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Forecasting Economic Cycle with a Structural Equation Model: Evidence from Thailand

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ABSTRACT

The study proposes a partial least squares structural equation modeling (PLS-SEM) evaluating the relationship among composite leading indices (CLIs) to forecast the economic cycle (EC) instead of using only individual CLI. The model of quarterly data in Thailand during 2013-2018 includes five constructs representing economic sectors that have the potential to be CLIs of EC. Those are two short-term CLIs including Short-leading economic index (SLEI) and International transmission (Trade channel) (ITT). SLEI composes Narrow money, Business sentiment index (Next 3 months), and Export volume index while ITT constructs from CLI of the major export partners. The Financial cycle (FC) has the potential to be the medium-term CLI, which includes Housing price index, Household debt to GDP, and Household debt. While Monetary condition (MC) and International transmission (Monetary channel) (ITM) are the long-term CLI. MC consists of Policy interest rate and real effective exchange rate whereas ITM is represented by the global economy using CLI for OECD and non-member economies as a proxy. The evidence from the forecasting performance in the out-of-sample by PLS-SEM outperforms the alternative models for all short-term, middle-term, and long-term periods. Therefore, the study convinces to apply the PLS-SEM to forecast EC.

Keywords: PLS-SEM, leading indicator, economic cycle, forecasting
JEL Classifications: E17, E32, E37

1. INTRODUCTION

World, region and individual countries have repeatedly faced economic fluctuation, and some of them become economic crises. That is the reason why the interest of developing early warning systems (EWSs) to signal policymakers before economic damages increases. Leading indicator aiming to signal ahead recessions and recoveries of economy is one of the popular tools in the EWSs area, which was developed by Mitchell and Burns (1938) in the 1930s. However, each leading indicator might have abilities to signal at different periods. As for the Organisation for Economic Co-operation and Development (OECD) separates leading indicators into two groups: a short-medium (leading 2-8 months) and a longer (leading over 8 months) leading indicator (Gyomai and Guidetti, 2012). While Babecký et al. (2013) classify their economic leading indicators into three groups: a late-warning (leading 1-3 quarters), an early-warning (leading 4-8 quarters), and an ultra-warning (leading since 9 quarters) leading indicator, and they also add that the financial indicators tend to lead the economic cycle (EC) longer than macroeconomic variables. Because of the higher ability of composite leading index (CLI) over individual indicators (Levanon et al., 2015; Stock and Watson, 1989), researchers generally combine leading indicators to be CLIs, which relevant to their leading ability horizon such as a short-term, a medium-term, and a long-term CLI. However, they are generally used as early warning tools separately.

To support "Two heads are better than one", the paper aims to demonstrate that the forecasting ability of the linkages of CLIs outperforms the individual CLI. Therefore, the study evaluates the relationships of CLIs to forecast EC of Thailand during Q1/2003-Q4/2018 by a partial least square-structural equation modeling (PLS-SEM). PLS-SEM prominently appropriates for this task because it can construct CLIs through a measurement model, and evaluate the relationship among those CLIs from a structural model. To forecast EC from the linkages of CLIs by PLS-SEM is a brand-new: to my knowledge, no one in the EWSs field applies this method before.

To pursue the study objective, the proposed linkages of CLIs based on the literature reviews provide in the next section. The methodologies and results are expressed in the third and the fourth section respectively. Finally, the study makes a research conclusion in the fifth section.

2. LITERATURE REVIEWS AND CONCEPTUAL MODEL

This section aims to provide the literature regarding the synchronization of both domestic and international sectors to EC and also to reviews the component indicators capturing them with the aim to propose the model hypotheses and the conceptual model.

2.1. Literature

The prier literature supports that there are the linkages between the monetary sector, the financial sector, the real sector, and the global sector, to EC. Moreover, those can signal the fluctuation of EC at different horizons.

To begin with, the monetary policy, which generally managed by the central bank, the ultimate goal of the monetary policy is to support the national economic expansion in the long run. The essential objective of the monetary policy is to stabilize the financial sector because financial stability is a crucial role in harnessing economic growth with sustainability, (Wongwachara et al., 2018). Generally, the financial instability captured by the financial cycle (FC) fluctuating from peak to trough continuously, the peaks of the financial cycle tend to follow by the financial crises and the economic fluctuations (Borio, 2014; Borio et al., 2018). There is a trade-off relationship between FC and the real economy; the increase of FC (the financial imbalance) tends to follow by the real economic downturn (Wongwachara et al., 2018). Based on the literature above, Hypothesis1 and Hypothesis2 are set as the following.

Hypothesis 1 *MC → EC* (-): Monetary condition (MC) is a long-term CLI with the counter-cyclical behavior of EC. (Tightening the monetary policy will significantly make a negative impact on EC with direct and/or indirect effects in the next 9-12 quarters).

Hypothesis 2 *FC → EC* (-): Financial cycle (FC) is a medium-term CLI with the counter-cyclical behavior of EC. (The increasing of the financial instability will significantly make a negative impact on EC with direct and/or indirect effects in the next 4-8 quarters).

Furthermore, the domestic economy possibly gets affected by global economic fluctuations through international transmission (IT). IT refers to the economic fluctuation in one or a group of countries affect other countries so that they are interdependent displaying the economic correlation across countries (Cantor and Mark, 1988), and widely literature concludes that they positively correlate (Schmitt–Grohé, 1998). Since trade and financial integration between countries increase, the countries have the synchronization of the business cycle (Kose et al., 2003). Sethapramote (2015) studies the business cycle synchronization of the Association of Southeast Asian Nations (ASEAN) from the internal and external regions. His study points out that trade transmission is an important factor in ASEAN synchronization because they rely on export revenue. Therefore, the fluctuation of their major partner countries of exportation can make an effect on them. Thailand is a small open economy in ASEAN, which also has a major revenue from exportation. Due to the demand for Thai goods and services rely on the partner economies, the economic fluctuations of those countries can make a spillover effect on the Thailand through the trade channel. Therefore, the Hypothesis3 is set as the following.

Hypothesis3 *ITT → EC* (+): International transmission (Trade channel) (ITT) is a short-term CLI with the pro-cyclical behavior of EC. (The economic fluctuations of the Thailand's export partners will significantly make an impact on EC through trade channel with direct and/or indirect effects in the next 1-3 quarters).

In addition, the global economy probably transmits to the domestic by the monetary sector. The variation of the global money supply, which relies on the global economy, has a tendency to affect the national interest rate and currency (Hickman, 1974). The Hypothesis4 comes from the above literature.

Hypothesis 4 *ITM → EC* (+): International transmission (Monetary channel) (ITM) is a long-term CLI with the pro-cyclical behavior of EC. (The variation of the global economy can significantly transmit to EC through the monetary sector with direct and/or indirect effects in the next 9-12 quarters).

Besides, in the short-run, policymakers normally monitor a group of indicators capturing the fluctuations of EC in advance, called a short-term leading economic index (SLEI). The SLEI provides early signals of EC, which generally has the ability to lead EC 1-3 quarters (Babecký et al., 2013; Bank of Thailand; Gyomai and Guidetti, 2012). Hence, the following is Hypothesis5.

Hypothesis 5 *SLEI → EC* (+): Short-leading economic index (SLEI) is a short-term CLI with the pro-cyclical behavior of EC. (The changing of SLEI has a significant positive impact on EC with direct and/or indirect effects in the next 1-3 quarters).

