overall competitiveness*. The value $(O_c^0 - 1) \times 100\%$ is the percentage of the competitiveness index of y^0 that can be increased.

This efficiency of overall competitiveness can be eliminated through expanding all dimensions proportionally or by changing dimension mix. The first, for country j, is measured by the *efficiency of proportional competitiveness*:

$$E_p^j = \max_{\theta,z} \theta$$

subject to

$$\sum_{k=1}^{K} z_k y_{mk} \geqq \theta y_{mj} \quad m = 1, \cdots, M$$

$$\sum_{k=1}^{K} z_k x_k \leqq x_j$$

$$\sum_{k=1}^{K} z_k = 1$$

$$z_k \geqq 0, k = 1, \ldots \text{K.}$$

The value $\left(E_p - 1\right) \times 100\%$ is the percentage of the competitiveness index that is currently lost if the dimension mix is kept constant. Let $C^p = \sum_{m=1}^{M} w_m \left(E_p y_m^0\right)$ denotes maximum competitiveness attainable when the dimension mix is kept constant. The second component of the efficiency of overall competitiveness is measured by the *efficiency of dimension mix*:

$$E_d = \frac{C^*}{C^p} = \left(\frac{C^*}{C^0}\right) / \left(\frac{C^p}{C^0}\right) = \frac{O_c}{E_p}.$$

The value $(E_d - 1) \times 100\%$ is the percentage of the component of competitiveness lost due to sub-optimal dimension mix. It is easy to see that all O_c, E_p, and E_d are greater than or equal to one. Thus $O_c = E_d E_p$, i.e., thus the potential of improving overall competitiveness as indicated by the efficiency of overall competitiveness (O_c) can be decomposed into the efficiency of proportional competitiveness (E_p) and the efficiency of dimension mix (E_d).

Appendix V: Competitiveness Mapping

Developing Countries					
Country	$1/E_d$	$1/E_p$	Country	$1/E_d$	$1/E_p$
Albania	0.9545	0.8392	Kenya	0.9974	0.8614
Algeria	0.9285	0.8189	Kuwait	0.9910	0.7795
Armenia	0.9424	0.8907	Kyrgyz Republic	0.9682	0.8236
Azerbaijan	0.9931	0.8586	Lesotho	0.9256	0.8349
Bangladesh	0.9948	0.8530	Madagascar	0.9972	0.8701
Bolivia	0.9187	0.8622	Malawi	1.0000	0.9718
Botswana	0.9247	0.8535	Mali	0.9620	0.8333
Bulgaria	0.9645	0.8705	Mongolia	0.9549	0.8234
Burundi	1.0000	0.9241	Morocco	0.9597	0.9062
Cambodia	0.9833	0.9050	Mozambique	0.9504	0.8266
Cameroon	0.9085	0.8848	Namibia	0.8598	0.9143
Chad	0.8715	0.7527	Nepal	0.9944	0.8708
China	1.0000	0.9681	Nicaragua	0.9302	0.8673
Colombia	0.9144	0.9006	Nigeria	0.9707	0.7721
Dominican Republic	0.8316	0.9074	Pakistan	0.9272	0.8221
Egypt	0.9045	0.8561	Paraguay	0.8778	0.8468
El Salvador	0.9088	0.8790	Peru	0.9560	0.8793
Ethiopia	1.0000	0.9268	Philippines	0.9961	0.9013
Gambia, The	1.0000	0.9202	South Africa	0.9993	0.8545
Georgia	0.9734	0.8801	Sri Lanka	1.0000	0.8850
Guatemala	0.9264	0.9078	Tanzania	0.9693	0.8641
Guyana	0.8948	0.8562	Thailand	0.9750	0.9385
Honduras	0.9324	0.8699	Uganda	0.9993	0.8591
India	1.0000	0.9256	Ukraine	1.0000	0.8442
Indonesia	0.9955	0.9344	Vietnam	1.0000	0.9045
Jamaica	0.8933	0.8718	Zambia	0.9579	0.8585
Jordan	0.9669	0.8808	Zimbabwe	0.9011	0.8708
Kazakhstan	0.9584	0.8648			

Appendix V: Competitiveness Mapping (Cont.)

Developed Countries					
Country	$1/E_d$	$1/E_p$	Country	$1/E_d$	$1/E_p$
Argentina	0.9160	0.8040	Lithuania	0.9700	0.8781
Australia	0.9843	0.9141	Luxembourg	0.9990	0.8957
Austria	0.9687	0.9457	Malaysia	1.0000	0.9818
Bahrain	0.9497	0.8826	Malta	0.9819	0.8419
Belgium	0.9976	0.9270	Mauritius	0.9578	0.8888
Brazil	0.9172	0.8959	Mexico	0.9096	0.9097
Canada	0.9988	0.9355	Netherlands	1.0000	0.9700
Chile	0.9784	0.9301	New Zealand	1.0000	0.9232
Costa Rica	0.9505	0.8792	Norway	1.0000	0.9281
Croatia	0.9123	0.8556	Panama	0.9320	0.9168
Cyprus	0.9739	0.8148	Poland	0.9549	0.8947
Czech Republic	0.9354	0.9163	Portugal	0.9675	0.8623
Denmark	0.9899	0.9435	Qatar	1.0000	0.9134
Estonia	0.9943	0.8923	Romania	0.9038	0.8936
Finland	1.0000	0.9785	Russian Federation	0.9426	0.8699
France	0.9887	0.9235	Singapore	1.0000	1.0000
Germany	1.0000	0.9804	Slovak Republic	0.9158	0.8638
Greece	0.9226	0.7966	Slovenia	0.9614	0.8288
Hong Kong SAR	1.0000	0.9836	Spain	0.9630	0.8684
Hungary	0.9089	0.9008	Sweden	1.0000	0.9703
Iceland	0.9902	0.8550	Switzerland	1.0000	1.0000
Ireland	0.9731	0.9026	Trinidad and Tobago	0.9049	0.8258
Israel	0.9987	0.9102	Turkey	0.9221	0.9152
Italy	0.9608	0.8371	United Arab Emirates	0.9951	0.9128
Japan	1.0000	0.9722	United Kingdom	1.0000	0.9737
Korea, Rep.	1.0000	0.9346	United States	1.0000	0.9757
Latvia	0.9571	0.8761	Uruguay	0.9141	0.8590

Biography of author(s)

Chun-Kei Tsang
Department of Economics and Finance, Hong Kong Shue Yan University, Hong Kong

Chun-Kei Tsang is an Assistant Professor at the Department of Economics and Finance of Hong Kong Shue Yan University. He obtained PhD at the Hong Kong Baptist University. His research interests include productivity and efficiency analysis, development economics, investment and portfolio analysis. He has published papers in Journal of Productivity Analysis, Research in International Business and Finance, Emerging Markets Finance and Trade, The Chinese Economy, Singapore Economic Review, and others.

Sung-Ko Li
Department of Economics and Finance, Hong Kong Shue Yan University, Hong Kong
Centre for Sustainable Development Studies, Hong Kong Baptist University, Hong Kong

Sung-Ko Li is an Adjunct Professor at the Department of Economics and Finance of Hong Kong Shue Yan University and a Senior Research Associate at the Centre for Sustainable Development Studies of Hong Kong Baptist University. He obtained PhD at the Southern Illinois University at Carbondale. His research interests include microeconomics, mathematical economics, productivity and efficiency analysis. He has published papers in Operations Research, Journal of Mathematical Economics, Journal of Productivity Analysis, European Journal of Operational Research, China Economic Review, and others.

Chapter 4
Structural Time Series Analysis of Data from Interwar European Hyperinflations of Germany, Hungary and Poland

Kai-Yin Woo

Abstract

The purpose of this paper is to test for the properties of money supply, prices and exchange rates using data from the interwar European hyperinflations of Germany, Hungary, and Poland, which are useful for bubbles testing in a Cagan'(1956) model (Woo, 2004). During that period, these countries experienced hyperinflations. Hence, their data may exhibit unique characteristics that are different from the data during the normal inflationary periods after the second World War. We adopt the structural time series modeling method for decomposing unobserved components of observed data series for study.

1. Introduction

In this paper, I will provide a brief description of the data series for the three inter-war European hyperinflations of Germany, Hungary and Poland. It is interesting to investigate the stochastic properties of economic variables during the abnormally high inflationary periods, which are expected to be different during the normal inflationary periods. I attempt a structural time series analysis to identify the unobserved stochastic components of the observed data series. From the reduced forms of the trend component, the integration orders of the data series can be found. In addition, some evidence of regime changes in data generation can be detected from the trend component or the slope of the trend. This paper is structured as follows. Section 2 introduces the statistical specifications of the unobserved components in a structural time series model. Section 3 discusses the data sources, sample lengths and definitions of the variables under study. The statistical and graphical analysis of the unobserved components will also be presented. Section 4 summarizes the findings.

2. Statistical Specifications of Structural Time Series Model

Using the structural time series modeling techniques (Harvey, 1989), I attempt to decompose and analyze the unobserved components of the observed data series in order to examine the stochastic properties of the economic variables under study. A univariate structural time series model is formulated as:

$$(1-\Psi(\boldsymbol{L}))\boldsymbol{y}_{o\boldsymbol{t}} = \mu_t + \gamma_t + \psi_t + \varepsilon_t, \quad \varepsilon_t \sim \text{NID}(0, \ \sigma_\varepsilon^2), \quad t = 1, \ldots, T, \tag{1}$$

where $\boldsymbol{y}_{o\boldsymbol{t}}$ is an observed time series variable, $\Psi(\boldsymbol{L}) = 1 - \Psi_1\boldsymbol{L} - \ldots - \Psi_p\boldsymbol{L}^p$ where Ψ_i is a parameter of a lagged value of $\boldsymbol{y}_{o\boldsymbol{t}}$, the elements μ_t, γ_t, ψ_t and ε_t represent the unobserved trend, seasonal, cyclical and irregular components respectively.[12]

The trend is the long-run component in the series, which indicates the general moving direction of the observed series under study. There are two parts to the trend specified as:

$$\mu_t = \mu_{t-1} + \beta_{t-1} + \eta_t, \ \eta_t \sim \text{NID}\left(0, \sigma_\eta^2\right), \tag{2a}$$

$$\beta_t = \beta_{t-1} + \zeta_t, \ \zeta_t \sim \text{NID}\left(0, \sigma_\zeta^2\right), \tag{2b}$$

where μ_t is the level, which is the actual value of the trend, β_t is the slope of the trend. If σ_η^2 and σ_ζ^2 are zero, μ_t and β_t will be fixed respectively.

Different properties of the level, slope, and irregular component would result in different specifications of the trend model. Let's illustrate them briefly.[13] When both σ_ε^2 and σ_η^2 are zero, then the trend specification is given by:

$$\mu_t = \mu_{t-1} + \beta_{t-1}, \tag{3a}$$

$$\beta_t = \beta_{t-1} + \zeta_t, \ \zeta_t \sim \text{NID}\left(0, \sigma_\zeta^2\right), \tag{3b}$$

is known as a second differencing model. When σ_ε^2 is not zero; the trend is known as a smooth trend model. Also, in case where both σ_ε^2 and σ_ζ^2 are zero, the trend model is specified as:

[12] A first-order autoregressive component and a vector of exogenous variables are also be included in the univariate structural time series model (1), but they are excluded here for simplicity.

[13] The details of the trend specifications are documented in Koopman et al. (2000).

$$\mu_t = \mu_{t-1} + \beta_{t-1} + \eta_t, \ \eta_t \sim \text{NID}(0, \sigma_\eta^2), \tag{4a}$$

$$\beta_t = \beta_{t-1}, \tag{4b}$$

is called random walk with a drift, or random walk if $\beta_t = \beta_{t-1} = 0$. While σ_ε^2 is not zero, the trend component is known as the local level with a drift or the local level, dependent upon whether $\beta_t = \beta_{t-1}$ is different from zero.

The seasonal component may be based on the dummy variable form, or the trigonometric formulation. Given that s refers to the number of seasonal frequencies, the seasonal dummy is given by:

$$\gamma_t = \sum_{j=1}^{s-1} -\gamma_{t-j} + \omega_t, \qquad \omega_t \sim \text{NID}(0, \ \sigma_\omega^2). \tag{5}$$

Moreover, the trigonometric seasonal formulation is:

$$\gamma_t = \sum_{j=1}^{s/2} (\cos\lambda_j \gamma_{j,t-1} + \sin\lambda_j \gamma_{j,t-1}^*) + \omega_{j,t}, \quad \text{j} = 1,\ldots,\frac{s}{2}. \quad \omega_{j,t} \sim \text{NID}(0, \ \sigma_{\omega_j}^2). \tag{6}$$

where $\lambda_j = 2j\pi / s$ refers to the frequency in radians, $\gamma_{j,t}^*$ is constructed to estimate γ_t.

The stochastic cycle is specified as follows:

$$\psi_t = \rho(\cos\lambda_c \psi_{t-1} + \sin\lambda_c \psi_{t-1}^* + \kappa_t), \ \kappa_t \sim \text{NID}\left(0, \sigma_\kappa^2\right). \tag{7}$$

where λ_c is the frequency in radians, in the range $0 \le \lambda_c \le \pi$, ρ is a damping factor in the range $0 \le \rho \le 1$ and as in the trigonometric seasonal form (3.6), ψ_{t-1}^* is constructed to generate ψ_t. The period of the cycle is equal to $2\pi / \lambda_c$.

All the disturbance terms of the structural components, and the irregular component, $\{\eta_t, \zeta_t, \omega_t, \omega_{j,t}, \kappa_t, \varepsilon_t\}$ are independent of one another. The inclusion of the disturbance terms produces stochastic properties of the corresponding unobserved components. The q-ratio is the ratio of the standard deviation of each disturbance term to the standard deviation associated with the largest variance. The q-ratio corresponding to a particular component is zero when that component is deterministic or nonexistent.

3. Data Description and Structural Time Series Analysis of Data

The data from Germany, Hungary and Poland include money supply, price index and exchange rate series. The money supply series are month-end data, whereas the other series are monthly averages; I therefore follow Abel *et al.* (1979) in applying the geometric averaging method to make the money supply series conform to the rest of the data. Also, all of the exchange rate series that are originally quoted as the number of US cents per unit of local currency are transformed in terms of the values of domestic currency per US dollar. The German exchange rate series and all the data for Hungary and Poland are taken from Young (1925), while the German money supply and price index are collected from Tinbergen (1934). All series are transformed into logarithm.

The statistical treatment of the univariate structural time series model (1) is based on the state space form. The values of the parameters and the unobserved components are estimated using the maximum likelihood (ML) method with the Kalman filter algorithms. Since the unobserved components are in general stochastic, they can only be assessed by examining their behaviours throughout the whole samples, not just at the end. The filtered and smoothed estimates of the components will then be plotted to provide a guide as to whether the model is best decomposed by the estimated components. The model can also be evaluated through goodness-of-fit measures and diagnostic statistics.

For each country under study, the log level and the log difference of money supply ($\boldsymbol{M}_t$ and $\Delta\boldsymbol{M}_t$), price index ($\pi_{1,t}$ and $\Delta\pi_{1,t}$) and exchange rate series ($\pi_{2,t}$ and $\Delta\pi_{2,t}$) as well as the log level of real money balances in terms of both price and exchange rate series ($\boldsymbol{M}_t - \pi_{1,t}$ and $\boldsymbol{M}_t - \pi_{2,t}$) will be decomposed into unobserved components for analysis. The stochastic properties of data are useful for bubbles testing in a Cagan'(1956) model (Woo, 2004).

3.1 Germany

The German data are collected from January 1920 to December 1923. Money in circulation is employed to represent the money supply series, and the cost-of-living index is used as a price index. The exchange rate figures are transformed from US cents per German mark.

Table 1 reports the empirical results and Figures 1 to 8 show the graphical components of the economic variables under study. From Table 1, all observed series do not contain any lagged dependent variables and irregular components, so that all of the Ψ_i and ε_t are equal to zero. The trend component for the series of $\boldsymbol{M}_t$, $\pi_{1,t}$ and $\pi_{2,t}$ follows a second differencing specification. From the q-ratio and the seasonal test, both $\pi_{1,t}$ and $\pi_{2,t}$ contain significant stochastic dummy seasonal components.

Further, $\boldsymbol{M}_t$ contains a fixed seasonal and $\pi_{1,t}$ contains a nonzero stochastic cycle. Furthermore, the trend component is a random walk with a fixed drift for the series of $\Delta\pi_{1,t}$, $\Delta\pi_{2,t}$, $\boldsymbol{M}_t - \pi_{1,t}$ and $\boldsymbol{M}_t - \pi_{2,t}$ as well as a random walk for the series of $\Delta\boldsymbol{M}_t$. The seasonals in $\boldsymbol{M}_t$, $\pi_{1,t}$ and $\pi_{2,t}$ remain in the structural components of $\Delta\pi_{1,t}$, $\Delta\pi_{2,t}$ $\boldsymbol{M}_t - \pi_{1,t}$ and $\boldsymbol{M}_t - \pi_{2,t}$. In addition, the stochastic cycle contained in $\pi_{1,t}$ is carried forward to $\Delta\pi_{1,t}$.

Table 1 ML Estimation Results of the Structural Time Series Model for Germany

Variables	$\boldsymbol{M}_t$	$\pi_{1,t}$	$\pi_{2,t}$	$\Delta\boldsymbol{M}_t$	$\Delta\pi_{1,t}$	$\Delta\pi_{2,t}$	$\boldsymbol{M}_t - \pi_{1,t}$	$\boldsymbol{M}_t - \pi_{2,t}$
Estimated standard deviation of disturbances [q-ratio]								
σ_η	——	——	——	0.5004 [1.0000]	0.0460 [0.0979]	0.4112 [0.8001]	0.1837 [1.0000]	0.2151 [1.0000]
σ_ζ	0.5024 [1.0000]	0.2895 [0.7189]	0.4506 [1.0000]	——	——	——	——	——
σ_κ	——	0.4026 [1.0000]	——	——	0.4703 [1.0000]	——	0.1139 [0.6198]	——
σ_ω	——	0.0711 [0.1767]	0.2958 [0.6564]	——	0.1557 [0.3311]	0.5139 [1.0000]	0.1328 [0.7228]	0.9401 [0.9401]
Filtered estimates of final state vector at time T with the corresponding root mean square error (RMSE) in the brackets								
μ_T	33.2690* (0.4544)	23.186* (1.0809)	29.373* (0.5543)	2.6041* (0.2694)	1.1880* (0.3342)	3.4429* (0.4157)	6.0249* (0.2683)	4.5411* (0.1974)
β_T	2.5691* (0.5701)	1.7910* (0.5297)	3.5183* (0.6051)	0.0566 (0.0789)	0.0377** (0.0158)	0.0861 (0.0659)	-0.0731** (0.0301)	-0.0691** (0.0343)
φ_T	——	4.0166* (2.7505)	——	——	1.5518 (2.2428)	——	-0.8133 (0.4415)	——
$\gamma_{1,T}$	-0.8713*** (0.4544)	0.6487 (2.6230)	-0.2587 (0.5543)	-0.2419 (0.2694)	-2.0990 (2.2129)	-2.8041* (0.4157)	0.8982** (0.4033)	0.3066 (0.1974)

$\gamma_{2,T}$	-0.8839** (0.4325)	3.4688 (2.6711)	2.6207* (0.4200)	-0.0318 (0.2617)	0.4432 (2.2157)	3.6239* (0.3267)	-0.6341 (0.4062)	-1.6454* (0.1577)
$\gamma_{3,T}$	-0.5708 (0.4245)	4.2237 (2.7078)	-0.8030*** (0.4075)	0.2899 (0.2578)	1.2357 (2.2030)	0.0011 (0.3035)	-0.6560 (0.4047)	0.6287* (0.1505)
$\gamma_{4,T}$	-0.0511 (0.4245)	4.0646 (2.7080)	-0.6008 (0.4127)	0.4926*** (0.2578)	1.2808 (2.2020)	0.1735 (0.3000)	-0.2270 (0.4037)	-0.1109 (0.1502)
$\gamma_{5,T}$	0.6133 (0.4325)	3.3656 (2.6712)	-0.7189 (0.4228)	0.6334** (0.2617)	2.2227 (2.2121)	0.1296 (0.2994)	-0.8710** (0.4064)	-0.3126** (0.1503)
$\gamma_{6,T}$	0.6925 (0.4544)	1.5230 (2.6257)	-0.8964** (0.4307)	0.0442 (0.2694)	2.0706 (2.2224)	-0.2761 (0.2993)	-0.5816 (0.4104)	0.0287 (0.1501)
$\gamma_{7,T}$	0.6790 (0.4557)	-0.7016 (2.6248)	-0.6769 (0.4309)	-0.0350 (0.2773)	1.4104 (2.2268)	-0.3992 (0.3001)	-0.1708 (0.4124)	0.2725*** (0.1507)
$\gamma_{8,T}$	0.5831 (0.4495)	-2.7581 (2.6712)	-0.2818 (0.4260)	-0.1037 (0.2825)	0.4452 (2.2149)	-0.1219 (0.3018)	0.0684 (0.4094)	0.2427 (0.1518)
$\gamma_{9,T}$	0.4370 (0.4443)	-4.1619 (2.7171)	-0.1315 (0.4222)	-0.1403 (0.2850)	-0.7557 (2.1988)	-0.3371 (0.3033)	0.4284 (0.4046)	0.4940* (0.1527)
$\gamma_{10,T}$	0.1600 (0.4443)	-4.4652 (2.7170)	0.2009 (0.4226)	-0.2576 (0.2850)	-1.8780 (2.1988)	-0.6201** (0.3038)	0.6170 (0.4045)	0.3923** (0.1530)
$\gamma_{11,T}$	-0.2185 (0.4495)	-3.4875 (2.6713)	0.7738*** (0.4270)	-0.3456 (0.2825)	-2.1109 (2.2151)	0.1295 (0.3031)	0.5048 (0.4093)	-0.1621 (0.1526)
Estimated parameters of cycle								
Variance	____	18.3227	____	____	8.0315	____	0.5105	____
ρ	____	0.9956	____	____	0.9861	____	0.9872	____
Period (yr.)	____	0.9604	____	____	0.9684	____	0.9218	____
λ_c	____	0.5452	____	____	0.5407	____	0.5680	____
Seasonal test (at time T)								
$\chi^2(11)$	____	21.5743**	421.345*	____	34.9284*	514.924*	95.5476*	361.616*
Goodness-of-fit measures and diagnostic checking								
SE	0.4175	0.7133	0.8542	0.4168	0.6535	0.8706	0.3613	0.3846
R(1)	0.2022	0.1393	-0.0865	0.1710	0.0991	-0.1347	-0.0388	-0.0414
R(6)	-0.0756	-0.0790	-0.0099	-0.0797	-0.0456	-0.0134	-0.0793	0.1283
Q(4)	6.3655	3.8261	1.3000	6.6425	5.3202	1.4800	8.6160	3.5528
Q(7)	6.8320	4.6983	3.1197	7.2309	5.6424	3.2953	9.0970	5.8950
PEV	0.1743	0.5087	0.7297	0.1737	0.4271	0.7579	0.1305	0.1479
R_d^2	0.8634	0.6813	0.5699	0.2581	0.4060	0.5412	0.3166	0.5676
AIC	-1.1281	0.1337	0.3515	-1.1314	-0.0412	0.3894	-1.2267	-1.2443
BIC	-0.5903	0.8370	0.9307	-0.5936	0.6621	0.9687	-0.5233	-0.6651
Max ln L	7.1769	-4.6230	-7.8919	7.8000	-2.4095	-7.8991	16.6318	15.6629

Notes:

A cycle component is not persistent throughout the series; a t-value is therefore not appropriate.

SE is the standard error of the residuals of the estimated equations.

r(k) is the residual autocorrelation coefficient at lags (k).

Q(k) is the Box-Ljung Q statistics with degrees of freedom = k.

PEV is the prediction error variance.

R_d^2 is a modified coefficient of determination based on the first difference of the dependent variable.

AIC and BIC refer to the Akaike information criterion and Bayes information criterion respectively.

Max ln L is the maximum log-likelihood function.

All computations are produced using the STAMP package written by Koopman, *et al.* (2000).

*/**/*** Denotes the significance at the 1%, 5%, and 10% level.

From the figures of the structural components, the slopes of the trend for the level series, M_t, $\pi_{1,t}$ and $\pi_{2,t}$, as well as the trend for $\Delta\pi_{1,t}$, $\Delta\pi_{2,t}$ $M_t - \pi_{1,t}$ and $M_t - \pi_{2,t}$ exhibit changes in moving direction toward the end of 1923. It signifies the possible regime shifts in data generation.