In summary, the monetary policy measured by MC will firstly make an impact on FC ($H_{MC, FC}$) and FC will consequently cause EC ($H_{FC, SLEI}$; $H_{FC, EC)}$ (Juselius et al., 2016). Generally, MC appears counter-cyclical to EC ($H_{MC, SLEI}$ and $H_{MC, EC)}$ referring to the study of Buckle et al. (2003). In the short-term, there are also some signals before turning point of EC; SLEI provides those signals ($H_{SLEI, EC)}$) (Babecký et al., 2013; Bank of Thailand; Gyomai and Guidetti, 2012). Moreover, the domestic economy probably gets an impact from the global economy through IT by trade ($H_{ITT, SLEI}$; $H_{ITT, EC}$) and monetary channels ($H_{ITM, MC}$; $H_{ITM, FC}$; $H_{ITM, SLEI}$; $H_{ITM, EC}$).

Nevertheless, EC, SLEI, FC, MC, ITT, and ITM cannot be directly observed, which are latent variables or unobserved variables. Hence, the study reviews the reasonable indicators to represent them or to be their proxies as the following.

EC is fluctuations in economic activities. It shows the increase and decrease in the production of goods and services in the economy. Generally, the cycle of real gross domestic product (GDP) or Manufacturing production index (MPI) is applied to measure EC or the proxy of the economic activities (Bilan et al., 2017).

SLEI is the combination of short-term leading indicators aiming to advance notice the fluctuations of EC about 1-3 quarters (Babecký et al., 2013; Bank of Thailand; Gyomai and Guidetti, 2012). Bank of Thailand develops SLEI to give advance signal of Thailand ahead 3-4 **mont**hs; it includes 7 components: the business sentiment index (next 3 **mont**hs), the export volume index (exclude gold), the money supply, the authorized capital of newly registered companies, the new construction area permitted, the stock exchange index of Thailand, and the Dubai oil price index.

FC is no consensus regarding its definition; nevertheless, it usually aims to capture the financial instability (Grinderslev et al., 2017) and forecast the financial crises (Wongwachara et al., 2018). In general, FC mainly consists of credit and property price (Alternatively, it can include others less important components) (Borio, 2014; Borio et al., 2018; Drehmann et al., 2012; Grinderslev et al., 2017) in order to represent the interaction between the financing constraints (credit) and the perceptions of value and risks (property prices) (Borio, 2014). Focusing on the medium-term of the financial cycle, Borio et al. (2018); Drehmann et al. (2012) construct the financial cycle by 3 components including the credit, the credit-to-GDP ratio, and the property prices. Following the concept of Drehmann et al. (2012), Wongwachara et al. (2018) construct FC of Thailand by equal weight from four components, namely the credit aggregates, the credit-to-GDP ratio, the single-detached house (including land) price index, and the land price index.

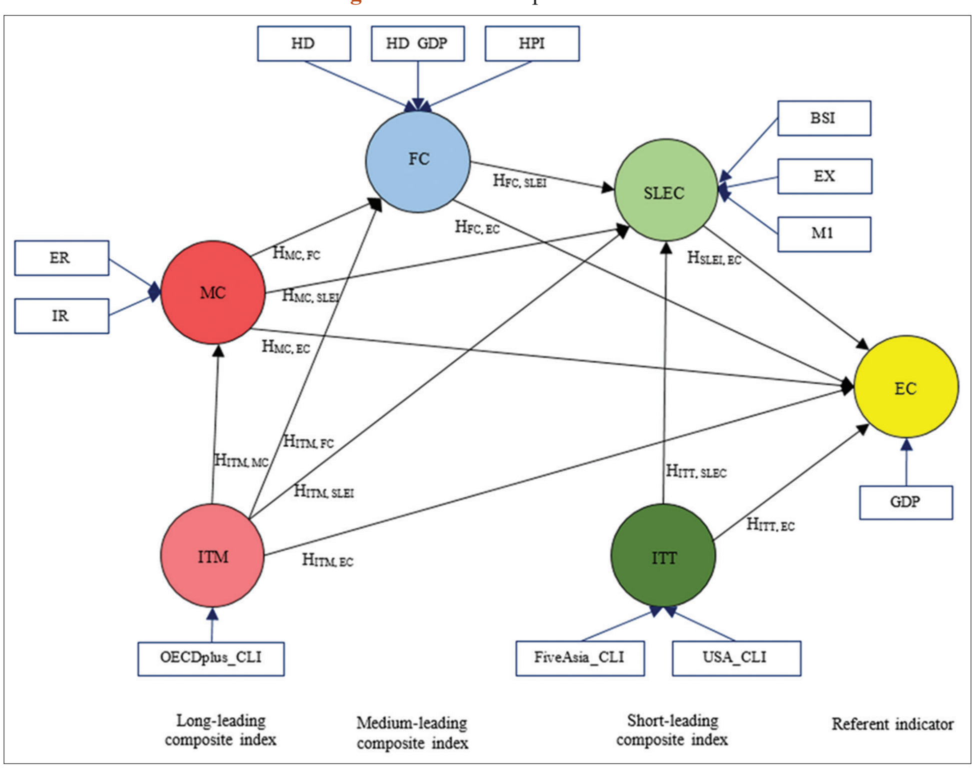
MC was developed by the Bank of Canada as the country's operational targets by combining the interest rate and exchange rate (Freedman, 1996). It gains popular use; various organizations with both government and private sectors construct MC to access the stance of monetary policy (Ericsson et al., 1998). Memon and Jabeen (2018) also construct MC for Gulf countries and interpret the changes of index as the tightening (MC increasing) or loosing (MC decreasing) monetary conditions; moreover, they also conclude that MC has the ability to forecast GDP.

In accordance with ITT, the study considers applying the economies of the US and the major five-ASIA countries (namely China, India, Indonesia, Japan, and Korea) as a proxy of ITT since they are the major export markets of Thailand (about 11.0% and 30.0% of the total Thai exportation in 2018 respectively). Since the demand happens before the exportation; therefore, the study considers the CLI of those countries as a proxy of ITT. While ITM is represented by the global economy. OECD plus CLI is applied as the proxy of ITM because it can give early signals of the world economic activity's turning points (Nilsson, 2006).

2.2. Conceptual Model

According to the above literature reviews, the SLEI, FC, MC, ITT, and ITM have the potential to be CLIs of EC; therefore, the study proposes the conceptual model explaining the linkages between those CLIs and their components to predict EC as in Figure 1.

Figure 1: The Conceptual model



3. DATA AND METHODOLOGY

The Empirical study utilizes time series data based on the literature reviews and analyzes the relationship among CLIs to forecast EC by PLS-SEM. The procedures are summarized as the following:

3.1. Data

The quarterly data are employed from various economic sectors, which are broadly related to Thailand (Table 1). Because of the limitation of available data, the study utilizes the data from Q1/2003 to Q4/2018, 16 years or 64 quarters.

3.2 Selection of the Reference Series and the Leading Indicators

The study identifies the reference and leading indicators of EC based on the literature review.

1) Reference series: The reference series is a proxy of what the early warning systems (EWSs) object to advance signal or to forecast. Forecasting EC is the aim of the study and the indicator commonly used to evaluate an EC is GDP at constant prices and MPI. However, MPI might not appropriate to be a proxy of economic activities because in some case it acts as a leading not coincident indicator of EC (Bilan et al., 2017). Therefore the study employs GDP as a reference series.
2) Leading indicators: The selection of leading indicators is to identify indicators having a tendency to lead EC in advance. These indicators are involved widely in economic sectors with the goal to advance signal EC in the short-term, the medium-term, and the long-term period. The study selects those leading indicators based on the literature reviews.