Figure 1. Structural Time Series Components of the German Money Supply Level (M_t)

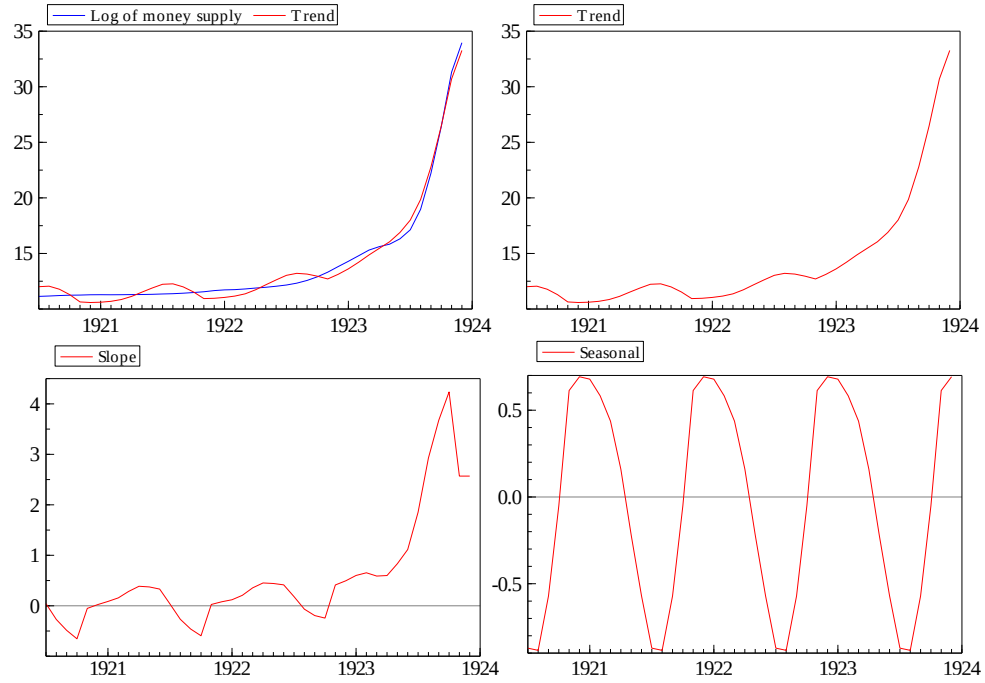


Figure 2. Structural Time Series Components of the German Consumer Price Level (π_{1t})

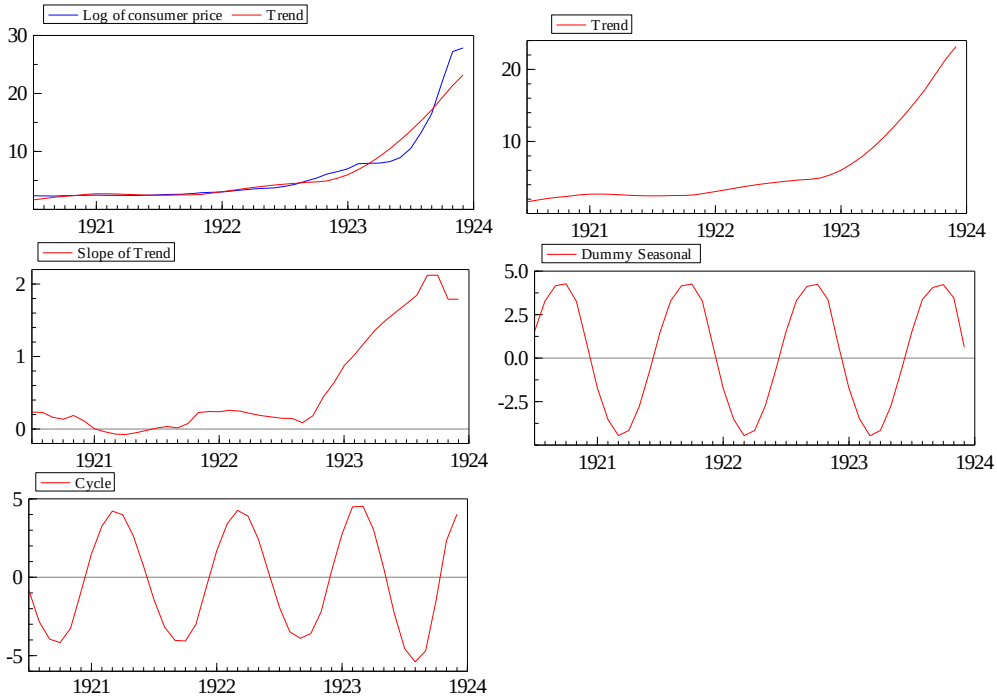


Figure 3. Structural Time Series Components of the German Exchange Rate (π_{2t})

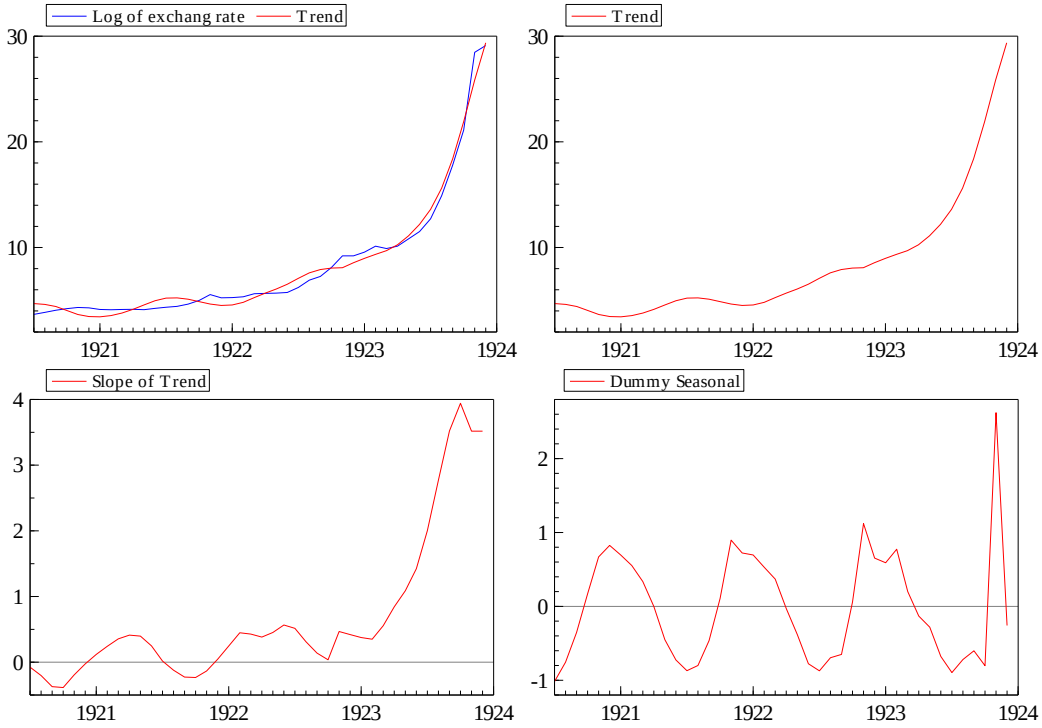


Figure 4. Structural Time Series Components of the Money Supply Growth (ΔM_t) for Germany

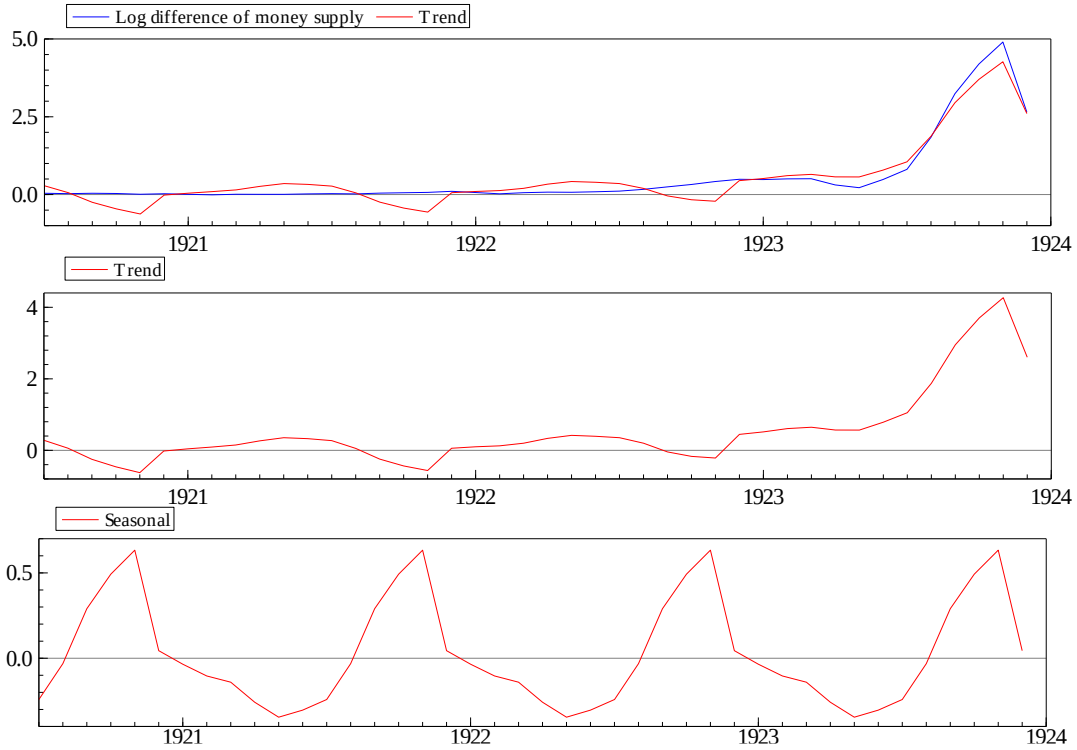


Figure 5. Structural Time Series Components of the Price Change ($\Delta\pi_{1t}$) for Germany

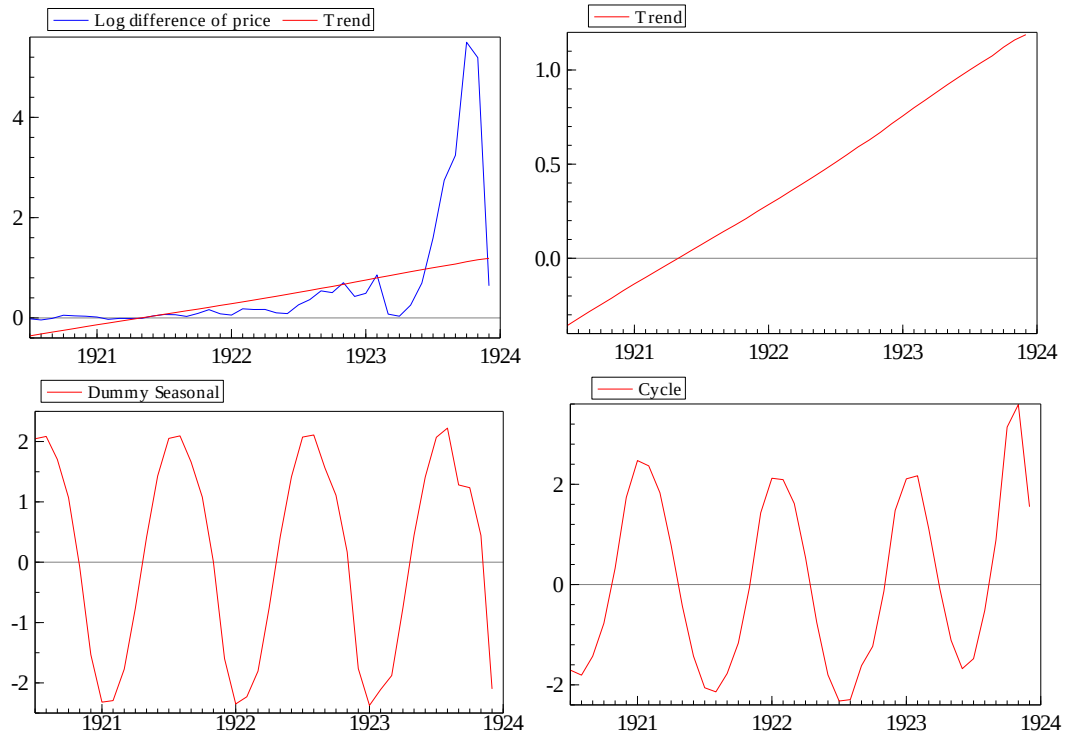


Figure 6. Structural Time Series Components of the Exchange Rate Change ($\Delta\pi_{2t}$) for Germany