3.3. Data Filtering and Standardization

The objective of this step is to evaluate the cyclical pattern of each indicator. To achieve this purpose, the study follows the growth cycle concept, which is defined as the movement in economic activities deviating up and down from the long-run potential level or fluctuating in the output-gap (Mintz, 1969). The study filters the indicators by removing their time series components such as decomposing seasonal factor and outlier by X12, extracting trend by Hodrick-Prescott[1], and smoothing them by Double Hodrick-Prescott, in order that no other factors obscure the cyclical pattern. However, many data have different units, the study needs to make a standardization for all data in order that they will not have the unit effect in the analysis. The above-mentioned steps follow the OECD CLI procedures (Gyomai and Guidetti, 2012).

3.4. PLS-SEM

To fulfill the study objective, PLS-SEM is applied to investigate the relationship among the monetary sector, the financial sector, the real sector, and the global sector, which are considered as the CLIs of EC. The structural equation model (SEM) prominently appropriates for the study because of the ability to evaluate the complex relationships among CLIs (unobserved variables) and their indicators.

SEM can be classified into two types: covariance-based (CB-SEM) and variance-base structural equation modeling (i.e., PLS-SEM). These two approaches have the distinction. The objective of CB-SEM is theory confirmation. It aims to minimize the difference between the estimated and the sample covariance matrices to evaluate model parameters, and the data applied in the model have to be normal distribution and quit a big sample size. Whereas, the purpose of PLS-SEM is to forecast the major target constructs. It attempts to maximize the explained variance of the endogenous unobserved variables. The method can estimate a complex model with all data distribution and a small sample size. Therefore there is much literature applying PLS-SEM with a forecasting purpose using a small sample size (Castro-González and Leon, 2017; Jabeur and Sghaier, 2018). Because of its outstanding ability, PLS-SEM become a common statistical method in many fields of science (F. Hair Jr et al., 2014; Hair Jr et al., 2016).

Aiming to predict EC with a quit small sample data, the model composing of a single-item construct, and all CLIs relying on

1 Nevertheless, Hamilton (2018) disagrees to use HP filter because it produces a result of spurious dynamics. However, Hamilton (2018) argues that we should still use the HP filter as long as the criticisms have no clear theoretical foundations, at least to generate credit gaps. They suggests that those criticisms are proposed gaps but not the indicators. Moreover, HP filter is still widely tool for identifying data cyclical (Bilan et al., 2017; Tule et al., 2016)

Table 1: Variables and data sources

Type of index	Unobserved variable	Indicators	Data sources
Reference index	Economic cycle (EC)	Real gross domestic product (GDP)	National Economic and Social Development Board of Thailand (NESDB)
Short-term CLI	Short-leading economic index (SLEI)	Narrow money (M1)	Bank of Thailand (BOT)
		Business sentiment index (Next 3 months) (BSI)	Bank of Thailand (BOT)
		Export volume index (Exclude gold) (EX)	Bank of Thailand (BOT)
	International transmission (Trade channel) (ITT)	OECD CLI for major five Asia (FiveAsia_CLI)	OECD.stat
		OECD CLI for United States (USA_CLI)	OECD.stat
Medium-term CLI	Financial cycle (FC)	Housing price index (Townhouse and land) (HPI)	Bank of Thailand (BOT)
		Household debt to GDP (HD_GDP)	Bank of Thailand (BOT)
		Household debt (HD)	Bank of Thailand (BOT)
Long-term CLI	Monetary condition (MC)	Policy interest rate (IR)	Bank of Thailand (BOT)
		Real effective exchange rate (ER)	Bank of Thailand (BOT)
	International transmission (Monetary channel) (ITM)	OECD CLI for OECD and non-member economies (OECDplus_CLI)	OECD.stat

formative concept, PLS-SEM is the most suitable for the study (Hair Jr et al., 2016; Lowry and Gaskin, 2014).

PLS-SEM developed by Wold (1975), the approach combines the principal components analysis and the ordinary least squares regressions to estimate partial model structures. The method composes of two parts: a measurement and a structural model. The measurement models are to construct unobserved variables from their indicators with unequal weight, and the structural model evaluates the relationships among those unobserved variables.

1) Measurement model: The measurement model displays the relationships between unobserved variables and their indicators. The study applies a formative measurement model, which is based on the concept of a composite index or a proxy of the unobserved variable (not a causal index) to build the unobserved variables or CLIs in this context. The unobserved variables are constructed by linear combination with no error term.

$$\xi = \Pi_x X \quad (1)$$

$$\eta = \Pi_y Y \quad (2)$$

Where,
ξ is a vector $[n \times 1]$ representing the exogenous variables.
η is a vector $[m \times 1]$ representing the endogenous variables.
Π_x is a matrix $[n \times q]$ representing the outer weights of the exogenous variables' indicators.
Π_y is a matrix $[m \times q]$ representing the outer weights of the endogenous variables' indicators.
X is a vector $[q \times 1]$ representing the manifest variables of the exogenous variableξ
Y is a vector $[p \times 1]$ representing the manifest variables of the endogenous variable η.

2) Structural model: The structural model shows the relationships between the unobserved variables. The study applies the structural model to evaluate the relationships between CLIs and EC with both direct and indirect relationships.

Table 2: The result of the Augmented Dickey-Fuller unit root test

Indicators	Variables	t-Statistic
Real gross domestic product	GDP	−5.02***
Narrow money	M1	−4.19***
Business sentiment index (Next 3 months)	BSI	−2.32**
Export volume index (Exclude Gold)	EX	−4.05***
OECD CLI for Major five Asia	FiveAsia_CLI	−4.19***
OECD CLI for United States	USA_CLI	−3.04***
Housing price index (Town House and Land)	HPI	−4.60***
Household Debt to GDP	HD_GDP	−2.98***
Household debt	HD	−3.08***
Policy interest rate	IR	−3.69***
Real effective exchange rate	ER	−4.24***
OECD CLI for OECD and non-member economies	OECDplus_CLI	−3.83***

The null hypothesis of the test is the indicator has a unit root on the data. ***, **,* significant at the 0.01, 0.05, 0.10 level respectively.

$$\eta = \mathrm{B}\eta + \Gamma\xi + \varsigma \quad (3)$$

Where,
B is a matrix $[m \times m]$ representing the structural coefficients relating to exogenous and endogenous variables.
Γ is a matrix $[m \times m]$ representing the structural coefficients relating to endogenous variables.
ζ is a vector $[n \times 1]$ representing the random disturbance term.

4. RESULTS

This section will explore the relationships among CLIs and their component indicators to forecast EC.

4.1. Filtering Data

First of all, the study applies GDP as a proxy of aggregate economic activities to identify EC and collects possible leading indicators of EC, during Q1/2003 to Q4/2018. Even though the data is quite a short time series, they still meet the sample size requirement of PLS-SEM. The method requires at least 10 times the largest number of indicators constructing an unobserved variable in a formative measurement model or 10 times the largest number of paths pointing at unobserved variables in the structural model (Hair Jr et al., 2016). Regarding to the proposed model in Figure 1, FC and SLEI are the unobserved variables in the formative measurement models, which have the highest number of indicators (3 indicators) pointing to the construct, and there are 5 paths directing at EC, which is the maximum number of paths pointing the unobserved variable. Hence, the proposed model requires at least 50 observations.

All indicators are filtered out the needless components and smoothed to retain only the cyclical pattern. Even though those filtered indicators will be stationary by their construction, the study also applied the Augmented Dickey-Fuller Unit Root Test to confirm that those filtered data do not have a unit root to cause a spurious relationship while analyzing PLS-SEM based on Ordinary least square estimation (OLS) as shown in Table 2.