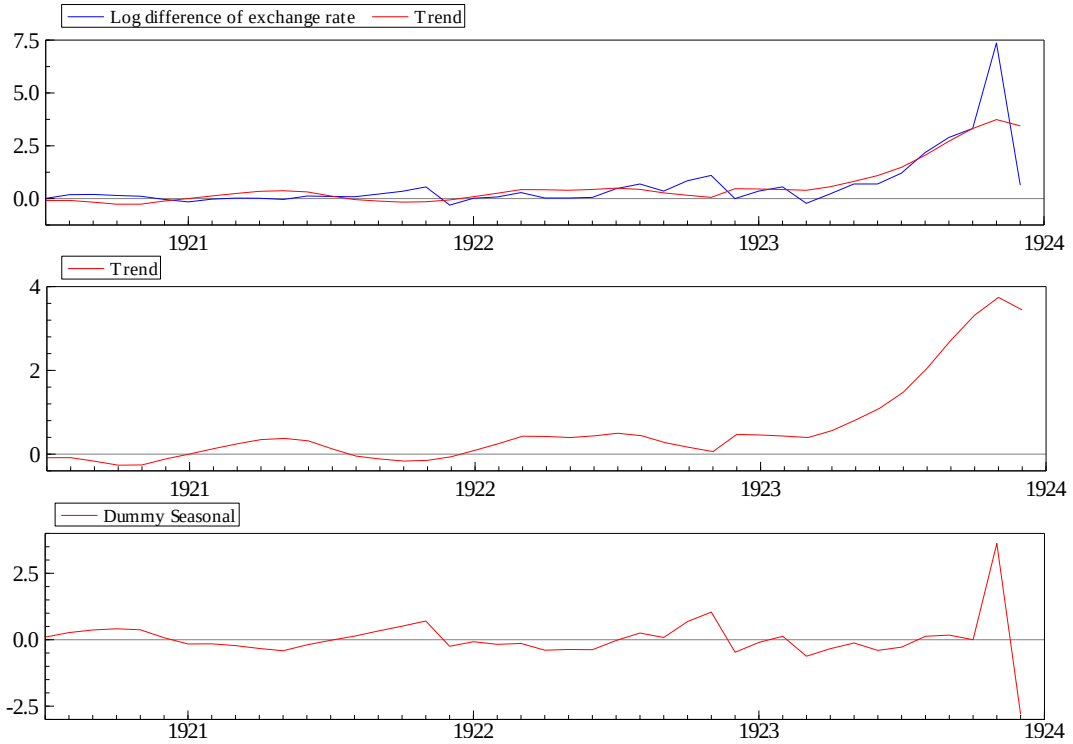


Figure 7. Structural Time Series Components of the Real Money Balance in terms of Consumer Price ($M_t - \pi_{1t}$) for Germany

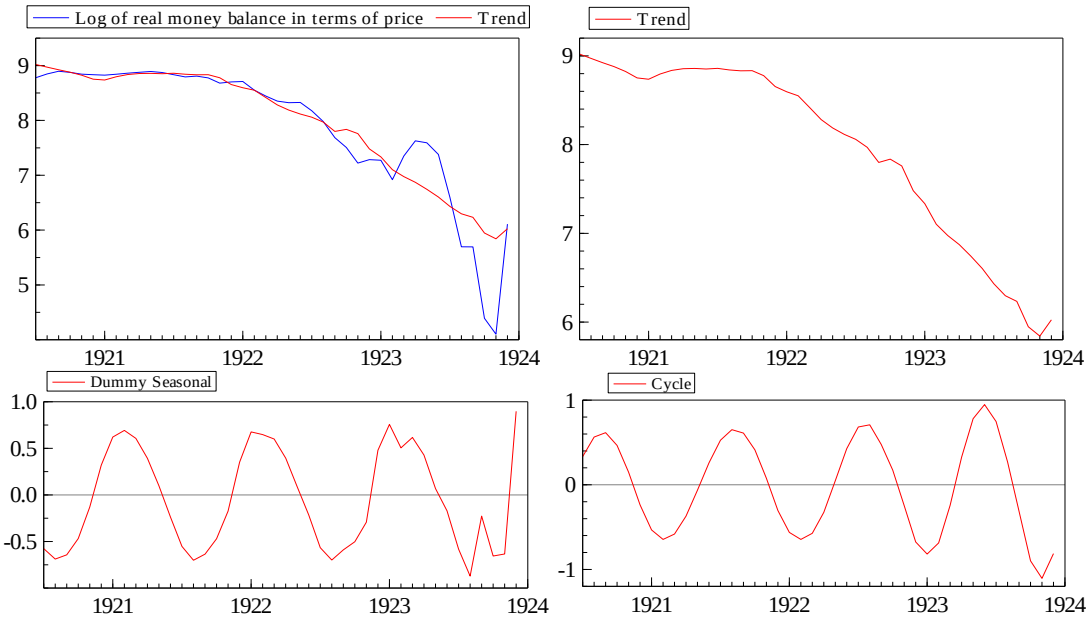
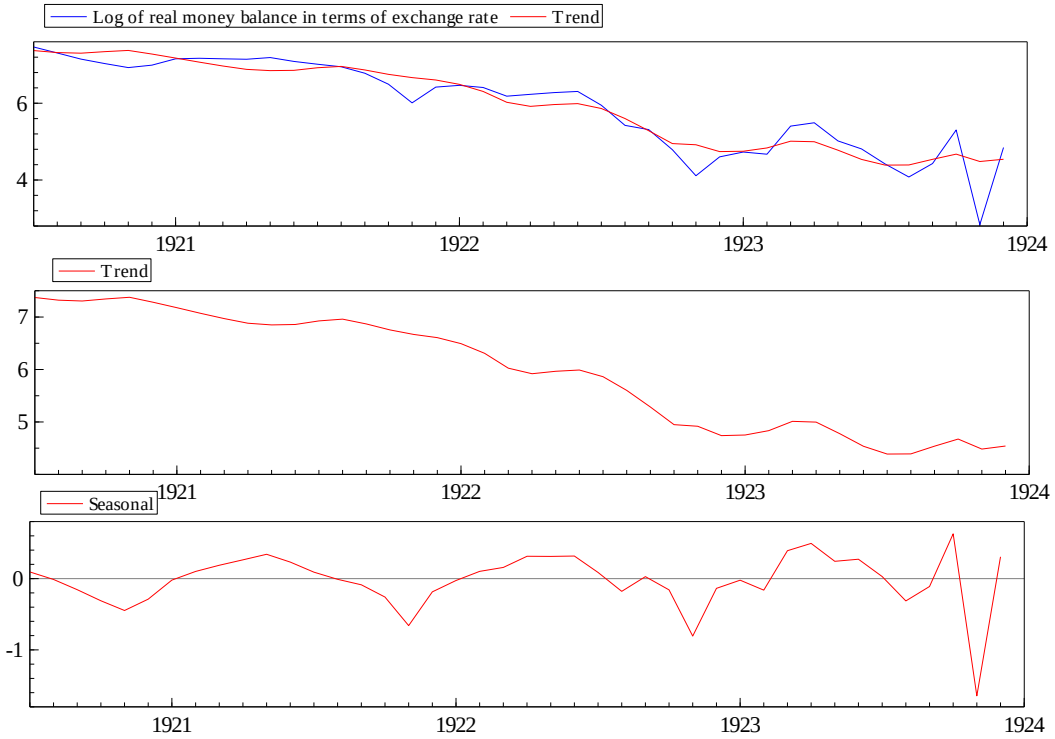


Figure 8. Structural Time Series Components of the Real Money Balance in terms of Exchange Rate ($M_t - \pi_{2t}$) for Germany



3.2. Hungary

The Hungarian data sets starts from July 1921 to March 1925. The money supply series includes notes in circulation and deposits. The price index numbers from July 1921 through December 1923 represent retail prices based on 60 commodities. From December 1923 through March 1925, the figures of the price index represent wholesale prices based on 52 commodities. The exchange rate data are originally quoted as US cents per Hungarian crown.

The empirical results of the structural time series models are presented in Table 3.2 with the components graphics plotted from Figures 9 to 16. All series under study do not contain any seasonal components. The trend for $\boldsymbol{M}_t$ and $\pi_{1,t}$ is found to follow a second differencing specification, but given that the irregular component is not zero, the trend for $\pi_{2,t}$ is known as a smooth trend specification. Moreover, there is one cyclical component found in $\boldsymbol{M}_t$, $\pi_{1,t}$ and $\pi_{2,t}$. The model for the series of $\boldsymbol{M}_t$, $\boldsymbol{M}_t - \pi_{1,t}$ and $\boldsymbol{M}_t - \pi_{2,t}$ include lagged values of the corresponding dependent variables.

The trend follows a random walk for the series of $\Delta\boldsymbol{M}_t$, $\Delta\pi_{1,t}$, and $\boldsymbol{M}_t - \pi_{1,t}$. When the irregular components are nonzero, the trend models for the series of $\boldsymbol{M}_t - \pi_{2,t}$ and $\Delta\pi_{2,t}$ are known as the local level and the local level with a fixed slope respectively, depending upon whether the fixed slope of the trend is existent or not. Also, the stochastic cycles are carried forward to the series of $\Delta\boldsymbol{M}_t$, $\Delta\pi_{1,t}$ and $\boldsymbol{M}_t - \pi_{1,t}$ from the series of $\boldsymbol{M}_t$ and $\pi_{1,t}$, but no cycle is found in the series of $\Delta\pi_{2,t}$ and $\boldsymbol{M}_t - \pi_{2,t}$.

Table 2 ML Estimation Results of the Structural Time Series Model for Hungary

Variables	$\boldsymbol{M}_t$	$\pi_{1,t}$	$\pi_{2,t}$	$\Delta\boldsymbol{M}_t$	$\Delta\pi_{1,t}$	$\Delta\pi_{2,t}$	$\boldsymbol{M}_t - \pi_{1,t}$	$\boldsymbol{M}_t - \pi_{2,t}$
Estimated standard deviation of disturbances [q-ratio]								
σ_η	——	——	——	0.0111 [0.7274]	0.0473 [0.4701]	0.0761 [0.4713]	0.0905 [1.0000]	0.1420 [1.0000]
σ_ζ	0.0150 [1.0000]	0.0531 [0.6997]	0.0393 [0.4932]	——	——	——	——	——
$\sigma_{\kappa 1}$	0.0132 [0.8826]	0.0759 [1.0000]	0.0796 [1.0000]	0.1520 [1.0000]	0.1006 [1.0000]	——	0.0716 [0.7917]	——
$\sigma_{\kappa 2}$	——	——	——	0.0109 [0.7142]	——	——	——	——
σ_ε	——	——	0.0667 [0.8372]	——	——	0.1615 [1.0000]	——	0.0813 [0.5724]
Filtered estimates of final state vector at time T and the estimated coefficient of lagged dependent variable with the corresponding RMSE in the brackets								

μ_T	5.5685* (0.9141)	14.571* (0.1138)	6.5584* (0.1476)	-0.0045 (0.0209)	-0.0153 (0.0737)	-0.0197 (0.1007)	0.5336* (0.1604)	5.2435* (1.2454)
β_T	0.0086 (0.0206)	-0.0227 (0.0826)	-0.0424 (0.0726)	____	____	-0.0057 (0.0121)	____	____
φ_{1T}	0.0025 (0.0178)	-0.0049 (0.1138)	0.0133 (0.1379)	0.0005 (0.02106)	-0.0313 (0.0737)	____	0.0254 (0.0868)	____
φ_{2T}	____	____	____	0.0101 (0.0201)	____	____	____	____
Ψ_1	1.4445* (0.0928)	____	____	0.7691* (0.1049)	____	____	0.5512* (0.1249)	0.4283* (0.1361)
Ψ_2	-0.7987* (0.0922)	____	____	____	____	____	____	____
Estimated parameters of the first cycle [second cycle]								
Variance	0.0006	0.0200	0.0411	0.0012 [0.0012]	0.0181	____	0.0130	____
ρ	0.8429	0.8438	0.9195	0.8979 [0.9513]	0.6645	____	0.7783	____
Period (yr.)	0.4424	0.6942	0.8341	0.4674 [0.8786]	0.5405	____	0.6661	____
λ_c	1.1834	0.7542	0.6278	1.1202 [0.5960]	0.9687	____	0.7861	____
Goodness-of-fit measures and diagnostic checking								
SE	0.0321	0.1403	0.1767	0.0325	0.1382	0.1997	0.1322	0.1748
R(1)	0.0203	0.1292	-0.0437	0.1149	0.0300	0.0886	0.0746	-0.0347
R(6)	-0.0389	0.0606	0.0126	-0.0821	0.0500	-0.1706	0.0518	-0.2389
Q(4)	4.5138	3.7516	4.4654	6.3933	2.8203	7.1317	5.2419	7.3353
Q(7)	6.7565	8.4173	6.2431	6.5268	5.6989	7.5821	8.3902	9.2621
PEV	0.0010	0.0197	0.0312	0.0011	0.0191	0.0399	0.0175	0.0306
R_d^2	0.9191	0.3233	0.1630	0.6929	0.2383	0.2479	0.3192	0.0893
AIC	-6.5683	-3.7064	-3.1996	-6.4889	-3.7769	-3.0852	-3.8200	-3.3518
BIC	-6.2873	-3.5057	-2.9587	-6.1645	-3.6147	-2.9636	-3.6173	-3.2302
Max ln L	140.084	83.0573	72.6282	142.888	84.2527	63.6983	83.8088	71.9792

Notes:

$\sigma_{\kappa 1}$ and $\sigma_{\kappa 2}$ are the standard deviation of the disturbance terms of the first and the second cycle respectively. Also, φ_{1T} and φ_{2T} are the final state of the first and the second cycle respectively.