4.2. Investigating the Relationship of CLIs to Forecast EC by PLS-SEM

With the aim to construct CLIs and investigate their relationships, the study employs PLS-SEM. PLS-SEM is analyzed by Smart-PLS version 3.2.8. Regarding the estimation setting, the study takes 300 iterations and sets a stop criterion at 10^{-7}.

4.2.1. Identifying the leading period for each CLIs

The formative measurement model is applied to construct CLIs including SLEI, FC, MC, ITT, while the study sets ITM as a single-item construct. To roughly identify those CLIs-leading period, the study constructs each CLI by a formative measurement model from its indicators at k leading period (t-k, k=0,1.,12) of EC_t (Figure 2), and considers only k producing absolute correlation ($|R|$) between $CLI_{t-k} \rightarrow EC_t > 0.7$ or $R^2 \geq 0.50$. According to the result (Table 3), $SLEI_{t-k}$ and ITT_{t-k} have the ability to lead EC_t one-period ahead (k=1) or they might be coincident index (k=0), FC_{t-k} has a tendency to lead EC_t seven-period ahead, and MC_{t-k} possibly lead ahead EC at five, eleven, or twelve-periods (k=5,11,12). Interestingly, ITM_{t-k}

Figure 2: The leading performance of each CLI

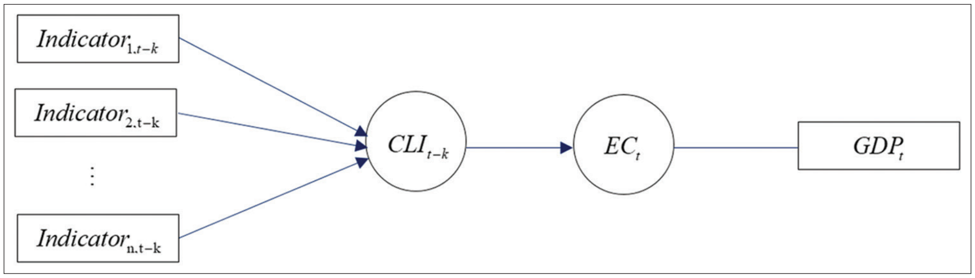


Figure 3: EWS from PLS-SEM

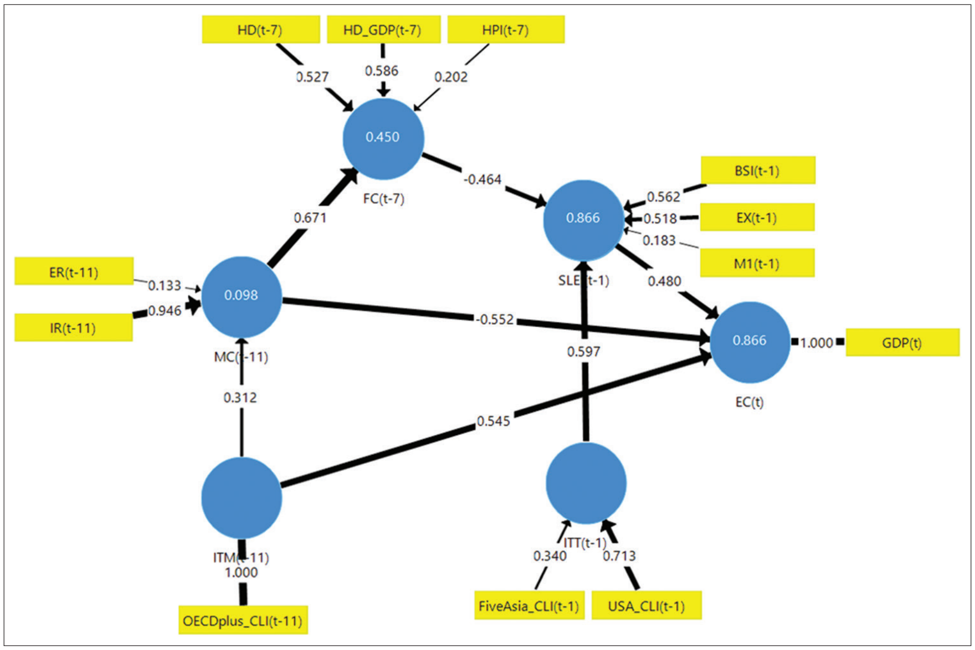


Table 3: The result of identifying the leading performance of each CLI to EC

CLI_{t-k}	k leading period producing $R_2 \geq 0.5$
$SLEI_{t-k}$	0,1
FC_{t-k}	7
MC_{t-k}	5,11,12
ITT_{t-k}	0,1

There is no k producing R^2 between $ITM_{t-k} \rightarrow EC_t \geq 0.50$; however $ITM_{t-11} \rightarrow MC_{t-11} \rightarrow EC_t$ produces $R^2 = 0.69$

Table 4: The variance inflation factor (VIF) of indicators

CLI_{t-k}	Variables	Outer VIF values
EC_t	GDP_t	1.00
$SLEI_{t-k}$	M_{t-1}	2.61
	BSI_{t-1}	1.25
	$M1_{t-1}$	2.26
ITT_{t-1}	$FiveAsia\_CLI_{t-1}$	2.50
	USA_CLI_{t-1}	2.50
FC_{t-7}	HPI_{t-7}	1.14
	HD_GDP_{t-1}	1.41
	HD_{t-7}	1.27
MC_{t-11}	IR_{t-11}	1.14
	ER_{t-11}	1.14
ITM_{t-1}	$OECDplus\_CLI_{t-11}$	1.00

does not have the ability to lead EC_t directly because there is no k producing R^2 between $ITM_{t-k} \rightarrow EC_t > 0.50$; however, ITM_{t-k} possibly makes an indirect effect EC_t through MC_{t-k} (mediator) because $ITM_{t-11} \rightarrow MC_{t-11} \rightarrow EC_t$ produces $R^2 = 0.69$

4.2.2. Developing the EWS from PLS-SEM

The various structural models are formulated between CLI_{t-k} at the selected k in Table 3 to forecast EC_t with the aim to produce the maximum R^2. $SLEI_{t-1}$ ITT_{t-1}, FC_{t-7}, MC_{t-11}, and ITM_{t-11} in the structural model produces the maximum R^2 at 0.87 and R^2_{adjust} at 0.86; however, some paths are not statistically significant. Therefore, the study eliminates those paths to develop EWS with the parsimonious model as for the Figure 3. The EWS still produces R^2 and R^2_{adjust} at 0.87 and 0.86 respectively, which include 54-11=53 observations after considering the lag-length.

4.2.3. Assessing the result of PLS-SEM

Assessing EWS by PLS-SEM output, the study evaluates the formative measurement models and the structural model. According to the parameter significant, PLS-SEM is nonparametric, which does not assume the data normality distribution; therefore, the study validates the hypotheses by the bootstrapping with 5,000 re-samples.