Since money supply level contains a stochastic trend component, the standard statistical inference of Ψ_1 and Ψ_2 is interpreted with care.

The figures for the structural components indicate that the slopes of the trend and the trend or the economic variables start to shift in the second half of 1923. They all display some evidence of regime-switching behaviour in the observed data series.

Figure 9 Structural Time Series Components of the Hungarian Money Supply Level (M_t)

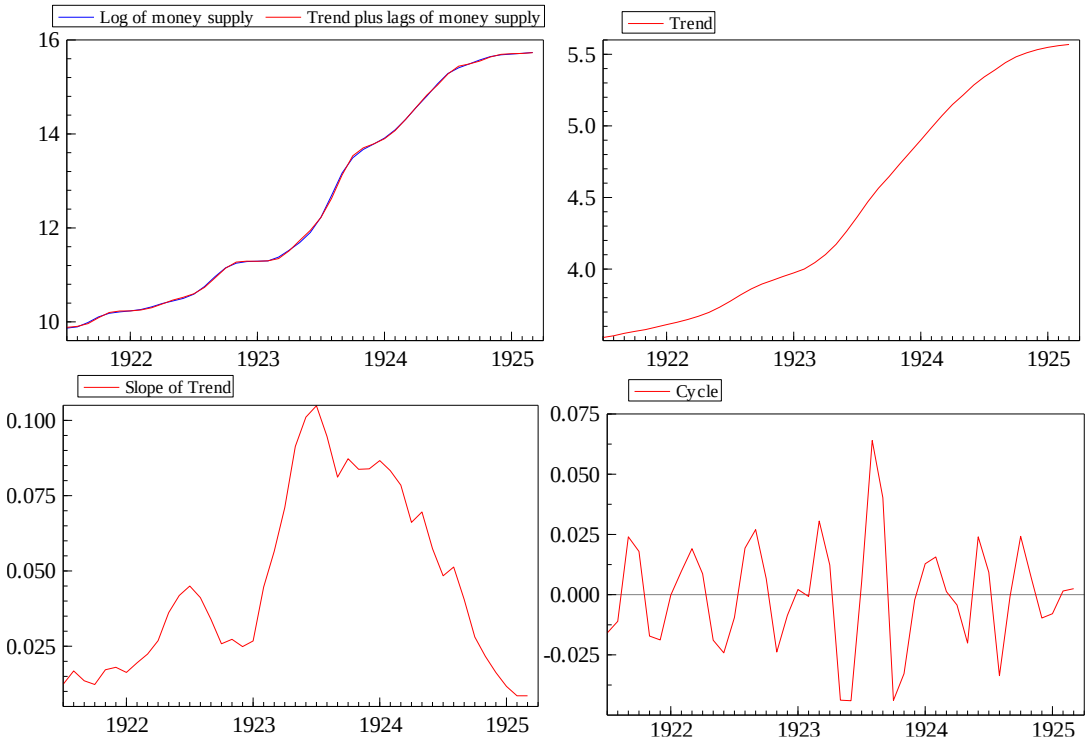


Figure 10 Structural Time Series Components of the Hungarian Composite Price Level (π_{1t})

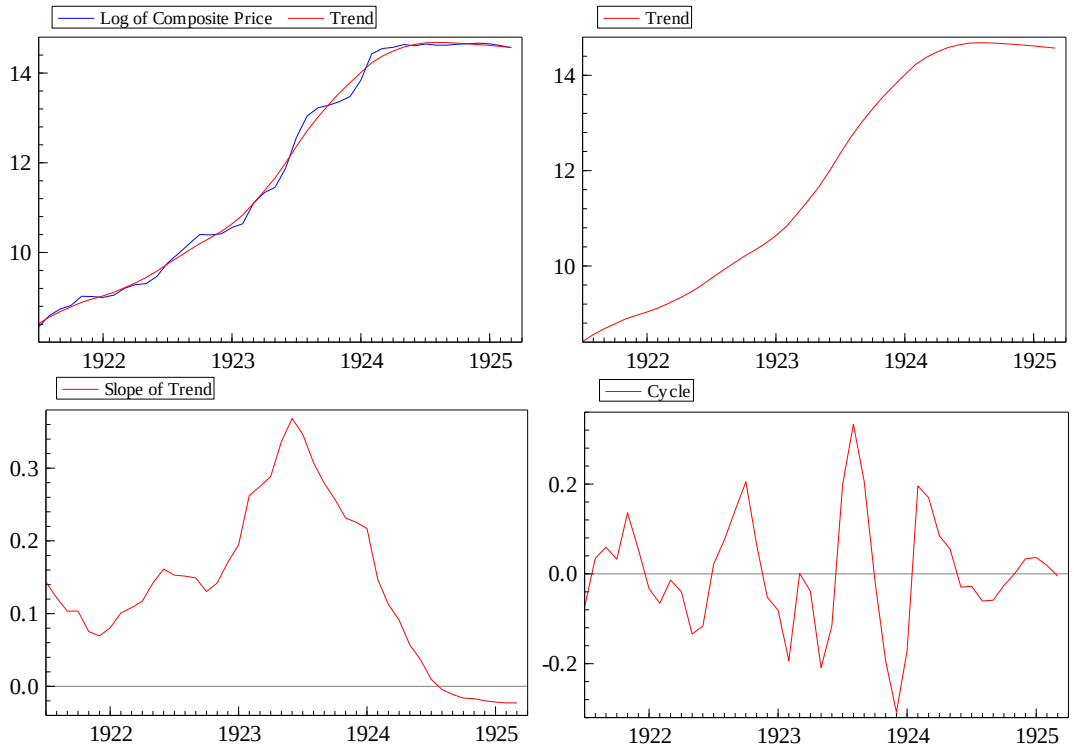


Figure 11. Structural Time Series Components of the Hungarian Exchange Rate (π_{2t})

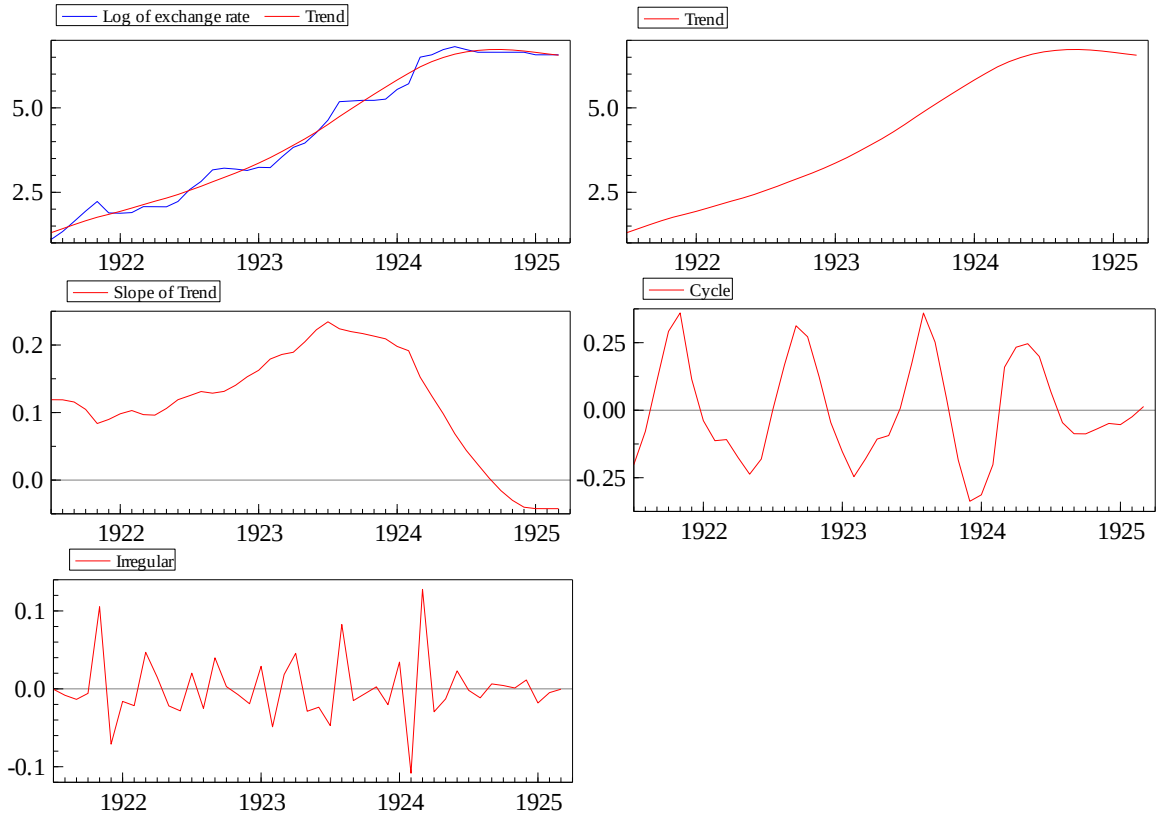


Figure 12. Structural Time Series Components of the Money Supply Change (ΔM_t) for Hungary

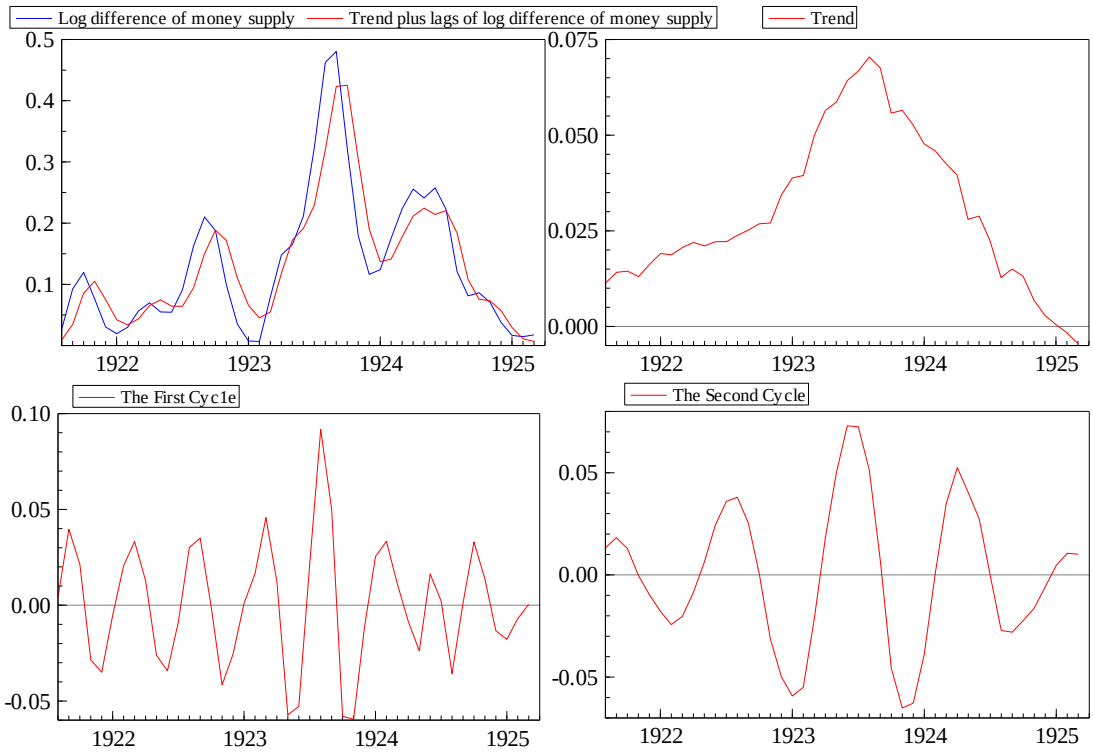


Figure 13. Structural Time Series Components of the Price Change ($\Delta\pi_{1t}$) for Hungary