Evaluation of the formative measurement models: The study evaluates the variance inflation factor (VIF), which is the statistical value to verify whether the collinearity problem exhibits among

Table 5: The weight significance in the measurement models from the bootstrapping

Indicator → CLI	The weight significance of the indicators				Outer loading
	Original Sample	Sample Mean	Standard Deviation	T Statistics	
$GDP_t \rightarrow EC_t$	1.00	1.00			1.00
$M1_{t-1} \rightarrow SLEI_{t-1}$	0.18	0.19	0.14	1.36	0.81
$BSI_{t-1} \rightarrow SLEI_{t-1}$	0.56	0.55	0.13	4.46***	0.78
$EVI_{t-1} \rightarrow SLEI_{t-1}$	0.52	0.52	0.12	4.28***	0.80
$FiveAsia\_CLI_{t-1} \rightarrow ITT_{t-1}$	0.34	0.33	0.21	1.65*	0.89
$USA\_CLI_{t-1} \rightarrow ITT_{t-1}$	0.71	0.72	0.19	3.85***	0.98
$HPI_{t-7} \rightarrow FC_{t-7}$	0.20	0.19	0.10	2.05**	0.37
$HD\_GDP_{t-7} \rightarrow FC_{t-7}$	0.59	0.59	0.09	6.204***	0.88
$HD_{t-7} \rightarrow FC_{t-7}$	0.53	0.53	0.10	5.49***	0.78
$IR_{t-11} \rightarrow MC_{t-11}$	0.95	0.93	0.08	11.95***	0.99
$ER_{t-11} \rightarrow MC_{t-11}$	0.13	0.14	0.15	0.91	0.50
$OECDplus\_CLI_{t-11} \rightarrow ITM_{t-11}$	1.00	1.00			1.00

The null hypothesis of the test is the indicator weight is not significant. ***, **,* significant at the 0.01, 0.05, 0.10 level respectively

leading indicators in the same CLI. The VIF confirms that there is no collinearity problem because all of them are under the threshold at 5.00. (Table 4) The bootstrapping is employed to test the weight significance of each indicator to their constructs. The result shows many of them are significant, which means that they are relatively important. Nevertheless, M_{t-1}, and ER_{t-11} are not significant, the study also retains them in the model because their loadings are high, which implies that they are relevant to the constructs (Table 5).

Evaluation of the structural models: To assess the structural model, the linkages of the given CLIs in the model produce the substantial predictive accuracy of EC evidenced from $R^2 = 0.87$ (Table 6). According to F. Hair Jr et al. (2014); Hair et al. (2019); Hair Jr et al. (2016), R^2 of endogenous latent variables are 0.75, 0.50, or 0.25, which are considered to substantial, moderate and weak respectively. Nevertheless, based on the context and in some cases, a very low value of R^2 as 0.10 is satisfactory (Hair et al., 2019).

To access the hypothesis testing, the result supports the Hypothesis $MC \rightarrow EC$; MC is the long-term CLI of EC. The changing of MC will make an impact on EC both direct and indirect effects. The total effect of MC on EC is -0.70 meaning that the increase of MC will make a negative impact on EC in the next 11 quarters. On account of the Hypothesis $FC \rightarrow EC$, FC makes an indirect effect on EC through SLEI. The total effect of FC on EC is -0.223, which infers that the increase of FC is, the reduction of EC will get in the next 7 quarters. Therefore, the study supports the Hypothesis $FC \rightarrow EC$. Evaluating the Hypothesis $SLEI \rightarrow EC$, the path coefficient of SLEI on EC is 0.480 referring that if the SLEI increase, EC will improve in the next quarter. Hence, the Hypothesis $SLEI \rightarrow EC$ is approved. According to International Transmission, it is separated into ITT and ITM. Start with ITM, it significantly affects EC both direct and indirect effects. The total effect of ITM on EC is 0.325 implying that the increase of ITM will positively cause EC in the next 11 quarters. Regarding ITT, it indirectly causes EC through SLEI with the total effect at 0.286 concluding that the changing of ITT will make a positive impact on EC in the next quarter. Hence, both the Hypothesis $ITM \rightarrow EC$ and Hypothesis $ITT \rightarrow EC$ are approved. (Table 7).

There is no collinearity problem among CLIs (Table 8) and all path coefficients are statistically significant (Table 9).

Table 6: R^2 and R^2_{adjust}

CLI	R^2	R^2_{adjust}
EC_t	0.87	0.86
$SLEI_{t-1}$	0.87	0.86
FC_{t-7}	0.45	0.44
MC_{t-11}	0.10	0.10

Table 7: The significant total effect in the structural model from the bootstrapping

Total effect	Original Sample	Sample Mean	Standard Deviation	T statistics
$SLEI_{t-1} \rightarrow EC_t$	0.48	0.48	0.08	5.74***
$ITT_{t-1} \rightarrow EC_t$	0.29	0.28	0.08	3.47***
$FC_{t-7} \rightarrow EC_t$	−0.22	−0.22	0.05	5.00***
$MC_{t-11} \rightarrow EC_t$	−0.70	−0.70	0.07	10.48***
$ITM_{t-11} \rightarrow EC_t$	0.33	0.32	0.14	2.29**
$ITM_{t-11} \rightarrow SLEI_{t-1}$	−0.10	−0.10	0.05	2.17**
$FC_{t-7} \rightarrow SLEI_{t-1}$	−0.46	−0.47	0.10	4.50***
$MC_{t-11} \rightarrow SLEI_{t-1}$	−0.31	−0.32	0.07	4.46***
$ITT_{t-1} \rightarrow SLEI_{t-1}$	0.60	0.59	0.11	5.61***
$MC_{t-11} \rightarrow FC_{t-7}$	0.67	0.68	0.07	9.63***
$ITM_{t-11} \rightarrow FC_{t-7}$	0.21	0.21	0.10	2.15**
$ITM_{t-11} \rightarrow MC_{t-11}$	0.31	0.31	0.13	2.33**

The null hypothesis of the test is the total effect is not significant. ***, **,* significant at the 0.01, 0.05, 0.10 level respectively

Table 8: The variance inflation factor (VIF) of the composite leading index (CLIs)

$CLI_{t-k} \rightarrow EC_t$	Inner VIF value
$SLEI_{t-1} \rightarrow EC_t$	1.78
$ITT_{t-1} \rightarrow SLEI_{t-1}$	1.39
$FC_{t-7} \rightarrow SLEI_{t-1}$	1.39
$MC_{t-11} \rightarrow EC_t$	1.86
$MC_{t-11} \rightarrow FC_{t-7}$	1.00
$ITM_{t-11} \rightarrow EC_t$	1.11
$ITM_{t-11} \rightarrow MC_{t-11}$	1.00

4.3. Evaluation of the EWS byPLS-SEM performance

This section compares the forecasting performance of EWS estimated by PLS-SEM with those of the two benchmark models. First, the study considers the CLI with equal weight, and the second, the study applies the ARIMA model.

4.3.1. Comparing the EWS with the individual CLIs

To evaluate the EWS forecasting performance and to confirm that the linkages of CLIs from PLS-SEM outperforms the individual CLI, the study estimates CLIs with equal weight for comparing the results with EWS. The individual equal-weighted CLIs (CLI1, CLI2, CLI3, CLI4, CLI5, CLI6, and CLI7) consist of the indicators the same as the indicators in the measurement model of PLS-SEM.

Table 9: The path significance in the structural model from the bootstrapping

Direct effect (Path)	Original sample	Bootstrap		
		Sample mean	Standard deviation	T statistics
$SLEI_{t-1} \rightarrow EC_t$	0.48	0.48	0.08	5.74***
$MC_{t-11} \rightarrow EC_t$	−0.55	−0.55	0.07	7.98***
$ITM_{t-11} \rightarrow EC_t$	0.54	0.53	0.16	3.52***
$FC_{t-7} \rightarrow SLEI_{t-1}$	−0.46	−0.47	0.10	4.50***
$ITT_{t-1} \rightarrow SLEI_{t-1}$	0.60	0.58	0.11	5.61***
$MC_{t-11} \rightarrow FC_{t-7}$	0.67	0.68	0.07	9.63***
$ITM_{t-11} \rightarrow MC_{t-11}$	0.31	0.31	0.13	2.33**

The null hypothesis of the test is the path is not significant. ***, **,* significant at the 0.01, 0.05, 0.10 level respectively

In this section, the EWS estimated from data 2003/Q1 to 2018/Q4 (Figure 3) can forecast EC in the short-term (one-quarter ahead) by EWS1, middle-term (seven-quarter ahead) by EWS7, long-term period (eleven-quarter ahead) by EWS11 as the Figure 4.

A cross-correlation structure is taken to consider forecasting performance between the EWSs and the equal-weighted CLIs. The study analyses the correlation coefficient (*ρ*) between the candidates and EC with 12 quarters forward and backward.

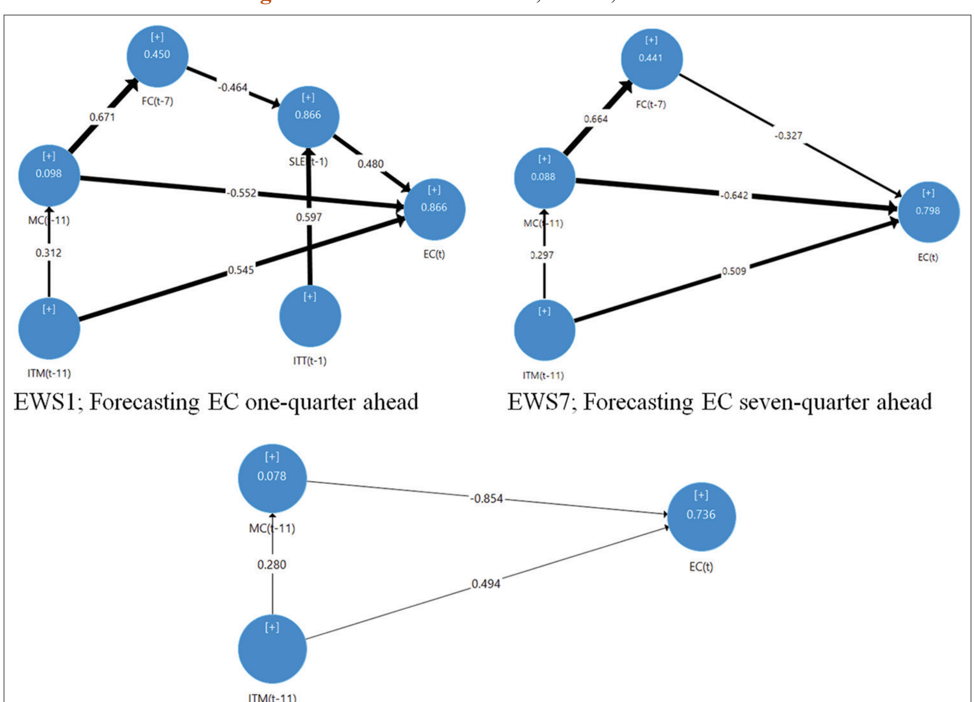
$$\rho_{EC_t,\text{Candidate}_{t-k}} = \frac{Cov(\text{EC}_t, \text{Candidate}_{t-k})}{\sqrt{Var(\text{EC}_t)\,\text{Var}(Candidate_{t-k})}} \quad (4)$$

Where *EC* is the Economic cycle, Candidate is an EWS or an equal-weighted CLI, *t* is time, and $k = 0, \pm 1, \pm 2, \pm 12$. The potential

Table 10: The forecasting performance of the EWSs and the individual equal-weighted CLI

Leading-performance	CLI	Maximum r (at k)	RMSE
Short-leading (one-quarter ahead)	CLI1 consist of M1, BSI, EX	0.737 (0)	0.726
	CLI2 consist of FiveAsia_CLI, USA_CLI	0.657 (1)	0.887
	CLI3 consist of M1, BSI, EX FiveAsia_CLI, USA_CLI	0.743 (0)	0.725
	EWS1	0.912 (1)	0.453
Middle-leading (7-quarter ahead)	CLI4 consist of HPI, HD_GDP, HD	−0.486 (7)	1.709
	EWS7	0.871 (7)	0.543
Long-leading (11-quarter ahead)	CLI5 consist of IR, ER	0.624 (−1)	0.808
	CLI6 consist of OECDplus_CLI	0.630 (+1)	0.948
	CLI7 consist of IR, ER, OECDplus_CLI	0.666 (0)	0.824
	EWS11	0.836 (+11)	0.608