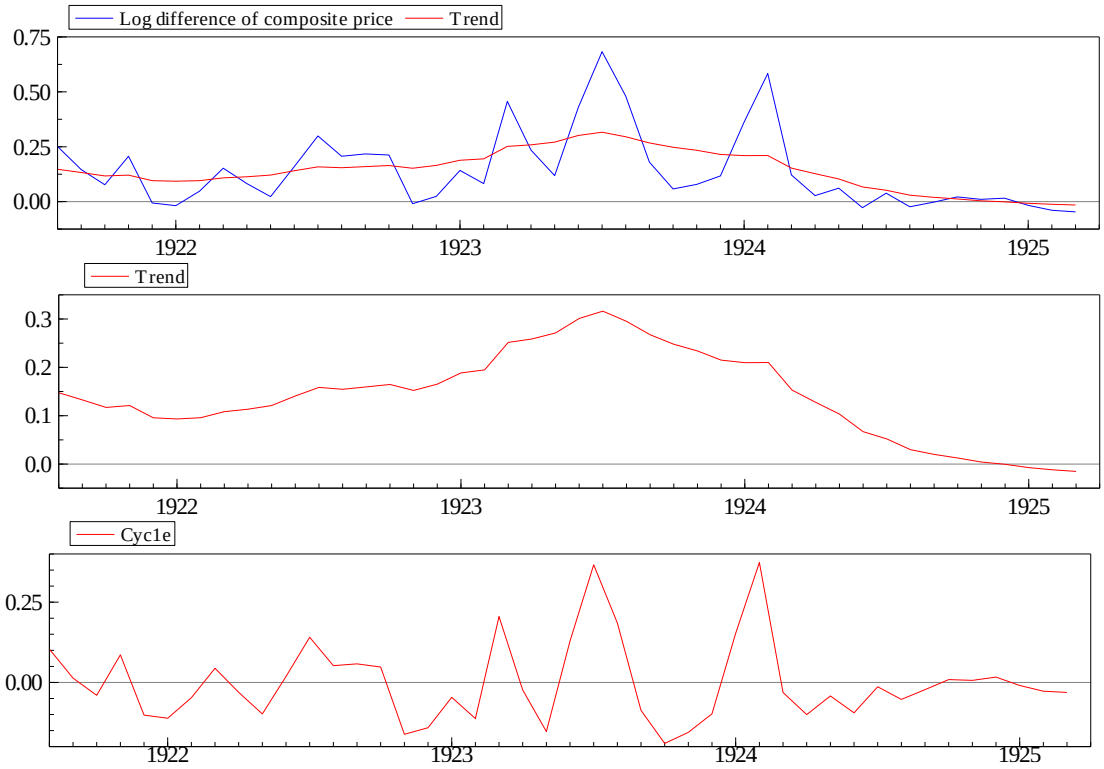


Figure 14. Structural Time Series Components of the Exchange Rate Change ($\Delta\pi_{2t}$) for Hungary

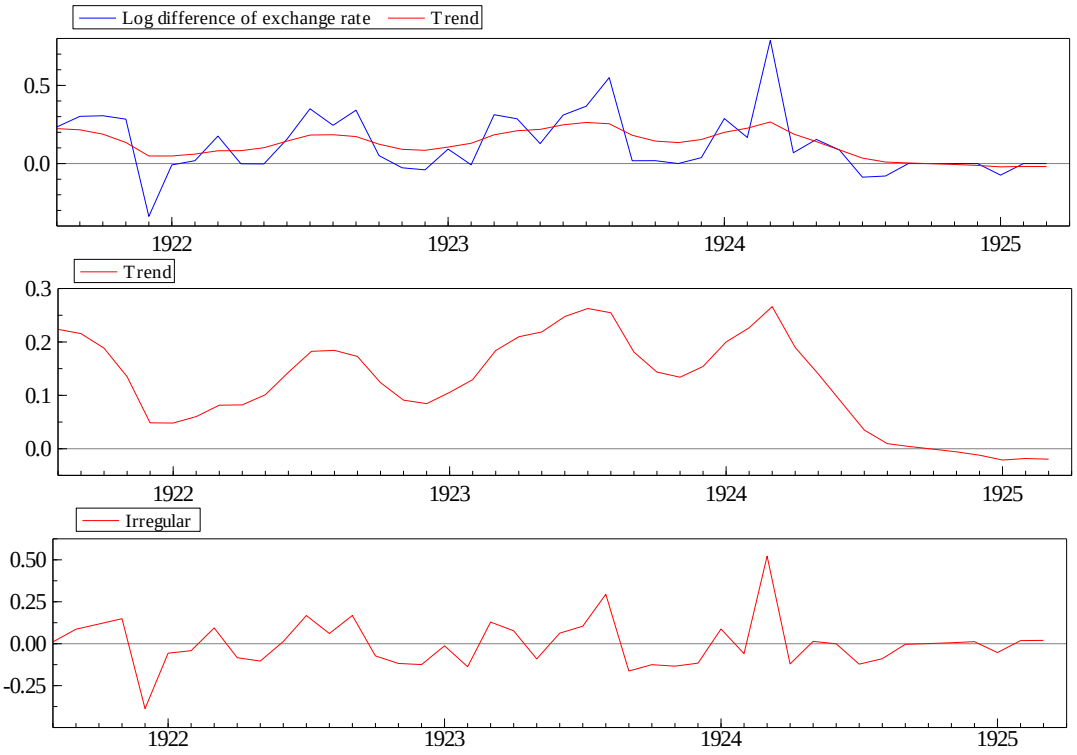


Figure 15. Structural Time Series Components of the Real Money Balance in terms of Composite Price ($M_t - \pi_{1t}$) for Hungary

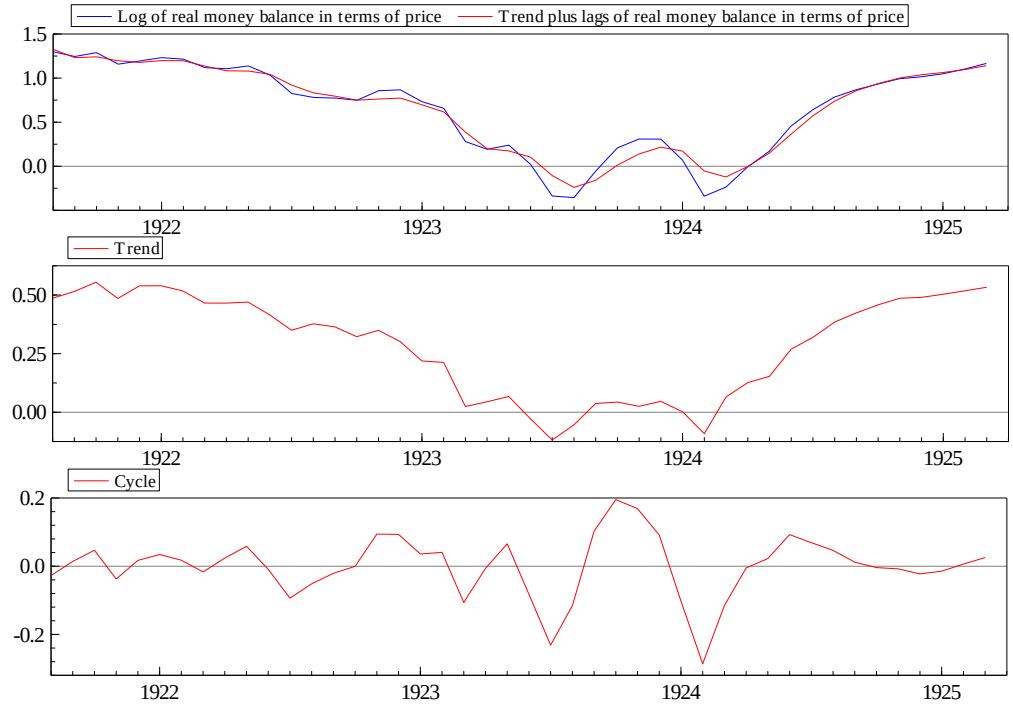
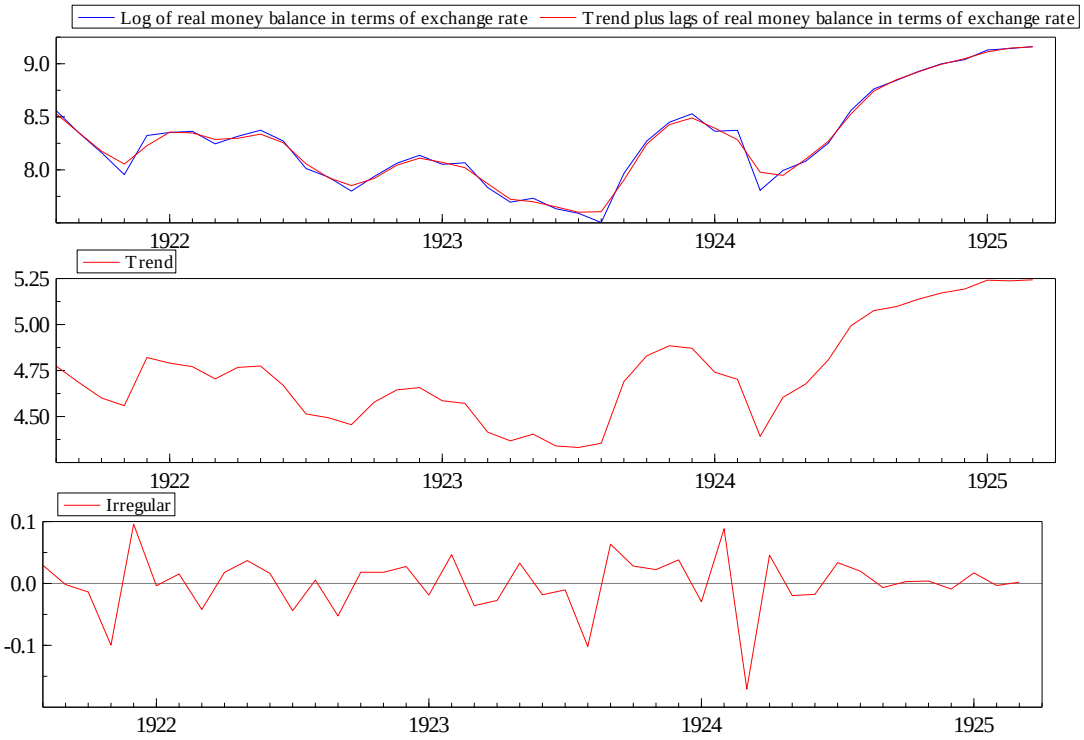


Figure 16. Structural Time Series Components of the Real Money Balance in terms of Exchange Rate ($M_t - \pi_{2t}$) for Hungary



3.3. Poland

The Polish data are collected from January 1921 to March 1924. The money supply includes notes in circulation and the wholesale price index is chosen to represent the price level. The exchange rate series is transformed from US cents per Polish mark.

The empirical results of the structural models are shown in Table 3. As in the case of Hungary, all observed series under study do not contain any seasonal components. Only the model for the series of $\boldsymbol{M}_t$ and $\Delta\boldsymbol{M}_t$ include corresponding lagged dependent variables.

The trend components for the series of $\boldsymbol{M}_t$ and $\pi_{2,t}$ follow a second differencing specification but the trend for $\pi_{1,t}$ is a smooth trend in which the irregular component exists. Moreover, $\pi_{1,t}$ and $\pi_{2,t}$ contain a stochastic cycle, which however cannot be found in $\boldsymbol{M}_t$.

Table 3. ML Estimation Results of the Structural Time Series Model for Poland

Variables	$\boldsymbol{M}_t$	$\pi_{1,t}$	$\pi_{2,t}$	$\Delta\boldsymbol{M}_t$	$\Delta\pi_{1,t}$	$\Delta\pi_{2,t}$	$\boldsymbol{M}_t-\pi_{1,t}$	$\boldsymbol{M}_t-\pi_{2,t}$
Estimated standard deviation of disturbances [q-ratio]								
σ_η	____	____	____	0.07877 [1.0000]	0.0608 [0.4229]	0.1068 [0.4595]	0.1468 [1.0000]	0.1159 [0.7036]
σ_ζ	0.0788 [1.0000]	0.0629 [0.4925]	0.0617 [0.3292]	____	____	____	____	____
σ_κ	____	0.1278 [1.0000]	0.1875 [1.0000]	____	0.0675 [0.4694]	____	0.0861 [0.5867]	0.1648 [1.0000]
σ_ε	____	0.0219 [0.1712]	____	____	0.1438 [1.0000]	0.2324 [1.0000]	____	____
Filtered estimates of final state vector at time T and the estimated coefficient of lagged dependent variable with the corresponding RMSE in the brackets								
μ_T	3.5694 (3.7453)	19.385* (0.2447)	11.350* (0.3109)	-0.2807** (0.1360)	0.4218* (0.1122)	0.2877** (0.1406)	0.2424 (0.1538)	8.1719* (0.1899)
β_T	-0.2807*** (0.1571)	0.4572* (0.1156)	0.4357* (0.1218)	____	____	____	____	____
φ_T	____	-0.1282 (0.2191)	0.0411 (0.3109)	____	-0.3867 (0.1127)	____	0.5860 (0.1538)	0.5837 (0.1899)
Ψ_i	0.8362* (0.1889)	____	____	0.8362* (0.1889)	____	____	____	____
Estimated parameters of cycle								
Variance	____	0.1384	0.1528	____	0.0392	____	0.0905	0.1114
ρ	____	0.9392	0.8774	____	0.9400	____	0.9581	0.8696

Period (yr.)	____	0.9567	1.0921	____	0.9142	____	0.7999	0.9153
λ_c	____	0.5473	0.4794	____	0.5727	____	0.6546	0.5720
Goodness-of-fit measures and diagnostic checking								
SE	0.0755	0.2104	0.2689	0.0766	0.2150	0.2880	0.1994	0.2399
R(1)	0.2588	-0.0226	-0.0386	0.2588	-0.0017	0.1144	0.1531	-0.0374
R(6)	-0.1492	-0.0100	0.0763	-0.1492	-0.0156	-0.0038	0.0433	0.0508
Q(4)	4.4356	1.4354	4.8692	4.4356	1.9140	3.0416	4.3929	6.2058
Q(7)	5.9300	2.6137	6.5065	5.9300	3.0594	6.6827	6.2526	8.1936
PEV	0.0057	0.0443	0.0723	0.0059	0.0462	0.0829	0.0397	0.0576
R_d^2	0.8936	0.4586	0.2024	0.3819	0.2135	0.2010	0.2749	0.1781
AIC	-5.0049	-2.8100	-2.3703	-5.0286	-2.8113	-2.3845	-3.0149	-2.6442
BIC	-4.8743	-2.5540	-2.1570	-4.9406	-2.5958	-2.2983	-2.8425	-2.4718
Max ln L	87.2775	55.8956	46.9873	87.2775	55.6872	45.3099	58.4529	51.9073

See Notes to Tables 1 and 2.