Figure 4: The model of EWS1, EWS7, and EWS11



EWS1; Forecasting EC one-quarter ahead

EWS7; Forecasting EC seven-quarter ahead

EWS11; Forecasting EC elven-quarter ahead

Table 11: Comparison of model accuracy between PLS-SEM and ARIMA model

EWS	ARIMA	Data in-sample	Data out-sample	RMSE						Percentage of Correct Predictions (SIGN)					
				PLS-SEM		ARIMA		Better Performance		PLS-SEM		ARIMA		Better Performance	
				In-sample	Out-of-sample	In-sample	Out-of-sample	In-sample	Out-of-sample	In-sample	Out-of-sample	In-sample	Out-of-sample	In-sample	Out-of-sample
EWS1			14Q1 to 14Q1	0.08	0.05	0.05	0.14	ARIMA	EWS	90.9	100.0	97.0	100.0	ARIMA	EWS=ARIMA
EWS7	(3 0 3)	03Q1 to 13Q4	14Q1 to 15Q3	0.10	0.13	0.04	0.13	ARIMA	EWS	87.9	100.0	93.9	57.1	ARIMA	EWS
EWS11			14Q1 to 16Q3	0.12	0.13	0.04	0.09	ARIMA	ARIMA	81.8	81.8	93.9	36.4	ARIMA	EWS
EWS1			14Q2 to 14Q2	0.08	0.14	0.04	0.82	ARIMA	EWS	91.2	100.0	97.1	100.0	ARIMA	EWS=ARIMA
EWS7	(2 0 4)	03Q1 to 14Q1	14Q2 to 15Q4	0.10	0.16	0.04	0.26	ARIMA	EWS	85.3	100.0	94.1	57.1	ARIMA	EWS
EWS11			14Q2 to 16Q4	0.11	0.08	0.04	0.18	ARIMA	EWS	82.4	90.9	94.1	54.5	ARIMA	EWS
EWS1			14Q3 to 14Q3	0.08	0.33	0.04	1.18	ARIMA	EWS	91.4	100.0	100.0	100.0	ARIMA	EWS=ARIMA
EWS7	(3 0 4)	03Q1 to 14Q2	14Q3 to 16Q1	0.09	0.15	0.03	0.38	ARIMA	EWS	85.7	100.0	94.3	57.1	ARIMA	EWS
EWS11			14Q3 to 17Q1	0.11	0.05	0.03	0.26	ARIMA	EWS	88.6	100.0	94.3	72.7	ARIMA	EWS
EWS1			14Q4 to 14Q4	0.07	0.10	0.03	0.39	ARIMA	EWS	91.7	100.0	100.0	100.0	ARIMA	EWS=ARIMA
EWS7	(3 0 4)	03Q1 to 14Q3	14Q4 to 16Q2	0.09	0.12	0.02	0.16	ARIMA	EWS	86.1	100.0	100.0	42.9	ARIMA	EWS
EWS11			14Q4 to 17Q2	0.10	0.07	0.02	0.15	ARIMA	EWS	88.9	81.8	100.0	36.4	ARIMA	EWS
EWS1			15Q1 to 15Q1	0.07	0.11	0.03	0.41	ARIMA	EWS	91.9	100.0	100.0	100.0	ARIMA	EWS=ARIMA
EWS7	(3 0 4)	03Q1 to 14Q4	15Q1 to 16Q3	0.08	0.12	0.02	0.15	ARIMA	EWS	86.5	85.7	100.0	28.6	ARIMA	EWS
EWS11			15Q1 to 17Q3	0.10	0.10	0.02	0.15	ARIMA	EWS	89.2	81.8	100.0	18.2	ARIMA	EWS
EWS1			15Q2 to 15Q2	0.07	0.18	0.03	0.27	ARIMA	EWS	92.1	100.0	100.0	100.0	ARIMA	EWS=ARIMA
EWS7	(3 0 4)	03Q1 to 15Q1	15Q2 to 16Q4	0.08	0.15	0.02	0.13	ARIMA	ARIMA	86.8	71.4	100.0	42.9	ARIMA	EWS
EWS11			15Q2 to 17Q4	0.10	0.10	0.02	0.12	ARIMA	EWS	86.8	81.8	100.0	54.5	ARIMA	EWS
EWS1			15Q3 to 15Q3	0.07	0.55	0.03	0.11	ARIMA	ARIMA	92.3	100.0	100.0	100.0	ARIMA	EWS=ARIMA
EWS7	(3 0 3)	03Q1 to 15Q2	15Q3 to 17Q1	0.08	0.19	0.02	0.16	ARIMA	ARIMA	87.2	71.4	100.0	28.6	ARIMA	EWS
EWS11			15Q3 to 18Q1	0.09	0.15	0.02	0.18	ARIMA	EWS	84.6	72.7	100.0	18.2	ARIMA	EWS
EWS1			15Q4 to 15Q4	0.07	0.72	0.03	0.29	ARIMA	ARIMA	92.5	100.0	100.0	100.0	ARIMA	EWS=ARIMA
EWS7	(2 0 3)	03Q1 to 15Q3	15Q4 to 17Q2	0.08	0.21	0.02	0.10	ARIMA	ARIMA	87.5	57.1	100.0	85.7	ARIMA	ARIMA
EWS11			15Q4 to 18Q2	0.09	0.16	0.02	0.17	ARIMA	EWS	85.0	63.6	100.0	63.6	ARIMA	EWS=ARIMA
EWS1			16Q1 to 16Q1	0.07	0.39	0.03	0.69	ARIMA	EWS	92.7	100.0	100.0	0.0	ARIMA	EWS
EWS7	(2 0 4)	03Q1 to 15Q4	16Q1 to 17Q3	0.08	0.17	0.02	0.25	ARIMA	EWS	90.2	71.4	97.6	0.0	ARIMA	EWS
EWS11			16Q1 to 18Q3	0.09	0.15	0.02	0.21	ARIMA	EWS	90.2	72.7	97.6	0.0	ARIMA	EWS
EWS1			16Q2 to 16Q2	0.10	0.40	0.03	0.84	ARIMA	EWS	88.1	100.0	97.6	0.0	ARIMA	EWS
EWS7	(2 0 4)	03Q1 to 16Q1	16Q2 to 17Q4	0.08	0.14	0.03	0.25	ARIMA	EWS	90.5	57.1	95.2	14.3	ARIMA	EWS
EWS11			16Q2 to 18Q4	0.09	0.15	0.03	0.20	ARIMA	EWS	90.5	54.5	95.2	9.1	ARIMA	EWS
EWS1			16Q3 to 16Q3	0.07	0.53	0.04	1.03	ARIMA	EWS	90.7	100.0	95.3	0.0	ARIMA	EWS
EWS7	(2 0 4)	03Q1 to 16Q2	16Q3 to 18Q1	0.08	0.15	0.03	0.26	ARIMA	EWS	90.7	57.1	95.3	0.0	ARIMA	EWS
EWS11			16Q3 to 19Q1	0.09	0.14	0.03	0.19	ARIMA	EWS	90.7	45.5	95.3	0.0	ARIMA	EWS
EWS1			16Q4 to 16Q4	0.07	0.84	0.04	0.83	ARIMA	ARIMA	90.9	0.0	93.2	0.0	ARIMA	EWS=ARIMA
EWS7	(2 0 4)	03Q1 to 16Q3	16Q4 to 18Q2	0.08	0.14	0.03	0.25	ARIMA	EWS	90.9	57.1	93.2	14.3	ARIMA	EWS
EWS11			16Q4 to 19Q2	0.09	0.12	0.03	0.17	ARIMA	EWS	88.6	54.5	93.2	9.1	ARIMA	EWS
EWS1			17Q1 to 17Q1	0.07	0.72	0.04	0.40	ARIMA	ARIMA	90.9	0.0	93.2	0.0	ARIMA	EWS=ARIMA
EWS7	(2 0 4)	03Q1 to 16Q4	17Q1 to 18Q3	0.08	0.12	0.04	0.20	ARIMA	EWS	90.9	71.4	93.2	57.1	ARIMA	EWS
EWS11			17Q1 to 19Q3	0.09	0.13	0.04	0.14	ARIMA	EWS	88.6	45.5	93.2	63.6	ARIMA	ARIMA
EWS1		AVERAGE		0.07	0.39	0.03	0.57	ARIMA	EWS	91.3	84.6	97.8	61.5	ARIMA	EWS
EWS7		AVERAGE		0.09	0.15	0.03	0.21	ARIMA	EWS	88.3	76.9	96.6	37.4	ARIMA	EWS
EWS11		AVERAGE		0.10	0.12	0.03	0.17	ARIMA	EWS	87.5	71.3	96.6	33.6	ARIMA	EWS

tools need to have a high correlation and $k > 0$, which means that those act as leading of EC (Tule et al., 2016).

In addition the correlation coefficient, the study also considers the root mean square error (RMSE) to compare EC forecasting and EC. The evidence from Table 10 shows that EWS outperforms the benchmark. First, the EWS has leading performance longer than the benchmark (at Long-leading period). EWS produces less RMSE meaning that they have forecasting accuracy than the benchmark.

4.3.2. Comparing the EWS with ARIMA model

The study compares the forecasting performance of EWS by PLS-SEM to the ARIMA model by considering RMSE and the correct sign prediction. Both EWS and ARIMA are estimated from sub-sample data by an increasing window rolling approach. The first sub-sample includes data 2003Q1-2013Q4, and the second sub-sample will add more one new data as for 2003Q1-2014Q1, and so on, the last sub-sample includes 2003Q1-2016Q4. Both the EWS and ARIMA model are estimated from those sub-samples to forecast out-of-sample data: 2014Q1-2016Q3, 2014Q2-2016Q4, and so on, the last one forecasts 2017Q1-2019Q3. According to the ARIMA model selection, the study considers the Akaike information criterion (AIC).

As for correct sign prediction, the study considers two stages of EC; prosperity (EC is over the zero), depression (EC is equal or less than zero). It will be considered the correct signal if the forecast models signal the same as the true data.

The result from both RMSE and the correct sign prediction shows that the ARIMA models outperform EWSs for the in-sample forecasting; however, the EWSs are evidently outstanding over ARIMA models for the out-of-sample forecasting (Table 11).

Because the aim of the study is to forecast EC in advance or the out-of-sample forecasting, hence the EWSs by PLS-SEM is overcome the ARIMA models.

5. CONCLUSION

The study applies PLS-SEM to develop EWS in order to forecast the EC of Thailand. Firstly, the composite indices are constructed to represent economic sectors, which have the potential to advance signal EC. Those indices are considered as CLIs of EC. Secondly, the relationship between those CLIs is examined from the structural model. The result shows that the EWS by PLS-SEM includes five constructs. There are two short-term CLIs, which are SLEI and ITT signaling EC at one-quarter ahead. SLEI compose of M1, BSI, and EX while ITT constructs from CLI of the major Thai export partners including FiveAsia_CLI and the USA_CLI. As a Medium-term CLI, FC leads EC seven-quarter in advance, which includes HPI, HD_GDP, and HD. While MC and ITM are the long-term CLI, with eleven-quarter ahead EC. MC consists of IR and ER whereas ITM is represented by the global economy using OECDplus_CLI as a proxy. The evidence from the forecasting accuracy in out-of-sample explicit that EWS by PLS-SEM outperforms the benchmark models (equal-weighted CLIs and the ARIMA model) for all short-term, middle-term, and long-term periods.

The finding provides important indicators and EWS to forecast EC not only for policymakers but also for business firms to their strategic planning. Moreover, the use of PLS-SEM could be applied to forecast other economic indicators such as exchange rate, interest rate, or inflation rate.

Therefore, the study convinces to apply the linkage of CLIs by PLS-SEM as EWSs, and confirm that “two heads are better than one”.

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REFERENCES

Babecký, J., Havránek, T., Matějů, J., Rusnák, M., Šmídková, K., Vašíček, B. (2013), Leading indicators of crisis incidence: Evidence from developed countries. Journal of International Money and Finance, 35, 1-19.

Bank of Thailand. Leading Economic Index and Components. Available from: https://www.bot.or.th/app/BTWS_STAT/statistics/downloadfile.aspx?file=ec_ei_002_s2_eng.pdf.

Bilan, Y., Gavurova, B., Stanisław, G., Tkacova, A. (2017), The composite coincident indicator (CCI) for business cycles. Acta Polytechnica Hungarica, 14(7), 71-90.

Borio, C. (2014), The financial cycle and macroeconomics: What have we learnt? Journal of Banking and Finance, 45, 182-198.

Borio, C., Drehmann, M., Xia, D. (2018), The financial cycle and recession risk. BIS Quarterly Review, 1, 59-71.

Buckle, R.A., Kunhong, K., McClellan, N. (2003), The Impact of Monetary Policy on New Zealand Business Cycles and Inflation Variability. New Zealand Treasury.

Cantor, R., Mark, N.C. (1988), The international transmission of real business cycles. International Economic Review, 1988, 493-507.

Castro-González, S., Leon, J.C.M. (2017), Economic crisis’s influence over the quantification of puerto rico’s shadow economy: Parsimonious econometric proposal. The Journal of Applied Business and Economics, 19(8), 48-62.

Drehmann, M., Borio, C.E., Tsatsaronis, K. (2012), Characterising the Financial Cycle: Don’t Lose Sight of the Medium Term! BIS Working Paper No. 380. Available from: https://www.ssrn.com/abstract=2084835.

Drehmann, M., Yetman, J. (2018), Why you should use the Hodrick-Prescott Filter at Least to Generate Credit Gaps. BIS Working Paper No. 744. Available from: https://www.ssrn.com/abstract=3275756.

Ericsson, N.R., Jansen, E.S., Kerbeshian, N.A., Nymoen, R. (1998), Interpreting a Monetary Conditions Index in Economic Policy. Paper Presented at the Bank for International Settlements Conference Papers.

Freedman, C. (1996), The role of monetary conditions and the monetary conditions index in the conduct of policy. The Transmission of Monetary Policy in Canada, 1, 81-86.

Grinderslev, O.J., Kramp, P.L., Kronborg, A.F., Pedersen, J. (2017), Financial Cycles: What are they and what do they Look

Like in Denmark? Available from: https://www.econstor.eu/bitstream/10419/171809/1/895031124.pdf.

Gyomai, G., Guidetti, E. (2012), OECD System of Composite Leading Indicators. Available from: http://www.oecd.org/sdd/leading-indicators/41629509.pdf.

Hair F.J. Jr., Sarstedt, M., Hopkins, L., Kuppelwieser, V.G. (2014), Partial least squares structural equation modeling (PLS-SEM) An emerging tool in business research. European Business Review, 26(2), 106-121.

Hair, J.F. Jr., Hult, G.T.M., Ringle, C., Sarstedt, M. (2016), A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM). New York: Sage Publications.

Hair, J.F., Risher, J.J., Sarstedt, M., Ringle, C.M. (2019), When to use and how to report the results of PLS-SEM. European Business Review, 31(1), 2-24.

Hamilton, J.D. (2018), Why you should never use the Hodrick-Prescott filter. Review of Economics and Statistics, 100(5), 831-843.

Hickman, B.G. (1974), International Transmission of Economic Fluctuations and Inflation. Boston: Paper Presented at the Federal Reserve Bank.

Jabeur, S.B., Sghaier, A. (2018), The relationship between energy, pollution, economic growth and corruption: A partial least squares structural equation modeling (PLS-SEM) approach. Economics Bulletin, 38(4), 1927-1946.

Juselius, M., Borio, C.E., Disyatat, P., Drehmann, M. (2016), Monetary Policy, the Financial Cycle and Ultralow Interest Rates. Bank of Finland Research Discussion Paper, No. 24.

Kose, M.A., Prasad, E.S., Terrones, M.E. (2003), How does globalization affect the synchronization of business cycles? American Economic Review, 93(2), 57-62.

Levanon, G., Manini, J.C., Ozyildirim, A., Schaitkin, B., Tanchua, J. (2015), Using financial indicators to predict turning points in the business cycle: The case of the leading economic index for the United States. International Journal of Forecasting, 31(2), 426-445.

Lowry, P.B., Gaskin, J. (2014), Partial least squares (PLS) structural equation modeling (SEM) for building and testing behavioral causal theory: When to choose it and how to use it. IEEE Transactions on Professional Communication, 57(2), 123-146.

Memon, I.A., Jabeen, H. (2018), Monetary condition index and its changing transmission on macro-economic variables. Arab Economic and Business Journal, 13(2), 111-124.

Mintz, I. (1969), Dating Postwar Business Cycles: Methods and their Application to Western Germany, 1950-67. Cambridge, Massachusetts: NBER.

Mitchell, W.C., Burns, A.F. (1938), Statistical indicators of cyclical revivals. In: Statistical Indicators of Cyclical Revivals. Cambridge, Massachusetts: NBER. p1-12.

Nilsson, R. (2006), Composite Leading Indicators and Growth Cycles in Major OECD Non-Member Economies and Recently new OECD Members Countries. OECD Statistics Working Papers, No. 2006/05.

Schmitt-Grohé, S. (1998), The international transmission of economic fluctuations: Effects of US business cycles on the Canadian economy. Journal of international Economics, 44(2), 257-287.

Sethapramote, Y. (2015), Synchronization of business cycles and economic policy linkages in ASEAN. Journal of Asian Economics, 39, 126-136.

Stock, J.H., Watson, M.W. (1989), New indexes of coincident and leading economic indicators. NBER Macroeconomics Annual, 4, 351-394.

Tule, M., Ajilore, T., Ebuh, G. (2016), A composite index of leading indicators of unemployment in Nigeria. Journal of African Business, 17(1), 87-105.

Wold, H. (1975), Path models with latent variables: The NIPALS approach. In: Quantitative Sociology. Amsterdam, Netherlands: Elsevier. p307-357.

Wongwachara, W., Jindarak, B., Nookhwun, N., Tunyavetchakit, S., Klungjaturavet, C. (2018), Integrating Monetary Policy and Financial Stability: A New Framework. Available from: https://www.pier.or.th/wp-content/uploads/2018/12/pier_dp_100.pdf.