For the series of $\Delta \boldsymbol{M}_t, \Delta\pi_{1,t}$, $\Delta\pi_{2,t}$, $\boldsymbol{M}_t - \pi_{1,t}$ and $\boldsymbol{M}_t - \pi_{2,t}$, the fixed slope of the trend cannot be found. Also, the irregular components exist for the series of $\Delta\pi_{1,t}$ and $\Delta\pi_{2,t}$ only. Hence, the trend model for the series of $\Delta \boldsymbol{M}_t$, $\boldsymbol{M}_t - \pi_{1,t}$ and $\boldsymbol{M}_t - \pi_{2,t}$ follows a random walk but it follows a local level for the series of $\Delta\pi_{1,t}$ and $\Delta\pi_{2,t}$. Furthermore, the stochastic cycles remain in series of $\Delta\pi_{1,t}$, $\boldsymbol{M}_t - \pi_{1,t}$ and $\boldsymbol{M}_t - \pi_{2,t}$ but not in $\Delta\pi_{2,t}$.

From the movements of the trend as well as the slope of trend for the time series variables under study shown in Figures 17 to 24, some evidence of structural changes is found in the data generation that occurred in the late 1923.

Figure 17. Structural Time Series Components of the Polish Money Supply Level ($\boldsymbol{M}_t$)

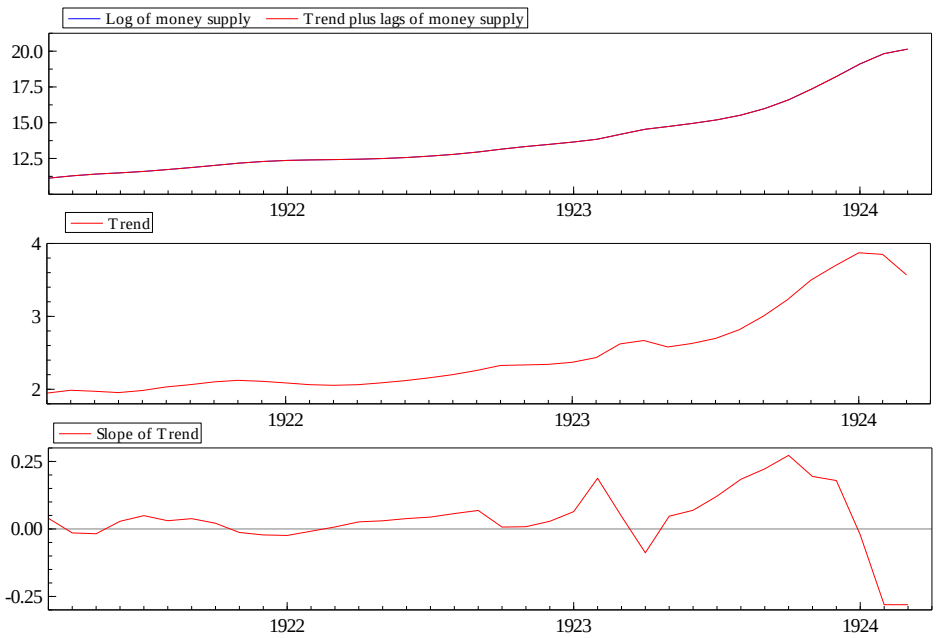


Figure 18. Structural Time Series Components of the Polish Wholesale Price Level (π_{1t})

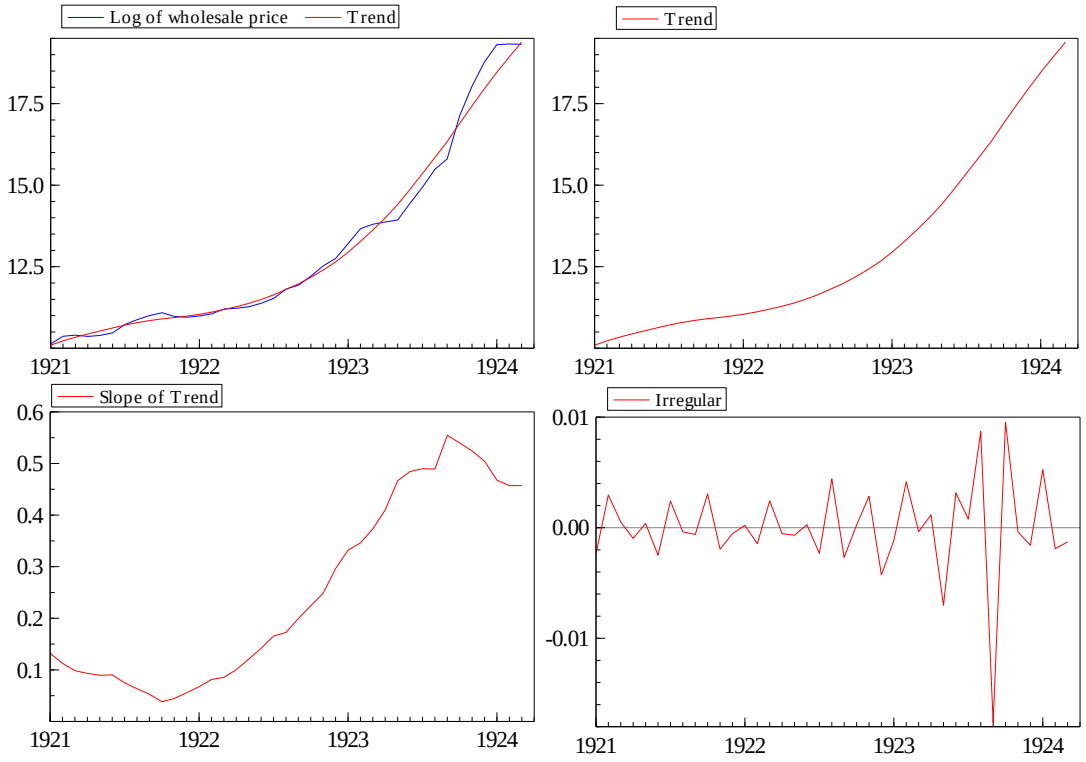


Figure 19. Structural Time Series Components of the Polish Exchange Rate (π_{2t})

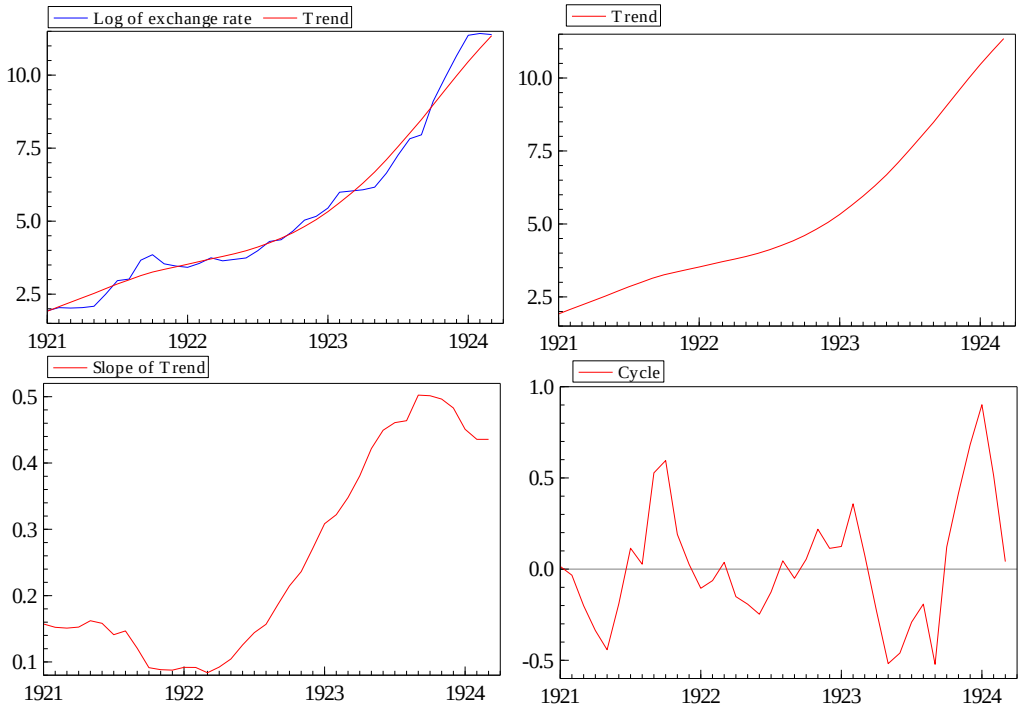


Figure 20. Structural Time Series Components of the Money Supply Growth (ΔM_t) for Poland

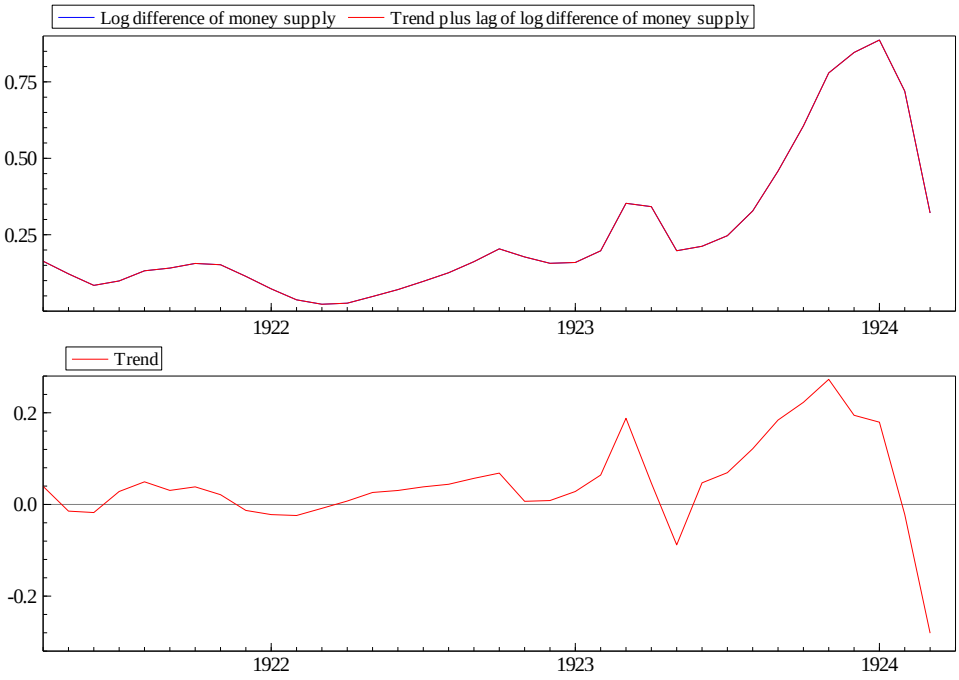


Figure 21. Structural Time Series Components of the Price Change ($\Delta\pi_{1t}$) for Poland

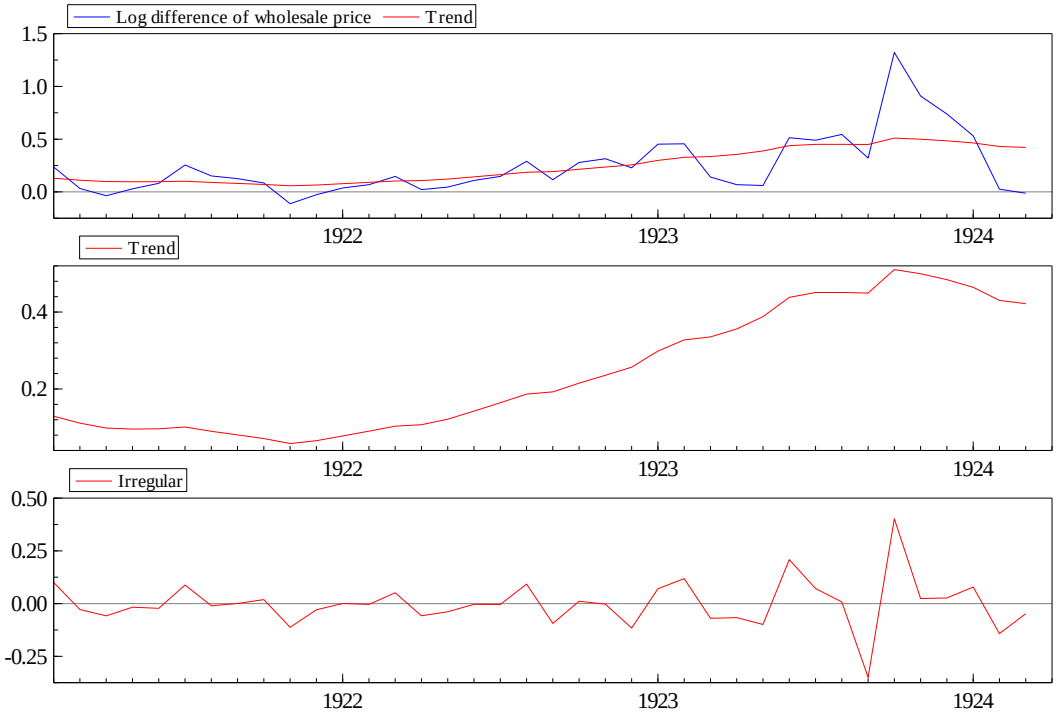


Figure 22. Structural Time Series Components of the Exchange Rate Change ($\Delta\pi_{2t}$) for Poland

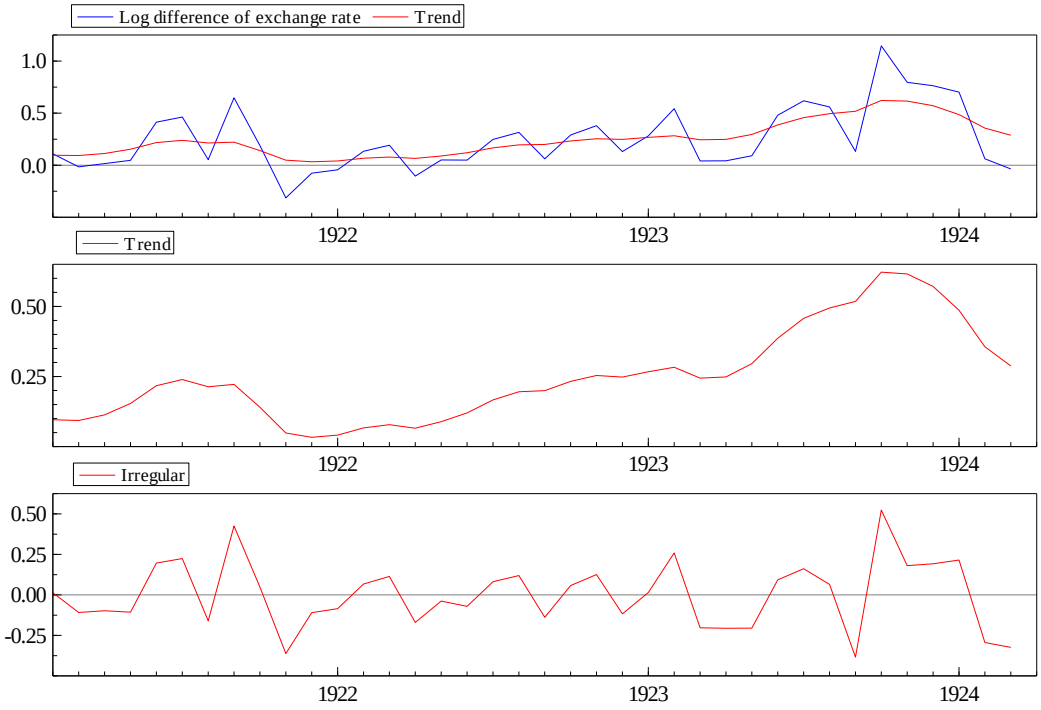


Figure 23. Structural Time Series Components of the Real Money Balance in terms of Wholesale Price ($M_t - \pi_{1t}$) for Poland

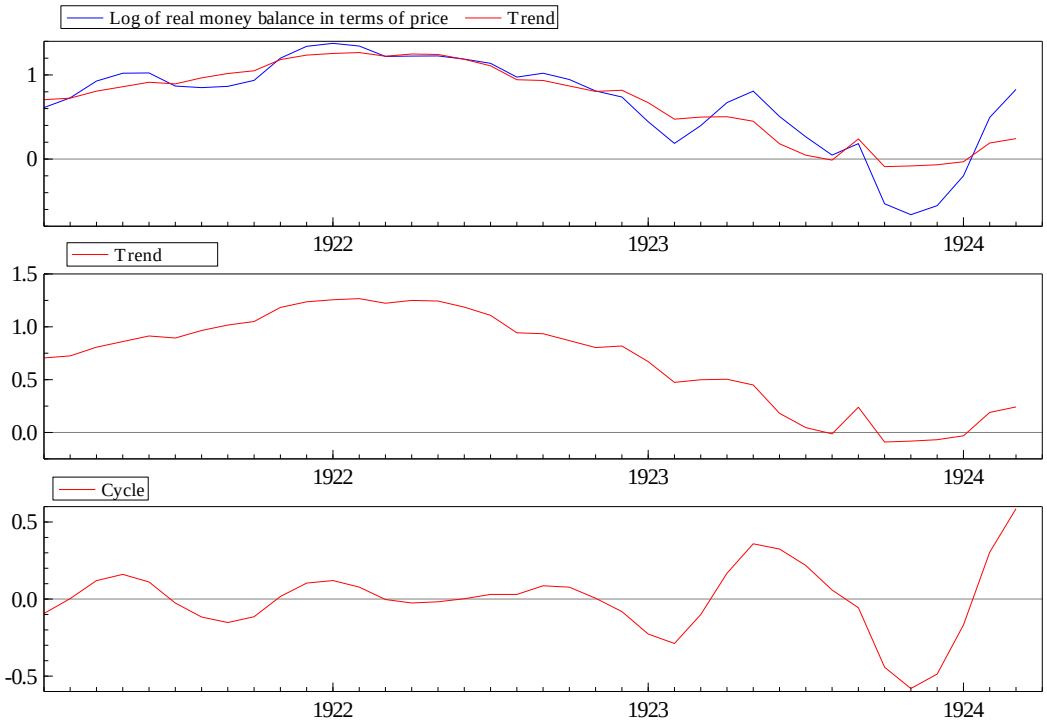
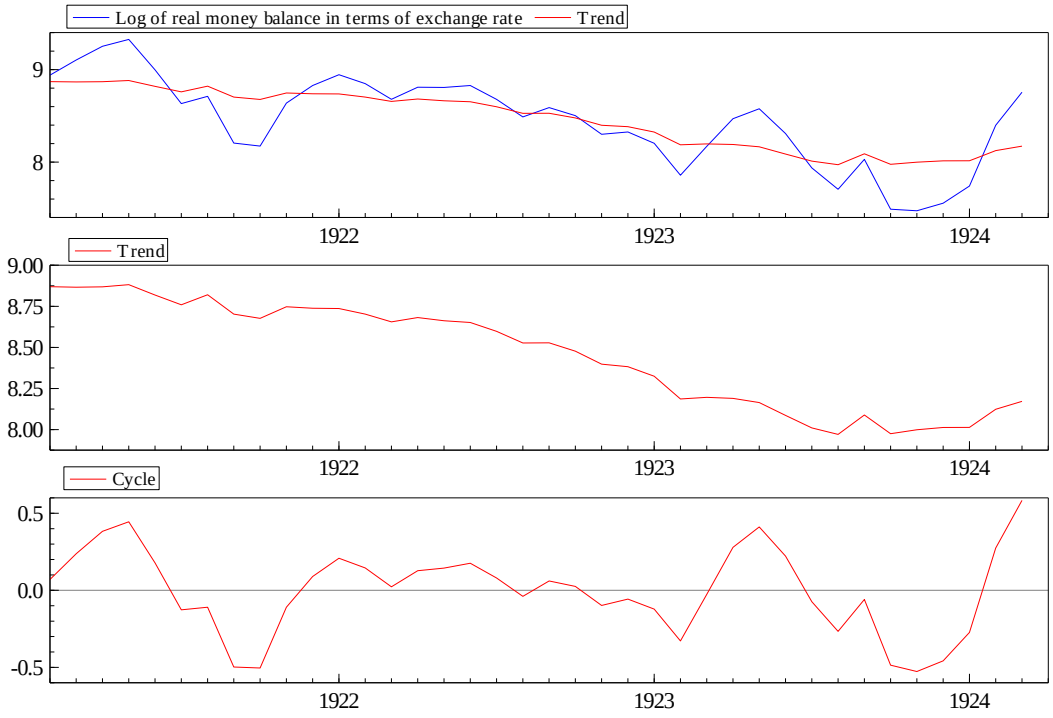


Figure 24. Structural Time Series Components of the Real Money Balance in terms of Exchange Rate ($M_t - \pi_{2t}$) for Poland



4. Conclusion

This paper is slightly modified from Chapter Three of Woo (2004). From the analysis of structural time series components, the cycles and seasonals are found in some data series. More importantly, the trend for the levels of money supply, price and exchange rate is composed of a fixed level with a stochastic slope. From the reduced form of the structural time series models (Harvey, 1989), the integration order of these level series is two; in other words, they contain double unit roots. It is consistent with Haldrup (1998) that the economic variables are likely to be I(2) during hyperinflation. Also, the real money balances, the first-differenced price, and exchange rate series have a stochastic trend with a fixed or zero slope, implying that these series contain a unit root. From the figures of the structural components, it indicates possible regime changes in data generation, resulting from monetary regime changes.

References

Abel, A., Dornbusch, R., Huizinga, J. & Marcus, A. (1979). Money Demand During Hyperinflation. Journal of Monetary Economics, 5, 97-104.

Cagan, P. (1956). The Monetary Dynamics of Hyperinflation. In M. Friedman (eds.), Studies in the Quantity Theory of Money. Chicago: University of Chicago Press.

Harvey, A.C. (1989). Forecasting, Structural Time Series Models and Kalman Filter. Cambridge University Press

Tinbergen, J. (ed.) (1934). International Abstract of Economic Statistics 1910-30. London: International Conference of Economic Services.

Woo, Kai-Yin (2004), Empirical Testing for Bubbles during the Inter-War European Hyperinflations, PhD Thesis, University of Stirling, Scotland, UK.

Young, J.P. (1925). European Currency and Finance, Vol. 2. Washington, D.C: U.S. Government Printing Office.

Biography of author(s)

Kai-Yin Woo

Hong Kong Shue Yan University, Hong Kong.

He is an Associate Professor at the Department of Economics and Finance of Hong Kong Shue Yan University. He obtained PhD at the University of Stirling, Scotland. His research interests include the economics of finance and applied econometrics. His research topics include bubble testing, investigation of price convergence and purchasing power parity, and empirical study on the Belt and Road Initiative and the Greater Bay Area of China. He has published journal articles in Economics Letters, Applied Economics, Economic Modelling, Journal of Macroeconomics, Singapore Economic Review, International Review of Economics and Finance, Advances in Decision Sciences, Applied Economics Letters, Empirical Economics and others.

CAUSALITY AND BEHAVIORAL FINANCE STUDIES

Free Download

https://scibiz.world/?p=171

NAME OF BOOK	Causality and Behavioral Finance Studies
AUTHORS	Raymond Wai-man Yeung Kai-Yin Woo Edward Chi-Ho Tang Jacky Ho-Man Lau Chun-Kei Tsang Sung-Ko Li Tai-Yuen Hon Wing-Kwong Au Wing-Keung Wong
PUBLISHER	Scientific and Business World 660 Geylang Rd., Singapore 389590
DATE OF PUBLICATION	2025 April /First Edition

eISBN:

PUBLISHED IN SINGAPORE